LIMESTONES OF CANADA

THEIR OCCURRENCE AND CHARACTERISTICS

PART III
QUEBEC

M. F. GOUDGE

MINES BRANCH
DEPARTMENT OF MINES
OTTAWA
1935
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Limestones of Canada

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Part III

Quebec

BY

M. F. Goudge

OTTAWA
J. O. PATENAUDE, I.S.O.,
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1935

Price, 50 cents

No. 755

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PREFACE

This report is based on a survey of the limestone resources of Canada, made with the object of obtaining data on the physical and chemical characteristics of the deposits, methods of quarrying and preparing the stone for the market, the technology of lime manufacture, and on the uses of lime and limestone in various industries. The importance of limestone to the industrial life of the country may be gauged by the fact that in 1932 approximately 9,300,000 tons of limestone, including marble, was raised from Canadian quarries, which, when manufactured into its primary products such as lime, cement, and stone for various purposes, had a selling value of $25,500,000. The peak production was reached in 1929 when nearly 13,000,000 tons was quarried.

The survey of the limestone resources was begun in 1925 and, as the work progressed, preliminary reports[1] on the resources of the various provinces were published. A detailed report "Canadian Limestones for Building Purposes" has also been published.

The present report deals particularly with the occurrence and chemical and physical characteristics of the limestones in the various provinces, the data obtained on the technology and uses of lime and limestone being reserved for a later report. It is being issued in five parts as follows:

Part I: Introductory.
Part II: Maritime Provinces.
Part III: Quebec.
Part IV: Ontario.
Part V: Western Canada.

It is manifestly impossible to examine all outcrops throughout a large country in which limestone is as plentiful as it is in Canada, but all active quarries, most of the inactive quarries, and many of the prominent outcrops within 3 miles of rail or water transportation were examined and sampled. Nearly all samples obtained were channel samples, or the equivalent, taken across the strata at right angles to the strike. Where a difference in character, either chemical or physical, was observed, a separate sample of each kind of stone was taken. The samples, some weighing as much as 50 pounds each, were crushed to a fineness of $\frac{1}{8}$ inch or less in a small jaw crusher, and then cut down to about 2 pounds in weight by means of a Jones sampler. The 2-pound sample was pulverized to approximately 100 mesh and from this an 8-ounce sample was obtained and sent to the chemical laboratory for analysis. Interbeds of shale present in the deposit were not included in the samples, for in any method of quarrying involving

[1] Mines Branch, Department of Mines, Ottawa.
Rept. No. 682: Limestones of Quebec and Ontario, Prelim. Rept.
Rept. No. 687: Invest. Min. Res. and the Min. Ind. 1926, pp. 35-52, Maritime Provinces, Gaspe, and Timiskaming.
Rept. No. 710: Invest. Min. Res. and the Min. Ind. 1928, pp. 1-18, Western Ontario and Prairie Provinces.
Rept. No. 719: Invest. Min. Res. and the Min. Ind. 1929, pp. 43-64, British Columbia.
Mem. Series, Rept. No. 50: Raw Materials for the Manufacture of Rock Wool in the Niagara Peninsula of Ontario.

hand-sorting, such as is general practice in quarrying stone for lime manufacture, the shale could be largely eliminated. Thus the chemical analyses of the samples obtained from some deposits indicate a purer stone than could be obtained by non-selective methods of quarrying, as, for example, where steam-shovel loading is employed. It is to be borne in mind that the analysis of a single sample from a deposit is merely indicative of the character of the deposit and much more detailed sampling and investigation than is practicable in a general survey of the resources is necessary to prove definitely the character of any individual deposit.

All chemical analyses of the samples, unless otherwise noted, were made by C. L. O'Brian of the Chemical Division and to him the writer's thanks are extended for co-operation in all matters pertaining to the chemical examination of limestones.

Previous reports on Canadian limestones include "The Limestones of Ontario" by the late Dr. W. G. Miller of the Ontario Department of Mines, and preliminary reports on the limestones of Ontario and Quebec by Howells Fréchette, published in the Mines Branch Summary Reports for 1915, 1916, and 1918. Much information on limestone is also given in Mines Branch report "The Building Stones of Canada" by Dr. W. A. Parks, published in 5 parts. There are also many references to limestone deposits in the publications of the Geological Survey of Canada, and of the Departments of Mines of the various provinces. These reports and references were of great assistance, particularly in the field work in connection with the present report, and indebtedness to the various authors is acknowledged.

The writer wishes to thank the owners and operators of the various limestone properties examined for many courtesies and for willing co-operation in supplying information regarding their properties and plants. Grateful thanks are also extended to Dr. T. H. Clark of McGill University for his kindness in perusing and criticizing that part of the manuscript dealing with the Montreal district and the Eastern Townships.

Limestones of Canada

Their Occurrence and Characteristics

PART III

QUEBEC

CHAPTER I

INTRODUCTORY

DEFINITION AND CLASSIFICATION OF LIMESTONES

Limestones are rocks of sedimentary origin consisting mainly of calcium carbonate (calcite) or of the double carbonate of calcium and magnesium (dolomite). Based on their content of these constituents limestones may be divided into three classes:—

1. *Calcium limestones,* or those in which calcium carbonate greatly predominates and which contain less than 10 per cent magnesium carbonate.
2. *Dolomites,* or those composed almost wholly of the mineral dolomite and containing between 40 and 45·65 per cent magnesium carbonate.
3. *Magnesian limestones,* or those intermediate in composition between the other two classes.

The term *high-calcium limestone* as used in this report is reserved to denote a calcium limestone containing not more than 3 per cent total impurities and not more than 2 per cent magnesium carbonate.

The distinction between the classes is purely arbitrary. The classification was adopted after a study of the chemical analyses of 1,500 samples of limestone collected from all parts of Canada, which showed that the greater proportion of limestones comes within the first two classes, and that, despite the wide range in composition allotted to the magnesian limestones, i.e. those containing from 10 to 40 per cent magnesium carbonate, this class is relatively small, particularly when only the purer limestones are considered. By "purer" limestones is meant those with less than 5 per cent total impurities.[1] Among the impure limestones the magnesian variety is somewhat more common but even here this variety is far in the minority. The presence of mechanically intermixed impurities, such as sand grains and argillaceous matter, often masks the true character of a dolomite and if the above classification were applied to all limestones a very impure dolomite would be grouped with the magesian limestones even though the ratio between the calcium and magnesium components in the rock was that of a true dolomite. A scientific classification applicable to all varieties of limestone would be one based on

[1] The common impurities are discussed on p. 5.

the ratio between the calcium and magnesium components present and this would be particularly applicable to limestones containing a high percentage of impurities. Such a classification based on the amounts of calcium oxide and magnesium oxide determined by analysis would be as follows:—

1. *Calcium limestones*, those in which the ratio of CaO to MgO is greater than 10·5:1.

2. *Magnesian limestones*, those in which the ratio of CaO to MgO is less than 10·5:1 and greater than 1·76:1.

3. *Dolomites*, those in which the ratio of CaO to MgO is less than 1·76 and greater than 1·39:1.

The ratios between calcium oxide and magnesium oxide are shown in the last column of each table of analyses in this report.

For commercial purposes, however, for which pure limestones are generally required, a classification such as the first, based on the actual percentages of the carbonates of calcium and magnesium, is more convenient and useful.

A few highly metamorphosed limestones are known that contain more than 45·65 per cent of magnesium carbonate, due apparently to replacement by magnesite (magnesium carbonate). Where the replacement is only partial such rocks are referred to as *magnesian dolomites* or *magnesitic dolomites*. Where the replacement is complete, or nearly so, the rock is termed *magnesite*.

All limestone deposits contain some sandy or clayey material, and the deposits may grade almost imperceptibly into a shale, sandstone, or other kind of rock. The usual dividing line, arbitrarily made, between a limestone and another type of rock is that if the rock contains a total of 50 per cent, or more, of the combined carbonates of calcium and magnesium, it is termed a limestone, if it contains less, it is otherwise classified.

ORIGIN OF LIMESTONE

Virtually all limestones have been formed under water by the action of organic or chemical agencies, or a combination of the two, on dissolved calcareous matter, and have been deposited in layers or beds usually separated by a layer of shaly material. Each bed represents a period of uninterrupted deposition and each interbed of shale represents a break in the process, or a change in conditions. The deposit may consist entirely of thick beds, or of thin beds; thick and thin beds may alternate; or the beds may become progressively thicker from the base to the top of the deposit, or vice versa. Again, where limestones have been deposited over a large area, the same bed may be thick in one place and thin in another. Every bed in fact is lenticular, attaining its maximum thickness where conditions were most favourable to accumulation, and thinning out toward the edges of the area. This lenticular character is typical of the great limestone formations as a whole, although in many cases the so-called lenses may be hundreds of miles across. Limestone conglomerates are formed largely by mechanical agencies whereby debris from previously formed limestones is transported to lakes or to the ocean where it again becomes consolidated.

During the process of accumulation, limestone is a loose mass of shell fragments and ooze. Consolidation into solid rock may be brought about by a number of factors acting singly or in combination. Probably the chief agency is the growth of cementing crystals of calcite, or dolomite, throughout the mass. It may also be brought about by the weight of the material itself or of beds of other material deposited on top. Pressure due to earth movements plays an important part in consolidating the deposits, and the heat of igneous intrusions is also effective. The consolidation may have been only partial as with chalk, or it may have been very complete as in the case of marble.

From their original position beneath the water, the deposits have been raised to dry land by movements of the earth's crust, many having been repeatedly raised and lowered. In some deposits the original bedding has not been disturbed, but in others the beds have been crumpled and broken and heaved up into mountain ranges.

CHARACTERISTICS OF LIMESTONE

Colour

Limestones range in colour from pure white through all shades of grey to black, and from blue through green, yellow, brown, and orange to red. Cream colours are also common and more rarely purple tints are present. These beautiful colours are due to the presence of small quantities of impurities of pigment-like nature. Limestones free from these impurities are white. Varying amounts of iron oxides are believed to cause the cream, buff, brown, yellow, orange, and red tints. The greys, blues, and blacks are due principally to very finely divided carbonaceous matter. In the weathered outcrop the colouring is never so vivid as on a polished or on a freshly broken surface, and some limestones change their surface colour completely when exposed to the weather, though this change seldom goes deep except with very impure stones. Black limestones rapidly become very light grey on the weathered surface, probably owing to a bleaching of the black carbonaceous pigment that colours them. This change is never more than skin deep and is accompanied by no decay in the stone. Some limestones, particularly dolomites, turn brown on the weathered surface, the change proceeding very slowly, but it may extend to a considerable depth. It is seemingly due to the oxidation of small amounts of ferrous carbonate, iron present in dolomites being usually in the ferrous condition. The white and light blue colour of many highly altered limestones, such as some of the marbles, is due to organic pigments having been destroyed by heat or else segregated into flakes of graphite, and to the inorganic pigments having been segregated into crystalline masses.

Texture

The texture of limestones varies considerably. Some limestones are compact, others are porous and full of cavities, still others are composed of shells and fossil remains knit together with varying degrees of firmness.

All limestones are crystalline. Even chalk, which appears amorphous, is actually composed of minute crystals of calcium carbonate visible only

under a high-powered microscope. Thus the common usage of the term "crystalline limestone" to designate marble and all limestones that have been recrystallized through the agencies of heat or pressure, or both, is misleading in that it implies that some limestones are non-crystalline or amorphous. The term metamorphic limestone is preferable when referring to limestones that have been greatly altered or recrystallized through metamorphic agencies. The visible changes usually wrought by intense metamorphism are to render the limestone lighter in colour, to obscure the original bedding planes and to cause segregation of inorganic impurities into larger crystals and masses.

The common sizes of individual crystals of calcite and dolomite composing limestones range from microscopic dimensions up to $\frac{1}{4}$ inch in diameter. In a few deposits crystals larger than $\frac{1}{2}$-inch diameter occur. Calcite crystals are rarely present in their true symmetrical forms but usually as shapeless grains tightly interlocked. Dolomite crystals, on the other hand, are generally well shaped. It is the size of glistening facets of the freshly broken crystals that gives a limestone the appearance of being either fine or coarse in grain. On a weathered surface the grain is not readily apparent. According to grain size limestones may be classified as follows:—

Dense limestones—individual crystals not perceptible to the eye.
Fine-grained—crystals visible but under $\frac{1}{32}$ inch in diameter.
Medium-grained—average crystal diameter between $\frac{1}{32}$ and $\frac{1}{16}$ inch.
Coarse-grained—average crystal diameter between $\frac{1}{16}$ and $\frac{1}{8}$ inch.
Very coarse-grained—average crystal diameter exceeding $\frac{1}{8}$ inch.

If the crystal or grain size is uniform, a limestone is termed *uniform-grained* irrespective of the size of the crystals. As a matter of fact, wide variations in size of grain within a single stratum are uncommon (mottled limestone and partly dolomitized limestone excepted), but in a succession of beds the variation may be considerable. The presence of complete fossils or fossil fragments thickly scattered through the stone may obscure the grain. When fossils are much in evidence and plainly visible the limestone is referred to as *fossiliferous limestone,* with distinctive names for the varieties depending on the characteristic fossil, as *shell limestone*, *coral limestone,* and *crinoidal limestone.* Many limestones are composed in part of little spherical and oval bodies called oolites. Usually the oolites are $\frac{1}{32}$ inch or less in diameter, although much larger ones also occur. When the oolites are sufficiently numerous to impart a characteristic texture the stone is called *oolitic limestone.*

Hardness

Limestones, even the very pure varieties, have a wide range in hardness. This may seem strange when it is considered that they are composed either of calcite with a hardness of 3, or of dolomite with a hardness of 3·5 to 4, but the amount and character of the cementing material, as well as the degree of cementation, have a great effect on the hardness. The common cementing materials in limestones are calcium carbonate and dolomite. Some limestones, such as certain of the oolitic and shell limestones that are

cemented only at the points of contact of the particles, are very friable. Dense-textured, well-cemented limestones are usually harder than coarse-grained varieties. A limestone having a siliceous cement is invariably harder than one having a purely calcareous cement. The soft chalks and marls are examples of limestones that are only partly consolidated and cemented.

PRINCIPAL MINERALS AND IMPURITIES OF LIMESTONES

No limestone deposit is entirely free from impurities, the most common of which are silica, alumina, iron compounds, sulphur, alkalis, organic matter, and phosphorus. They may be present in such small quantities that their sum total amounts to less than 1 per cent, or at the other extreme, some of them, particularly silica and alumina, may constitute a large percentage of the deposit.

Impurities are not always undesirable, in fact, limestones containing appreciable quantities of certain impurities are preferred for some purposes. For instance, a siliceous limestone is preferred to a very pure limestone for road metal on account of its greater hardness and toughness. An argillaceous limestone having a low content of magnesium carbonate is used in the manufacture of Portland cement, and an argillaceous dolomite is used in the manufacture of rock wool. However, for these and other uses demanding impure limestones, the impurities must be uniformly distributed through the stone and not be present in streaks and nodules.

A description of the principal minerals and impurities of limestone, generally reported in a chemical analysis, follows.

Calcite

Calcite ($CaCO_3$) is an essential constituent of all limestones, excepting the dolomites. All dolomites contain calcium carbonate but it is mostly in combination with magnesium carbonate in the form of the mineral dolomite and not as calcite, though minor amounts of calcite are commonly present. In limestones the calcite occurs in crystals of many shapes, all of which cleave to a rhombohedron of 105 degrees, but in most limestones the calcite is present as irregular grains instead of definite crystals. The hardness is 3. that is, it can be easily scratched with a knife. The specific gravity is 2·71 to 2·72. When pure it is colourless or white and has a vitreous lustre. Calcite can be readily distinguished from other minerals, excepting aragonite, by its vigorous effervescence when dilute acid is placed on it. Aragonite is of the same composition as is calcite but differs in crystal form, is heavier and slightly harder, and is not of known importance as a constituent of the older limestones.

Dolomite

Dolomite ($CaMg(CO_3)_2$), the double carbonate of calcium and magnesium, is named after the French geologist Dolomieu, who announced some of its characteristics in 1791. Like calcite it possesses perfect rhombohedral fracture and commonly occurs in rhombohedral crystals, but the faces of the dolomite crystals are often curved. When pure, dolomite is white or yellowish white, has a hardness of 3·5 to 4, a specific gravity of 2·8

to 2·9, and a pearly to vitreous lustre. It may be distinguished from calcite by the very faint reaction or, in many cases, entire lack of effervescence, when cold dilute acid is applied to a fragment of the mineral, but if the cold acid is applied to the powdered mineral, or if hot acid is applied to a fragment, brisk effervescence will result. Dolomite forms large rock deposits of itself and it is present to some extent in all limestones.

Silica

Silica (SiO_2) is present in all limestones and dolomites in proportions varying from a trace to very large quantities. It may occur in visible form as sand grains, chert nodules, quartz veins, and silicified fossils, or it may be present as a constituent of microscopic silt, clay, and siliceous ooze deposited throughout the limestone. Where the limestone has been metamorphosed a great variety of silicate minerals may be developed, of which the most common are serpentine, diopside, tremolite, actinolite, hornblende, talc, sphene, and certain aluminium silicates, some of which are mentioned below.

Alumina

Alumina (Al_2O_3) is present in combination with silica in the form of shale or argillaceous matter. It may occur in mere traces disseminated throughout the stone, or in thin films along the bedding planes; or at the other extreme it may form a large proportion of the rock, in which case the limestone is referred to as *"argillaceous."* The argillaceous matter is always in an extremely fine state of division so that no characteristic crystals can be observed, but if much is present it may be detected by the characteristic earthy odour given off when the stone is breathed on. In highly metamorphosed limestone, aluminium silicates such as garnet, tourmaline, epidote, and the several varieties of feldspar and mica are common.

Iron

Iron occurs in limestone principally in the form of oxides and sulphides. In chemical analyses, however, it is commonly recorded only as the ferric oxide (Fe_2O_3). Iron minerals are normally present only in small amounts but some of the oxides are pigments to which, in large measure, is due the colour of the stone.

Hematite (Fe_2O_3) and *turgite* ($2Fe_2.O_3H_2O$) even if present in very small quantities will impart a red colour, and *limonite* ($2Fe_2O_3.3H_2O$) gives yellow and brown tints. *Pyrite,* iron sulphide (FeS_2) in cubical, brassy-yellow crystals is very common in limestones. It is often visible on joint planes and in cracks, and is also scattered through the stone in crystals both sufficiently large to be readily seen and of microscopic size. Less common is *marcasite,* or white iron pyrites(FeS_2), which is of the same composition as pyrite but is distinguishable from the latter by its paler colour and by its being present usually in nodular masses instead of distinct crystals. Iron carbonate, *siderite* ($FeCO_3$), is sometimes found in limestones. When fresh it is grey or brown in colour but it oxidizes to the yellow limonite. In many metamorphosed limestones, *magnetite* (Fe_3O_4) and *specular hematite* are present. Ferrous iron is particularly characteristic of dolomites, in which it is usually present in very small quantities.

Sulphur

Sulphur occurs in limestones principally in combination with iron as either pyrite or marcasite. It is also present in the sulphate form combined with calcium, barium, and strontium, and rarely with magnesium. Crystals of native sulphur have occasionally been observed in limestones associated with gypsum. The fetid smell given off by some limestones when struck with a hammer is attributed to the presence of hydrogen sulphide gas (H_2S) occluded in the stone. Sulphides of lead, zinc, and copper also occur.

Organic Matter

Organic matter, resulting from vegetable matter deposited in the limestone at the time it was formed, and from the soft parts of the creatures whose shells and skeletons compose a great part of the rock, is a common constituent of limestone. Carbonaceous matter even in very small amounts distributed through the stone acts as a pigment, and to it most of the black and dark grey limestones owe their colour. In the form of petroleum, both liquid and solidified, it fills cavities in the stone. The partings, or thin films of shale between beds, often contain a high percentage of organic matter. Much of the organic matter is destroyed under the action of metamorphic agencies, but a portion of the carbon thereof may be converted into *graphite* which is commonly found in tiny flakes disseminated through metamorphosed limestones, to which it imparts bluish tints.

Other Impurities

Phosphorus in very small quantities is present in practically all Canadian limestones. The combination in which it occurs has not been determined but it is probably present as calcium phosphate, in which hypothetical combination it is shown in the analyses in this report.

Alkalis. The analysis of many limestones, particularly the impure varieties, often reveals the presence of *soda* (Na_2O) and *potash* (K_2O) compounds, chiefly the latter. The exact combination in which the alkalis occur in Canadian limestones has not been determined, but they are probably in the form of feldspars.

In addition to the more widely occurring impurities enumerated above, compounds of lead, zinc, arsenic, manganese, titanium, fluorine, strontium, and barium are also found in limestones.

CHAPTER II

GENERAL DISTRIBUTION AND CHARACTERISTICS OF QUEBEC LIMESTONES

The province of Quebec possesses great resources of calcium and high-calcium limestone, much of which is of a high degree of purity, and also has large resources of impure dolomite, but pure dolomite is relatively scarce and is known to occur only in a few scattered deposits of Precambrian age.

The limestone deposits occur mostly in the valleys of the St. Lawrence and Ottawa rivers and in the Eastern Townships, where they are well distributed with respect to the larger centres of population and to rail and highway transportation. Other important limestone areas are in Gaspe peninsula and in the Lake St. John-Saguenay River region. As shown in Table I, limestones of geological ages ranging from Precambian to Carboniferous are available. The major part of the production comes from the calcium and high-calcium limestones, which, in addition to being of value for crushed stone and construction, find use in the chemical, metallurgical, and agricultural industries of the province and also are utilized for the making of lime, whereas the great proportion of the dolomite available in Quebec is suitable only for use as crushed stone.

TABLE I

Rock Formations of Quebec, Showing Stratigraphic Position of Limestones

System	Formation	Types of Rock
Quaternary		Unconsolidated deposits.
Carboniferous		Sandstone, shale, and impure limestone.
Devonian		Sandstone, shale, and limestone.
Silurian		Limestone, shale, and sandstone.
Ordovician	Lorraine	Shale.
	Utica	Shale.
	Trenton	Limestone.
	Black River group	Limestone.
	Chazy	Limestone and shale.
	Beekmantown	Limestone.
Cambrian		Sandstone and impure limestone.
Precambrian	Unclassified	Granites and other igneous rocks, with minor amounts of limestone.
	Grenville series	Metamorphosed limestone, gneiss, and quartzite.

Quebec is divided into two geological "provinces" by a great fault or break known as the St. Lawrence and Champlain fault. This fault extends from the foot of lake Champlain to a point on St. Lawrence river opposite Quebec and then follows the bed of the St. Lawrence northeastward. North and west of this fault is a great area of Precambrian rock which in places, in the valleys of St. Lawrence and Ottawa rivers, is overlain by flat-lying and undisturbed strata of Cambrian and Ordovician ages. The Cambrian rocks of this area contain no limestone, but in the Ordovician are the Beekmantown, Chazy, Black River, and Trenton limestones, and from the Chazy and Trenton is obtained by far the greater part of the limestone production of Quebec.

South and east of this major fault, the country is rugged and mountainous and forms part of the Appalachian Mountain system of the New England states. It is in this territory that the Silurian, Devonian, and Carboniferous limestones together with some of Ordovician and Cambrian ages are found. The Ordovician limestones of this area, however, were deposited in an entirely separate basin of sedimentation from those of corresponding age on the other side of the fault and bear almost no resemblance to them, either in appearance or composition. For instance the Beekmantown formation in the area north and west of the fault consists entirely of impure, unaltered magnesian limestone and impure dolomite, whereas the Beekmantown formation east of the great fault contains bands of metamorphosed, high-calcium limestone that yield, in addition to marble, some of the purest chemical limestone obtainable in the province.

In the Appalachian region of Quebec the strata have been repeatedly folded, faulted, and crushed. This has resulted in a highly complicated structure. Furthermore the intense metamorphism to which many of the limestones have been subjected has in part, and in some cases entirely, obliterated the contained fossils, thus rendering it extremely difficult to determine the age of any particular deposit, and many differing opinions are on record in geological literature regarding the age of certain limestone deposits in this area. The age of a limestone is immaterial from the standpoint of its ultilization, but as limestones of the same geological age deposited in the same basin of sedimentation usually possess common characteristics, age does provide a good basis for classification. In this report in classifying the limestones according to their age an endeavour has been made to follow the most recent authoritative literature. Since the publication of "Preliminary Report on the Limestones of Quebec and Ontario," several geological papers have been published giving the results of recent detailed investigations that had to do in part with the limestone deposits in the Appalachian region of Quebec and in which definite evidence is presented at variance with opinions previously held regarding the age of certain limestones. In the present report some statements made in the preliminary report regarding the ages of certain limestones in the Eastern Townships have been changed to conform with the new information available.

PRECAMBRIAN LIMESTONES

Grenville Limestone

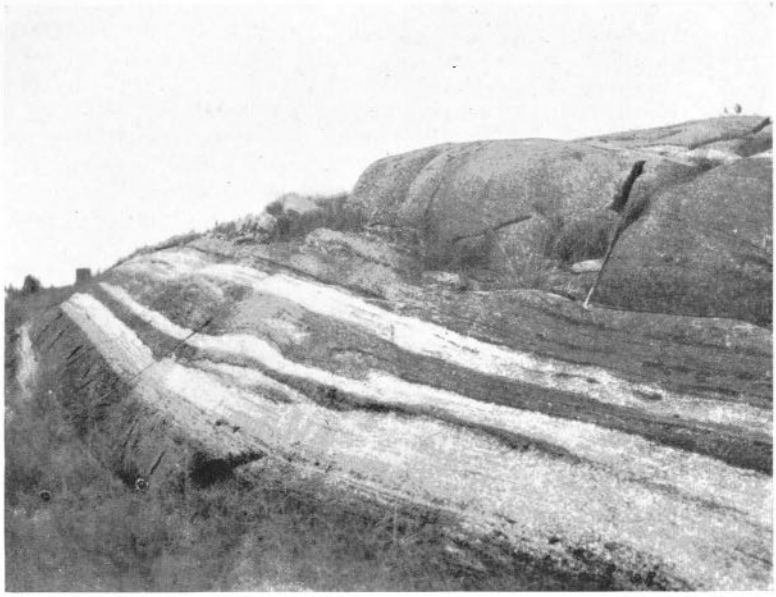
Highly altered, coarsely crystalline limestone forms a large part of a series of intensely metamorphosed sedimentary rocks known as the Grenville series, which is widely distributed in the wooded, hilly country north of Ottawa and St. Lawrence rivers. The other rocks of the series are gneiss and quartzite. The series has been greatly crumpled and faulted and has been so invaded by masses of igneous rock, such as granite and pyroxenite, that it now presents a heterogeneous mixture of rocks, though in many places the interbanding of limestone, gneiss, and quartzite is preserved.

The maximum thickness of the limestone in the Grenville series cannot be accurately determined because of the great amount of crumpling and deformation that the series has undergone, but it is undoubtedly great, and the Grenville limestone is considered as one of the major limestone formations of the North American continent.

Deposits of Grenville limestone occur from the eastern part of Pontiac county to the Lake St. John district but they are particularly numerous in Pontiac, Hull, Labelle, and Argenteuil counties. They have a prevailing northeast-southwest trend and range in size from those that are very small to those that are several square miles in extent. These larger areas contain masses of gneiss and quartzite in which are intrusive dykes and masses of igneous rock. There are, however, many deposits of quarriable size that are free or nearly free from foreign rock.

Most of the Grenville limestone is very coarsely crystalline, and consequently is somewhat softer and more friable than the finer grained Palæozoic limestone. The prevailing colours are light grey, white, and light blue, but some deposits have pink and brown tints, and where serpentine is present the limestone has a pale greenish colour. Only rarely is highly coloured limestone found in the Grenville series of Quebec. Foreign matter in the deposits, in addition to masses of gneiss and quartzite (Plate IB, page 11) and intrusions of various igneous rocks, includes other minerals that have been developed by the action of metamorphic agencies and that occur in the form of grains, flakes, irregular masses, and veins throughout the limestone. Among the more common of these minerals may be mentioned—serpentine, quartz, biotite, muscovite, phlogopite, graphite, galena, pyrite, pyrrhotite, sphalerite, apatite, barite, hornblende, pyroxene, scapolite, sphene, chondrodite, and epidote. In many deposits these minerals are largely concentrated in parallel streaks, giving a banded or stratified appearance to the deposit, and in some deposits the minerals are so numerous as to render the limestone worthless for chemical uses or for making lime.

In chemical composition Grenville limestones range from high-calcium to magnesitic dolomite, the latter type, so far as known, being found only in certain deposits in Argenteuil county. The majority of the deposits, however, are of the calcium type, though some consist of interbanded calcium limestone and dolomite. (Plate IA, page 11). As a rule the dolomitic limestone does not contain so many impurities as does the calcium limestone but it is commonly siliceous. The Grenville limestone in general contains less iron than the Palæozoic limestones of the province, and it is entirely free from organic matter.



A. Precambrian limestone consisting of interbanded dolomite (dark) and high-calcium limestone, Aylwin township, Hull county.

B. Precambrian limestone containing one large and many small inclusions of gneiss, Aylwin township, Hull county

Comparatively little use is being made of the Grenville limestone. This is due in part to its occurring mostly in sparsely settled territory remote from large markets, but also because its physical properties render it less desirable than the unaltered limestones for many uses. Owing to its generally coarse grain and to the siliceous impurities being concentrated in individual grains instead of being disseminated throughout the stone as in the fine-grained, unaltered limestones, where they act as bonding and hardening mediums, much of the Grenville limestone is soft and inclined to be friable, and stone of this nature is not well suited for use as road metal, for which purpose a hard, compact stone is desired. Lime for local use is being made from the Grenville limestone in a few localities, as at Ste. Thècle in Champlain county, but the coarse-grained stone tends to crumble when calcined, and this is the reason why some of the deposits of pure stone have not been utilized for the making of lime. Attempts have been made to quarry marble in block form from some of the deposits of white and of pink limestone, but owing either to the shattered nature of the deposits or to the presence of veins and masses of quartz and other hard impurities, the attempts were not successful. However, for terrazzo, stucco dash, poultry grit, as an ingredient for the making of artificial stone, and for limestone with a low iron content for use in the manufacture of glass, white Grenville limestone is being quarried at Portage du Fort in Pontiac county, and at L'Annonciation in Labelle county. At Dolbeau and near St. Jérôme in the Lake St. John district, Grenville limestone nearly free from mica and graphite is being quarried for use in the sulphite-pulp mills of that district.

CAMBRIAN LIMESTONES

Cambrian limestones are found in Quebec only east of the St. Lawrence and Champlain fault and south of the St. Lawrence river, where they occur at intervals, generally in steeply dipping deposits, from the International Boundary to the tip of the Gaspe peninsula. They include both calcium limestone and dolomite, but are for the most part very impure. Some of the largest deposits occur in Missisquoi and Bagot counties. Those in Missisquoi county are east and north of lake Champlain and consist entirely of metamorphosed, sandy and otherwise siliceous, light blue dolomite. Those in Bagot county believed to be of Cambrian age are in the vicinity of and northeast of Acton Vale and consist of rather siliceous, metamorphosed calcium limestone. At Acton Vale one of these deposits is quarried for crushed stone.

In Brome and Shefford counties is a band of steeply dipping, highly metamorphosed limestone enclosed in schist, and until recently believed to be of Precambrian age, but now considered to be of either Cambrian or Ordovician age. This limestone band is 150 to 250 feet in width and is exposed at intervals from southeast of Brome lake to beyond Lawrenceville in Shefford county. The limestone is fine-grained and varies in colour from white to light blue with veinings of green, violet, yellow, and brown. Stringers of quartz are common. In places the band consists entirely of impure dolomite, in other places of calcium limestone, and in still other places of both dolomite and calcium limestone. At South Stukely the limestone of this band is quarried for crushed stone, and nearby it was formerly quarried for marble. Lime for local use was formerly made at a

number of places along the band, and occasionally is still made near Lawrenceville.

Lenticular deposits of impure limestone, believed to be of Cambrian age, some of which are dolomitic and others of which consist of calcium limestone, occur associated with slate in the counties of Megantic, Lotbinière, Dorchester, and Drummond. Certain of these deposits near Trenholm, Oxford mountain, and St. Joseph de Beauce have a reddish colour and have been worked in a small way for marble, others have served as a source of lime for local use, but the majority of the deposits are small and of little economic value except where they constitute the only deposits of limestone in the district, in which case they are of potential value as sources of agricultural limestone.

The deposits of Cambrian limestone in the counties along the lower St. Lawrence river and in the Gaspe peninsula are mostly in rather inaccessible localities and little is known concerning their characteristics. The few deposits examined in this territory are for the most part impure and of small extent, though some large deposits are reported to occur in places remote from good transportation facilities. Near Rivière Blanche in Matane county a deposit of thinly bedded limestone interbedded with shale is quarried on a small scale for making lime and agricultural limestone.

ORDOVICIAN LIMESTONES

Limestones of the Ordovician system are widely distributed throughout southern Quebec, and from them the greater part of the limestone production of the province is obtained. West of the Champlain and St. Lawrence fault the Ordovician limestones are practically unaltered and are found in generally flat-lying strata over large areas north of the Ottawa and St. Lawrence rivers and also in the territory south of the St. Lawrence and west of Richelieu river, where they comprise a large proportion of the Ordovician rocks. Ordovician limestones are also found on Anticosti island and on the Mingan islands, in the Gulf of St. Lawrence.

East of the great fault the Ordovician rocks consist largely of slate, but large deposits of very pure limestone are found in Missisquoi county and large deposits of impure limestone interbedded with slate are found in Stanstead, Sherbrooke, and Compton counties. Elsewhere through the Eastern Townships the limestone deposits are small and generally impure. Both dolomitic and calcium limestones occur in the Ordovician system, but the calcium type prevails. The dolomite is all impure and is not being utilized to the same extent as is the calcium limestone, some of which is very pure.

West of the St. Lawrence and Champlain fault are the following Ordovician limestone formations:—

Beekmantown
Chazy
Black River
Trenton

East of the fault the rocks have been so faulted, folded and metamorphosed that it is difficult to divide them into formations except in a few localities.

Beekmantown Limestone

The Beekmantown formation, as exposed west of the St. Lawrence and Champlain fault, consists of sandy magnesian limestone and dolomite and has an estimated thickness of 100 feet. It is extensively exposed near the junction of the Ottawa and St. Lawrence rivers, where, associated with the underlying Potsdam sandstone, it occurs in flat-lying beds over a wide area extending from the Archaean escarpment southerly to the International Boundary. (*See* Map No. 757 in pocket.)

From the northern part of this main area a long, narrow strip of Beekmantown limestone extends northeasterly along the base of the Archaean escarpment to a short distance east of St. Maurice river, where it apparently ends, but this limestone is again seen on the Mingan islands, 450 miles to the eastward.

Westward from the main area isolated outcrops occur along the north shore of Ottawa river and on the islands therein as far west as Allumette island, Pontiac county.

The Beekmantown limestone is fine-grained and on fresh fracture is blue-grey to brownish grey in colour, but on exposure to the weather it turns to a drab brown. Individual beds rarely exceed 2 feet in thickness, and the bedding is generally uneven, though in some localities it is regular. Sand grains are prevalent, especially toward the base of the formation. Irregular cavities filled partly or entirely with white and pink crystals of dolomite and of calcite are also a feature of the Beekmantown limestone. In some localities layers of shale occur between the upper beds of the formation, the shale layers increasing in thickness and the limestone beds decreasing in thickness until the overlying Chazy shale is reached. In other localities where the shale member of the Chazy is absent, and Chazy limestone rests directly on the Beekmantown limestone, the latter is not shaly, though, in general, the upper beds of the Beekmantown formation are more argillaceous than the lower. The amount of total impurities is rarely less than 5 per cent and it may run as high as 50 per cent in some parts of the formation. The proportions of magnesium carbonate and calcium carbonate also vary widely. Beds of dolomite and of magnesian limestone alternate, and in some deposits a horizontal variation in composition was noted. The amount of iron (calculated as ferric oxide) is usually over 0·5 per cent.

Crushed stone is produced from a few quarries in the Beekmantown limestone, in the vicinities of Montreal, Lachute, Valleyfield, and Ste. Clothilde (Chateauguay county), and for this purpose it is well suited on account of its hardness and toughness. Small quantities of rubble for building purposes are quarried from the Beekmantown limestone at Ville de Lery (Beauharnois county) and at Lachute. These at present are the only uses being made of the Beekmantown limestone as found west of the St. Lawrence and Champlain fault. Some beds of the Beekmantown dolomite have the composition suitable for the making of rock wool.[1] but the obtaining of stone of uniform composition would be difficult owing to the variability of the deposits as noted above.

[1] Mines Branch Mem. Series No. 50.

East of the fault, limestone considered to be of Beekmantown age constitutes a major part of the Philipsburg series of rocks in Missisquoi county, just east of Missisquoi bay. This limestone occurs over a strip of country 1 to 1½ miles in width, extending northerly for 8 miles from the International Boundary to near Bedford. It is underlain by Cambrian dolomite and overlain by slates. It is entirely different from the limestone of Beekmantown age found on the west side of the St. Lawrence and Champlain fault. As noted previously, the limestones east of the fault were deposited in a basin of sedimentation entirely separate from that in which were deposited the limestones west of the fault. The Beekmantown limestone in the Philipsburg area has an apparent thickness in excess of 1,700 feet, and consists of alternate bands of calcium limestone and dolomite. Some of the calcium limestone is very pure and some is very argillaceous, but all of the dolomite is very impure, owing largely to the presence of sand grains and argillaceous matter. The stone of both types is fine-grained, some is much metamorphosed, and all occurs in highly tilted beds.

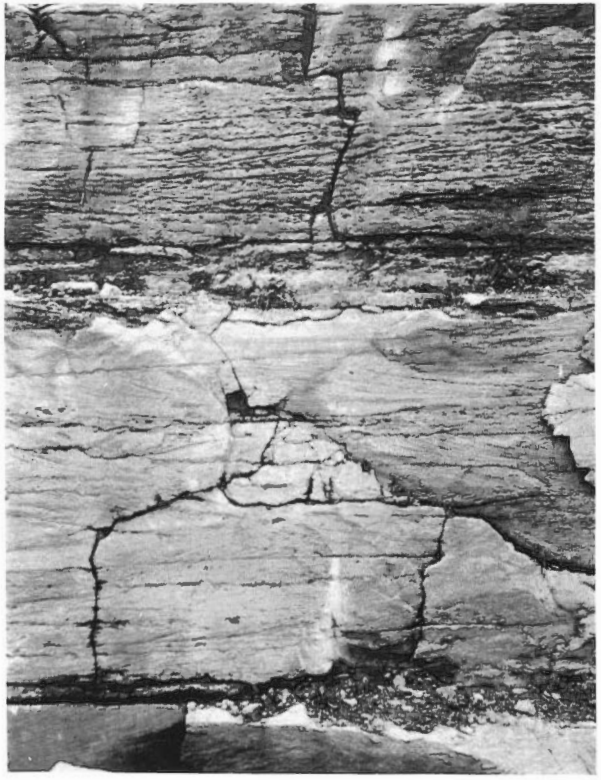
At the village of Philipsburg, the band of highly altered, fine-grained, grey and greenish grey calcium limestone that forms the base of the Beekmantown formation in that locality is being extensively quarried for marble. A smaller quarry for black marble is also worked in the very dark-coloured band of impure calcium limestone that overlies the light-coloured band. Near Bedford a thick band of dense-textured, dove-coloured, high-calcium limestone veined with white calcite, that occurs near the top of the limestone division of the Philipsburg series, is quarried on a large scale for chemical uses, crushed stone, and for agricultural purposes. Waste from the grey marble quarried at Philipsburg is marketed for chemical uses, and stone from certain of the white beds in that quarry is sold for the manufacture of whiting substitute.

Chazy Limestone

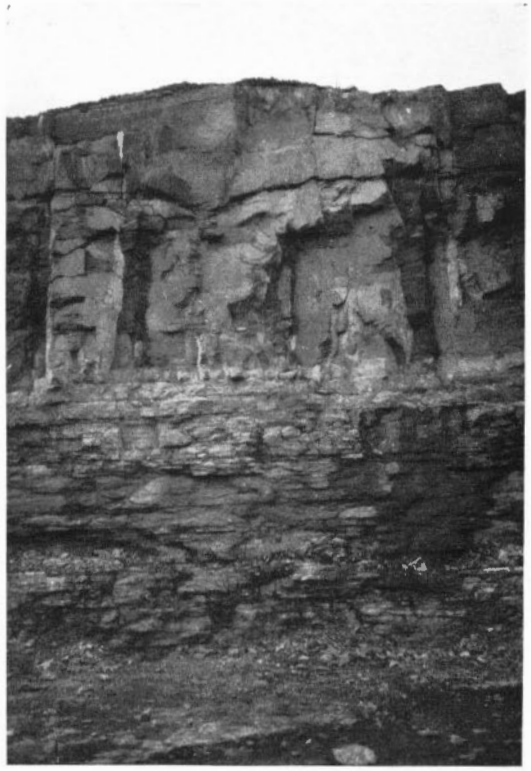
The Chazy formation succeeds the Beekmantown. West of the St. Lawrence and Champlain fault this formation consists largely of calcium limestone. East of the fault, rocks that have been identified as of Chazy age consist largely of slate with minor bands of limestone; such occur chiefly in Missisquoi county.

West of the fault, Chazy limestone occurs in flat or in gently inclined strata in a belt of varying width extending northerly from the International Boundary, just west of Richelieu river, to Montreal, and thence paralleling the north shore of the St. Lawrence, at some little distance inland, as far as St. Maurice river, beyond which the Chazy has not been definitely recognized until the Mingan and Anticosti islands are reached. Other areas of Chazy limestone are found on the north shore of Ottawa river near Grenville, Hull, and on Allumette island. A ridge of limestone, part of which at least is believed to be of Chazy age, occurs in Bagot county in the vicinity of St. Dominique, immediately adjacent to the St. Lawrence and Champlain fault.

The lower part of the Chazy formation as exposed north of Ottawa river and in some places in the Montreal area consists of sandy shale



A. Weathered face of Chazy limestone in Montreal district, showing cross-bedding and pitted surface due to the disintegration of fine-grained magnesian material.



B. Thinly bedded Trenton limestone overlain by a thick sill of trap rock, Montreal.

and sandstone, but over much of the Montreal area, and south and northeast thereof, the shaly and sandy strata are either poorly represented or are entirely absent and the Chazy limestone rests directly on the Beekmantown dolomite. The estimated thickness of the Chazy formation is 100 feet.

The limestone varies from very fine to coarse in grain, and the prevailing colours are blue-grey and brownish grey, the coarse-grained stone being always lighter in colour than the fine-grained and occurring mostly in zones at and near the top of the formation. Individual beds range from a few inches to an observed maximum of 4 feet. Thin, irregular seams of shale are present in many of the beds, and in some these seams are sufficiently numerous to impart a nodular appearance to the stone, but other beds are nearly free from this feature. On exposure the stone assumes a light grey colour. Fossils, both well preserved and fragmentary, are very numerous, some strata being composed almost entirely of fossil shells and of oolites. A characteristic and widespread feature of the medium- to coarse-grained Chazy limestone of the Montreal area, and of that west of Richelieu river, is the presence of irregularly shaped crystals of red and pink calcite, apparently fossil fragments. These are so numerous in some places as to give a pinkish tinge to the rock. Another characteristic but undesirable feature of much of the Chazy limestone in the same districts, is the presence of mottlings, streaks, and occasional beds, of siliceous and ferruginous magnesian material in what otherwise would be a calcium or high-calcium limestone. This material is scarcely distinguishable from the remainder of the stone on fresh fracture but on exposure it weathers rapidly to a rusty, drab colour and tends to disintegrate leaving pits in the stone, Plate IIA, page 16. Its presence in appreciable quantity spoils the rock for chemical use, for the manufacture of high-grade lime, and for building purposes. North and east of the Montreal district and also in some places within the Montreal district and south thereof, this undesirable material is not present in quantity in the Chazy limestone. The magnesian material does not approach a dolomite in composition, as the highest content of magnesium carbonate, revealed by analyses so far made, is 24·45 per cent, and over a succession of strata 11·11 per cent is the highest on record.

Crushed stone and building stone are the principal products obtained from the Chazy limestone. The crushed stone quarries are worked in the fine-grained, rather impure stone, and the building stone quarries are opened in the medium- and coarse-grained stone. The chief centre of production of both commodities is the Montreal district.

Lime is produced only on a very small scale from the Chazy limestone. It is said that stone in which the ferruginous magnesian material is present yields a dark-coloured lime and one that air-slakes readily.

Some of the Chazy limestone west of the St. Lawrence and Champlain fault is of sufficient purity to be utilized in certain chemical and metallurgical industries but it is being little used for these purposes.

East of the St. Lawrence and Champlain fault, limestone that has been recognized as of Chazy age occurs in the Philipsburg series in Missisquoi county. Until recently considerable confusion prevailed as to which of the strata composing this series were of Beekmantown and which

were of Chazy age. In 1933 T. H. Clark[1] completed a detailed study of the rocks of this district and according to his findings the greater part of the limestones of the Philipsburg series, including the pure high-calcium bands, is of Beekmantown age, and only the limestone conglomerate found in the vicinity of Mystic is of Chazy age. This conglomerate is described on pages 221-222 of this report. It has been quarried in the past for making lime for local use.

Limestones of the Black River Group

This group is represented by three thin formations, in ascending order, as follows:—

Pamelia, Lowville, and *Leray.*

Pamelia Formation. Until recently it was not known that this formation occurs in Quebec but Dr. T. H. Clark of McGill University, in a personal communication to the writer, states he has established that the impure magnesian limestone seen in the Devito quarry at Pointe Claire (Island of Montreal), and in the large idle quarry at St. Vincent de Paul (Island of Montreal), belongs to the Pamelia formation. The maximum thickness of this type of limestone is about 12 feet. It is argillaceous and ferruginous and on weathering turns to a rusty colour.

Lowville Formation. This formation consists of dense-textured, creamy grey calcium limestone in beds up to 18 inches in individual thickness. It is seen in the quarries at Pointe Claire on the Island of Montreal, where it was formerly quarried for use as dimension stone for engineering construction, but is now being quarried for crushed stone and rubble. The total thickness of the Lowville is between 25 and 30 feet.

Leray Formation. The Leray, 30 to 40 feet thick, and consisting for the most part of heavily bedded, dark grey, dense-textured calcium limestone, which in some localities is studded with nodules of chert, is the most widely distributed of the Black River limestones, being found at such widely separated localities as Allumette island in the Ottawa river (Pontiac county), and the Mingan islands in the Gulf of St. Lawrence. The principal localities where the Leray is available, however, are near Hull and Aylmer in Hull county; at several places in the Montreal district; and in the valley of the Ouareau river at Les Dalles near Joliette. Eastward from Joliette no Black River limestone has been identified until Baie St. Paul is reached. It is believed that the dense-textured, blue limestone at St. Dominique, in Bagot county, is in part of Black River age.

Crushed stone and rubble are the only products at present obtained from the Leray formation, though at one time quantities of dimension stone for engineering construction were quarried from this and the underlying Lowville formation at Pointe Claire. North of Aylmer the pure coarse-grained Black River limestone has been utilized for making lime, but the lime plant is now dismantled.

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[1] Clark, T. H.: Structure and Stratigraphy of Southern Quebec, Bull. Geol. Soc. Am., vol. 45, p. 6 (1934).

Trenton Limestone

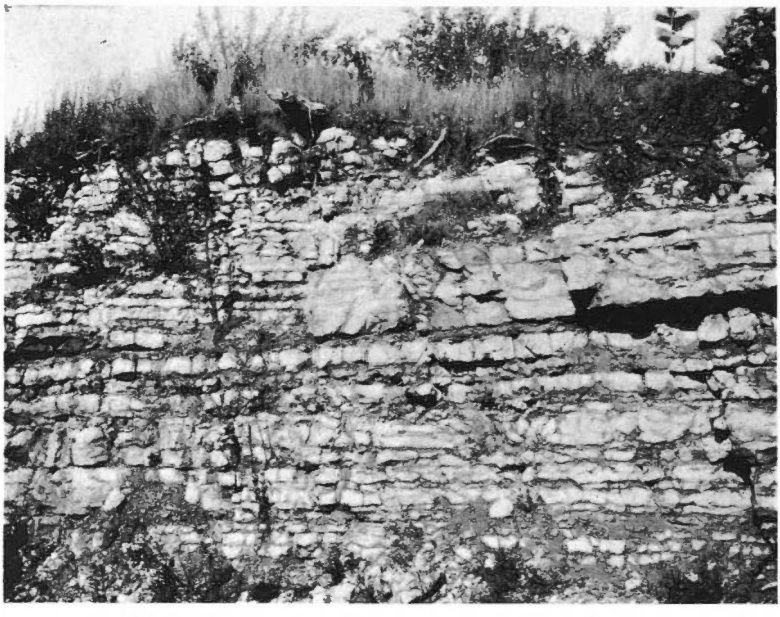
The Trenton formation consisting of dark bluish grey and brownish grey, calcium and high-calcium limestone provides the great bulk of the limestone produced in Quebec. In generally flat-lying beds the Trenton limestone extends in a sinuous belt, 2 to 3 miles wide, from the Richelieu river at St. Johns northwesterly to the Montreal district, where it underlies most of the Island of Montreal, almost encircles Ile Jesus, and from thence forms the greater part of the important limestone belt that parallels the north shore of the St. Lawrence river to below Quebec. An important area of Trenton limestone also occurs at Hull, and outliers of Trenton limestone occur in the Lake St. John-Saguenay River region, and at Baie St. Paul and Murray Bay on the north shore of St. Lawrence river below the city of Quebec.

The Trenton limestone appears to attain its maximum thickness in the Montreal district where it has an estimated thickness of 600 feet[1]. Throughout most of this district the lower part of the formation consists of alternate zones of medium-grained brownish grey and bluish grey, high-calcium limestone in beds up to 2 feet in thickness, and of fine-grained, dark brownish grey calcium limestone, in thin beds with partings of black bituminous shale. In places the medium-grained stone appears to compose the basal strata, and in other places the fine-grained stone is at the base. Towards the middle part of the formation, thinner beds of fine-grained, rather argillaceous stone, separated by shale partings, predominate, and the entire upper part of the formation is composed of thin-bedded, fine-grained to dense-textured, argillaceous limestone streaked with brownish calcareous shale and interbedded with the same type of shale. At Hull the Trenton limestone is of the same general character as the lower part of the formation in the Montreal district, but here many nodules of chert are present in the finer grained bands though they are less common in the bands of medium-grained stone. East of Montreal as far as Berthier county, chert nodules are present in much of the Trenton limestone, but they were not observed east of the latter locality. In the neighbourhood of Quebec and east thereof, the Trenton limestone is practically all fine-grained to dense-textured, rather argillaceous and is relatively thin-bedded. Fine-grained stone is characteristic of most of the Trenton outliers in the Lake St. John-Saguenay River region, and chert is present in some deposits in that area.

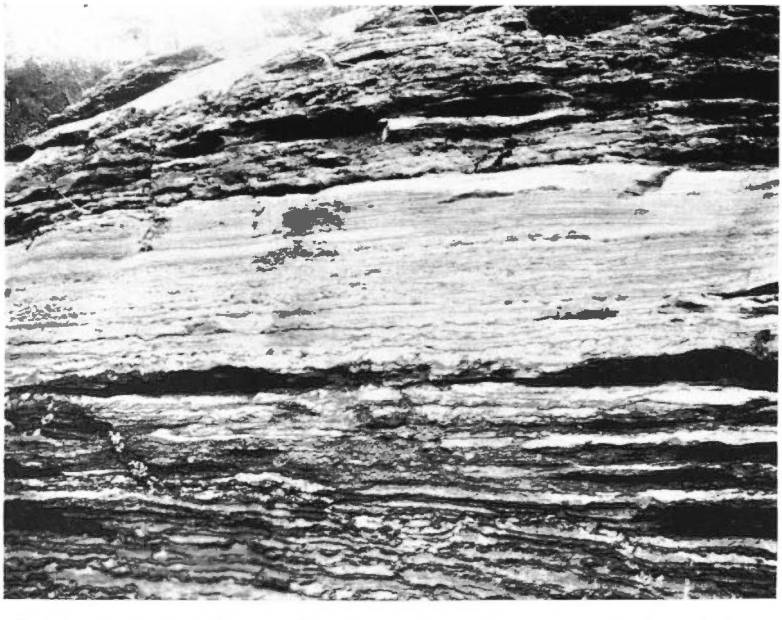
Pure high-calcium limestone is obtainable from certain zones of the Trenton formation and is being utilized for the making of lime and for chemical purposes at Hull, Montreal, Joliette, St. Marc des Carrières, and at St. Louis de France near Three Rivers, though in the latter locality the stone is not of exceptional purity.

The siliceous and argillaceous variety of the Trenton has a very low content of magnesium carbonate and thus is suitable for the manufacture of Portland cement, and is being used for this purpose at Montreal and Hull. At Montreal the composition of the stone composing the upper part of the formation closely approximates that of the raw mix desired for the making of Portland cement, and but very little other material has

[1] Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. O, p. 21 (1901).



A. Thinly bedded Trenton limestones with interbeds of shale, Montreal.



B. Heavily bedded Trenton limestone with shaly laminae which project on weathered surface, St. Alban, Portneuf county.

to be added before it is charged to the kilns. At Hull the Trenton contains less silica and alumina, and clay must be added to make cement.

Crushed stone in very large quantities is produced from the Trenton limestone, the fine-grained, hard, rather siliceous variety being preferred for this purpose. Crushing plants are located at Hull, Montreal and vicinity; St. Barthélémi, Joliette, St. Louis de France, Quebec and vicinity, Chateau Richer, St. Johns, and at Roberval. In addition, crushed stone for local use has been produced in many other localities.

Building stone is quarried in large amount from the heavily bedded, medium-grained Trenton limestone at St. Marc des Carrières, and in lesser quantity in the Montreal area, and at Joliette and Hull. Rubble for building purposes is quarried in many places.

Stone for use in making sulphite pulp, agricultural limestone, for flux, asphalt filler, and for a number of minor uses is also obtained from this formation.

Unclassified Ordovician Limestones

East of the St. Lawrence and Champlain fault large areas of Ordovician strata are shown on geological maps of the Eastern Townships. These strata consist largely of dark-coloured slates and quartzites with, in places, bands of dark slaty limestone. The limestones are most numerous in Stanstead, Compton, and Sherbrooke counties. Some of the limestones have been quarried for road metal and for making lime, but, in general, they are very impure and of little economic value except as sources of agricultural limestone in districts remote from other sources of supply.

Ordovician strata including some limestone also occur in the Gaspe peninsula and along the south shore of the lower St. Lawrence river. These limestones, however, are in relatively inaccessible locations and are not being quarried except possibly on a very small scale for local use Little is known regarding their composition.

SILURIAN AND DEVONIAN LIMESTONES

With the exception of the small deposits of Silurian limestone on the Quebec side of lake Timiskaming and of the deposits on the island of Anticosti, limestones of Silurian and Devonian ages are found in Quebec only in the region of complicated rock structures east of the St. Lawrence and Champlain fault and south of the St. Lawrence river where, as a result of the folding, faulting and alteration that the limestones have been subjected to, with consequent partial and in some cases complete obliteration of fossils, it is very difficult to correlate the various strata and to definitely state whether they are of Silurian or Devonian age. The problem is further complicated by the close resemblance in appearance and composition that the Silurian and Devonian limestones, both in the Eastern Townships and in Gaspe, bear to each other.

In the Eastern Townships lenticular deposits of Silurian and Devonian limestones associated with slates occur at intervals from lake Memphremagog to lake Aylmer, and an isolated outlier of Devonian limestone occurs northeast of Chaudière river at St. George in Beauce county. The only quarry at present worked in this territory is at Lime Ridge where

a very pure high-calcium limestone is quarried on a large scale for making lime. Formerly flagstones were quarried from a very siliceous limestone at Bishops Crossing, and also attempts were made to produce marble from the pure, fine-grained stone at Marbleton. Most of the Silurian and Devonian limestones in this territory contain but a very small percentage of magnesium carbonate, though some impure magnesian bands do occur. In general there is a wide range in purity, some of the limestone being very pure, but most is very siliceous.

In Gaspe peninsula large deposits of Silurian and Devonian limestones are found in Bonaventure and Gaspe counties along the south shore of the peninsula. They are apparently all of calcium and high-calcium composition, and all are fine-grained. In many places these limestones are highly coloured. Deposits in the vicinity of Port Daniel, Gascons, and Nouvelle are quarried in small amount for use in pulp mills and for agricultural purposes.

The Silurian limestone on Burnt island in lake Timiskaming consists of dolomite and magnesian limestone and is mostly siliceous and argillaceous; none sampled containing less than 4 per cent total impurities. It has been quarried in small amount for making lime and for building stone.

Available information on the Silurian limestone of Anticosti island indicates that it is all characterized by an unusually low content of magnesium carbonate and that the limestone ranges in purity from very pure to very argillaceous. This stone has not been quarried except for local use in building lighthouses.

CARBONIFEROUS LIMESTONE

The only known rocks of Carboniferous age in Quebec are on the south side of the Gaspe peninsula where they fringe the coast at intervals between Escuminac bay and Gaspe bay. The rocks consist mostly of sandstone but in one or two localities, as in the valley of the Cascapedia river, there are lenses of sandy and conglomeratic calcium limestone, one of which is being quarried near St. Jules for making agricultural limestone.

CHAPTER III

PRODUCTION AND UTILIZATION OF LIMESTONE IN QUEBEC

Statistics on the production of limestone, marble, and lime are given in Tables II and III, and are shown graphically in Figures 1, 2, and 3. Data prior to 1921 were obtained from the records of the Mines Branch, and for 1921 and subsequent years, from the records of the Dominion Bureau of Statistics. The production figures do not include the large tonnages of limestone used in Portland cement plants in Quebec. In the years 1930 to 1933 inclusive, the Portland cement industry used limestone in the quantities indicated below, the production in all cases being obtained from quarries operated in connection with the plants.

Year	Tons
1930	1,387,036
1931	1,338,069
1932	560,639
1933	403,335

The chief products of the Quebec quarries are crushed stone, stone for making Portland cement and lime, building stone, rubble and riprap, marble, agricultural limestone, flux, asphalt filler, stone for the making of calcium carbide and for use in the manufacture of sulphite pulp, and for stucco dash, terrazzo, chicken grit, and whiting substitute. Information regarding these products is briefly given below.

TABLE II

Production of Limestone and Marble in Quebec

Year	Limestone[1]		Marble	
	Tons	Value	Tons	Value
		$		$
1909	650,000*	972,253	.....	130,000
1910	620,000*	962,429	.....	151,000
1911	1,000,000*	1,296,577	.....	135,187
1912	950,000*	1,187,751	.....	247,838
1913	1,090,000*	1,307,428	.....	231,137
1914	1,100,000*	1,326,943	.....	98,890
1915	960,000*	1,189,633	.....	145,400
1916	610,000*	799,354	.....	118,810
1917	450,000*	625,711	.....	55,820
1918	460,000*	601,970	2	100
1919	526,000*	745,635	3,505	192,489
1920	660,000*	958,180	7,190	240,053
1921	679,446	1,072,572	1,650	172,720
1922	884,311	1,420,223	1,912	231,894
1923	1,057,284	1,671,309	2,473	201,518
1924	1,465,237	2,058,432	4,379	322,455
1925	1,677,514	2,160,790	3,046	254,922
1926	1,784,434	2,316,997	4,709	507,817
1927	2,251,499	2,863,690	4,609	484,437
1928	2,684,305	3,116,753	6,643	380,307
1929	2,827,740	3,139,389	13,081	397,074
1930	2,811,300	2,774,539	11,619	717,362
1931	2,675,186	2,774,060	14,919	624,356
1932	1,622,802	1,337,688	9,832	206,502
1933	1,129,248	940,019	7,983	42,283

[1] These figures do not include the limestone used by the lime and cement industries.
*Estimated from incomplete data on record at Mines Branch.

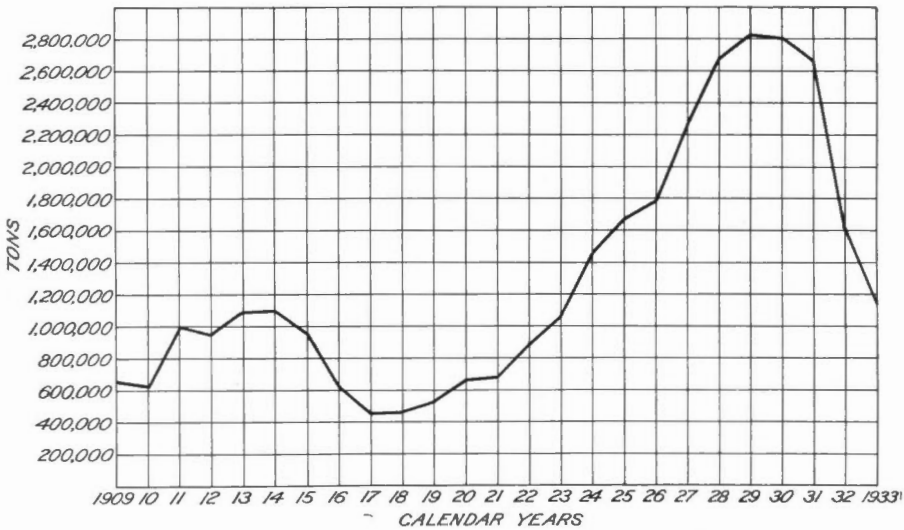


Figure 1. Production of limestone in Quebec.

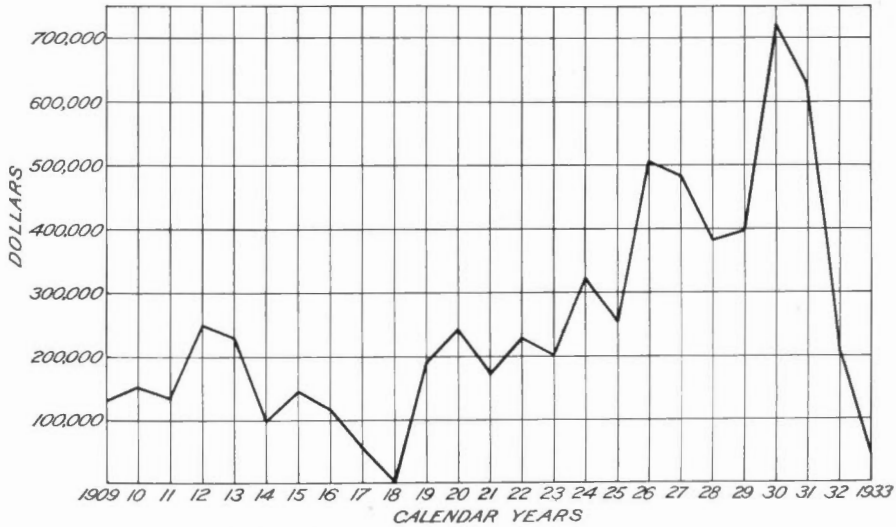


Figure 2. Production of marble in Quebec.

Crushed stone, used for highway construction, concrete aggregate, railway ballast, and for a number of minor uses, constitutes the main product both in tonnage and in total value, though in value per ton it is one of the cheapest of the limestone products. Fine-grained, hard and tough limestone, generally of a siliceous nature, is preferred for this purpose. As may be seen by referring to the list of quarries on pages 30 to 35 this commodity is produced in many parts of the province, but the principal centres

TABLE III

Production of Lime in Quebec

Year	Quicklime		Hydrated Lime		Total Lime	
	Tons	Value	Tons	Value	Tons	Value
		$		$		$
1906	32,640	201,816	.....	.....	32,640	201,816
1907	36,885	262,990	.....	.....	36,885	262,990
1908	30,020	201,357	.....	.....	30,020	201,357
1909	44,864	315,633	.....	.....	44,864	315,633
1910	42,964	299,126	.....	.....	42,964	299,126
1911	49,994	356,453	.....	.....	49,994	356,453
1912	60,536	474,595	.....	.....	60,536	474,595
1913	56,576	418,008	.....	.....	56,576	418,008
1914	61,878	389,064	.....	.....	61,878	389,064
1915	47,296	274,831	.....	.....	47,296	274,831
1916	52,460	267,119	.....	.....	52,460	267,119
1917	51,467	335,012	.....	.....	51,467	335,012
1918	53,472	418,888	.....	.....	53,472	418,888
1919	62,889	493,762	.....	.....	62,889	493,762
1920	73,787	826,044	.....	.....	73,787	826,044
1921	67,921	754,375	3,495	36,128	71,416	790,503
1922	73,798	634,157	5,278	55,642	79,076	689,799
1923	76,932	576,731	5,685	57,482	82,617	634,213
1924	77,677	640,990	5,848	58,947	83,526	699,937
1925	79,546	601,081	9,432	72,249	88,978	673,330
1926	87,815	667,480	11,922	98,636	99,737	766,116
1927	97,078	725,876	10,576	80,789	107,654	806,665
1928	102,859	795,999	11,271	100,783	114,130	896,782
1929	157,414	1,183,148	9,478	81,046	166,892	1,264,194
1930	117,358	874,077	11,992	93,573	129,350	967,650
1931	101,186	720,049	10,310	84,169	111,496	804,218
1932	76,983	493,787	16,830	94,114	93,813	587,901
1933	89,740	539,603	20,594	107,955	110,334	647,558

Prior to 1921 statistics showing production of hydrated lime were not separately recorded but were included under "quicklime."

Until 1928 the quantity of lime produced was recorded in bushels. In this table bushels have been converted into tons.

of production are, in the area north of the Ottawa and St. Lawrence rivers, in the vicinities of Montreal, Quebec, Chateau Richer, Hull, Three Rivers, and Joliette. Minor quantities of crushed stone are also produced in the Lake St. John district. South of the St. Lawrence river crushed stone is produced on a small scale in a number of localities among which are St. Johns, Valleyfield, Caughnawaga, Acton Vale, South Stukely, and Ste. Clothilde, and, in conjunction with other limestone products, crushed stone is produced at Lime Ridge and Bedford. Quarries have been opened in many localities to supply crushed stone for work being undertaken in the district, such as highway construction, and have been closed on its completion.

Rubble and riprap for use in the construction of wharves, breakwaters, and highways are supplied mostly as by-products from the crushed stone quarries. The term rubble is applied to relatively small fragments of stone such as can be lifted by one man. Riprap refers to masses of stone of irregular shape and of such size that they must be handled by derricks.

Building stone in blocks of large dimensions is quarried at St. Marc des Carrières, Montreal, and Hull; and building stone of smaller dimensions is produced at Joliette, Chateau Richer, and Ville de Lery (Boisbriand). Detailed information on the limestones quarried for building purposes is given in Mines Branch Report No. 733 "Canadian Limestones for Building Purposes."

Chemical limestone, by which is meant a pure limestone suitable for use in chemical and metallurgical industries, is being quarried at many places. The limestone quarried for these purposes is of the high-calcium

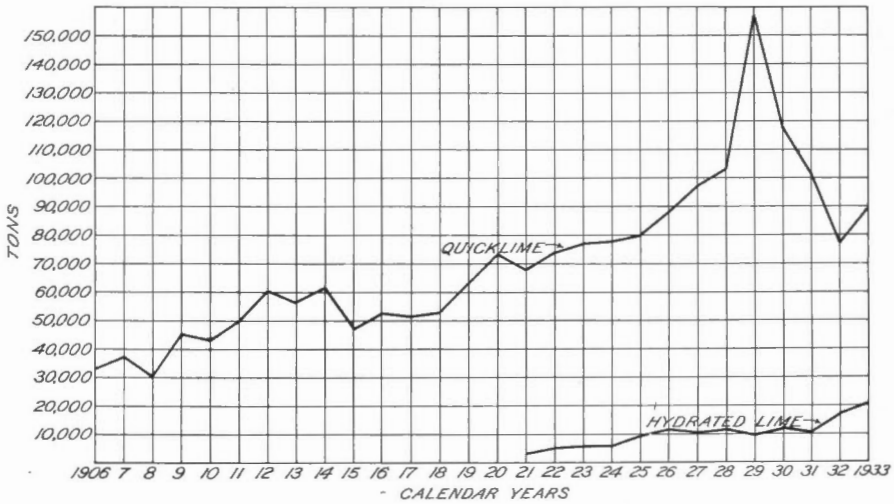


Figure 3. Production of quicklime and hydrated lime in Quebec.

type, there being very little pure dolomite available and practically none is being quarried for these uses. The magnesitic dolomite quarried and processed at Kilmar and at Harrington East in Argenteuil county is used as a refractory material but not for chemical purposes. The largest quarry producing chemical limestone almost exclusively is at Bedford in the Eastern Townships and is operated by Shawinigan Chemicals, Ltd. to supply its calcium carbide plant at Shawinigan Falls. Most of the limestone quarried for chemical and metallurgical use is obtained from quarries producing stone for other purposes. Thus, pure limestone sold for use in sulphite-pulp mills is a by-product from building stone quarries at St. Marc des Carrières and from the marble quarry at Philipsburg, and is quarried in conjunction with the production of crushed stone at Hull, and at Joliette in connection with the production of lime and crushed stone. In the Lake St. John region and in the Gaspe peninsula, however, quarries are worked primarily for limestone for use in making sulphite pulp. Flux is produced along with other limestone products at Montreal, Hull, Joliette, and occasionally at St. Dominique.

Marble in block form for cutting into slabs for interior decorative purposes is quarried at Philipsburg, where a black marble and several

varieties of grey marble are produced. The brownish grey Trenton limestone, quarried at St. Marc des Carrières primarily for building stone, takes a good polish, and some of the output of these quarries is used as marble. A bed of red Chazy limestone at Village Belanger on Ile Jesus is utilized for monumental purposes. White marble for use as terrazzo, stucco dash, chicken grit, marble flour, and other purposes, is quarried from deposits of metamorphosed Grenville limestone at Portage du Fort and at L'Annonciation. Waste marble from the Philipsburg quarry is used for these purposes, as well as for making whiting substitute and in the manufacture of sulphite pulp.

There are many deposits of marble, principally of Cambrian and Precambrian ages, in Quebec, a number of which have been exploited to a small extent, chiefly during the years 1905 to 1916. During this period quarries producing red marble were opened at Oxford mountain and at St. Joseph de Beauce, white marble veined with violet and brown at South Stukely, white marble at Portage du Fort, and pink and white marble at Ste. Thècle in Champlain county, but for various reasons these quarries were closed down and have not been re-opened.

Agricultural limestone, or limestone pulverized for use on farm land, is produced at a number of places in the province. As a rule agricultural limestone is produced as a by-product from quarries operated for other purposes, and the fine screenings from many crushed stone plants are sold for agricultural use. A number of the quarry companies, however, have installed special machinery to make the finer grades of agricultural limestone; plants producing this material are at Hull, Joliette, St. Marc des Carrières, Bedford, Lime Ridge, and Philipsburg. In addition, small grinding plants are producing agricultural limestone in the Lake St. John region, along the lower St. Lawrence and in the Gaspe peninsula. Marl is also used extensively for agricultural purposes in place of pulverized limestone in the latter locality. Relatively small quantities of quicklime and hydrated lime are also used for liming soil.

The Department of Agriculture of the province of Quebec has done much to promote the use of limestone on the farm lands of the province and as a result a much greater tonnage of limestone is used in Quebec than in the other provinces of the Dominion. The following extract is taken from a circular issued by the Quebec Department of Agriculture setting forth the way in which the Department is prepared to assist farmers to purchase agricultural limestone.

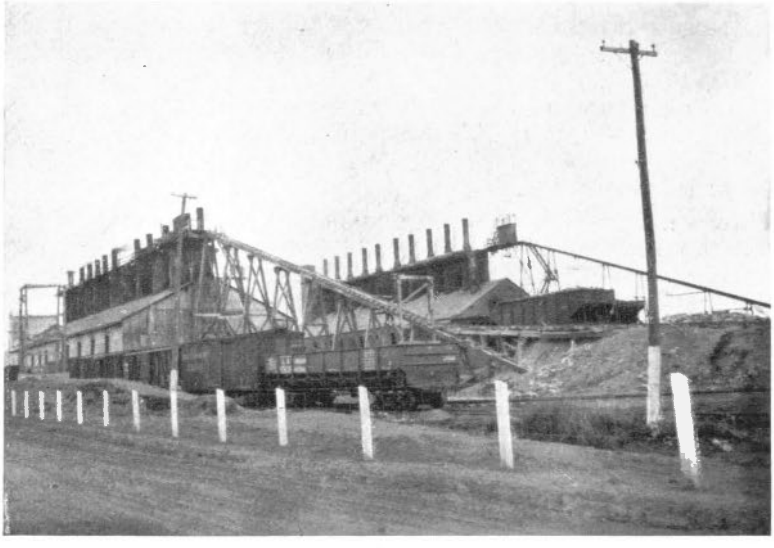
If the freight charge is less or equal to $1.10 per ton, the total cost of transport will be refunded to the buyer or to the vendor, as the case may be.

If it costs more than $1.10 per ton, the Department of Agriculture shall refund $1.10 plus half of the amount exceeding $1.10 per ton, but its contribution shall not exceed $1.30 per ton.

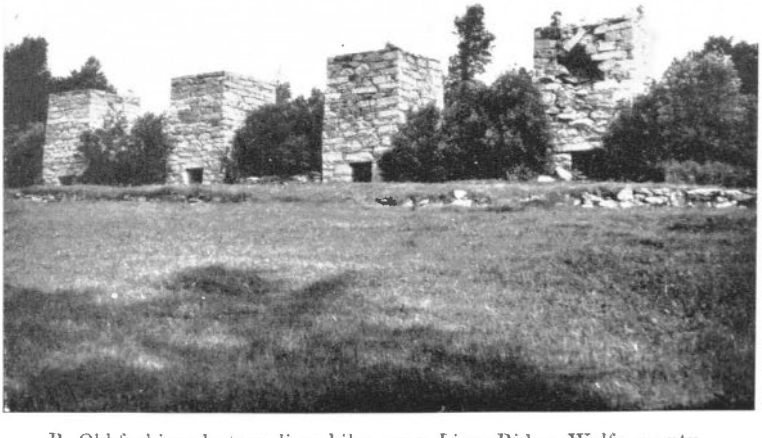
This reimbursement of the cost of freight will be made only in favour of lime or crushed limestone used for agricultural purposes, and applies only in the case of carloads weighing a minimum of thirty tons.

Whenever it would be more economical to utilize trucks or wagons, rather than the railway, for the transportation from the quarries to the farm, the Department of Agriculture will grant a subsidy of $0.06 per ton-mile, up to a maximum of $0.48.

PLATE IV



A. Modern lime plant, Standard Lime Company, Ltd., Joliette, Que.



B. Old-fashioned stone lime kilns near Lime Ridge, Wolfe county.

The lime (or limestone) must meet the following requirements:—

(*a*) *Pulverized limestone:* To contain a minimum of 85 per cent of calcium carbonate. To be ground so fine that 100 per cent will pass through a screen with 10 meshes to the linear inch, and 30 per cent through a screen with 100 meshes to the linear inch.

(*b*) *Quicklime:* To contain at least 85 per cent of calcium oxide.

(*c*) *Hydrated lime:* To contain at least 85 per cent of calcium hydrate.

The maximum selling price, f.o.b. shipping point (bags or barrels not included), must not be in excess of the following for the various categories of lime:—

$2.50 a ton for pulverized limestone;
$3.50 a ton for hydrated lime;
$5.50 a ton for quicklime.

Full details in connection with the operation of the above regulations may be obtained on application to the Department of Agriculture, Quebec.

Lime constitutes an important product of Quebec limestone quarries. Large lime plants are situated at Joliette, St. Marc des Carrières, Lime Ridge, Montreal, and Shawinigan Falls. Smaller plants are in operation at Hull, St. Dominique, St. Louis de France, and Ste. Anne de Chicoutimi; and in a number of widely scattered localities small kilns are operated occasionally to supply local demands. The lime plant at Shawinigan Falls—a rotary kiln plant—which is the largest in the province, is operated in connection with the chemical plant of Shawinigan Chemicals, Ltd., but part of the hydrated lime obtained as a by-product is marketed for various uses.

All lime produced in the province is of the high-calcium type for the reason that no deposits of dolomite suitable for the production of high-grade dolomitic lime are known to occur in readily accessible localities. Some of the magnesitic dolomite quarried in Argenteuil county is marketed in the caustic-calcined state but it is being used for purposes other than those for which lime is used.

The lime production is marketed as lump lime, crushed quicklime, and hydrated lime; plants producing hydrated lime in addition to quicklime being those at Joliette, Lime Ridge, Shawinigan Falls, and Hull.

The greater part of the lime produced is used within the province, though some of the hydrated lime is shipped to the Maritime Provinces.

Portland cement is made at Montreal East and at Hull in the plants of the Canada Cement Company. At both plants the wet process of cement making is employed. At St. François de Sales is the plant of the Unic Cement Company, which has not been operated within recent years, and at Montreal East is the fully equipped plant of the National Cement Co., which has not been operated since 1931.

QUEBEC MINING LAWS RELATING TO LIMESTONE

Limestone belongs to the owner of the soil. All quarries, however, are subject to the regulations set forth in the "Mining Laws of Quebec" as regards the method of operation, statistics, and protection of workmen. Information on these regulations may be had on application to the Director, Bureau of Mines, Quebec.

TABLE IV

Limestone and Marble Quarries in Quebec

Operator	Location of Quarry	Product
	Argenteuil County	
Canadian Refractories, Ltd., Canada Cement Building, Montreal.	Kilmar	Dead-burned refractory materials, caustic-calcined magnesitic dolomite.
International Magnesite Co., Ltd., Calumet.	"	Caustic-calcined magnesitic dolomite.
Adélard Filion, Lachute	Lachute	Rubble, foundation stone.
A. Laurendeau & Co., Ltd., 10 St. James St., West, Montreal.	"	Crushed stone.
Town of Lachute	"	Crushed stone.
	Bagot County	
Kennedy Construction Co., Ltd., 407 McGill St., Montreal.	Acton Vale	Crushed stone, rubble, agricultural limestone.
Joseph Lalumière, St. Dominique	St. Dominique	Quicklime.
Emile Lapointe, St. Dominique	"	Crushed stone, rubble.
Magloire Leclerc	"	Quicklime.
Henri Loiselle, St. Dominique	"	Flux stone, rubble.
Camille Mercure, 9 St. Denis St., St. Hyacinthe.	"	Quicklime.
O. F. St. Onge, St. Dominique	"	Crushed stone.
	Beauharnois County	
City of Valleyfield, Valleyfield	De Salaberry Island	Crushed stone.
Quebec Department of Highways, Quebec.	St. Timothée	Crushed stone.
	Berthier County	
St. Barthélémi Quarry Co., St. Barthélémi.	St. Barthélémi	Crushed stone.
Gaspard Desfonds, St. Cuthbert.	St. Cuthbert	Quicklime.
	Bonaventure County	
H. Z. Arseneau, St. Jean l'Evangéliste.	St. Jean l'Evangéliste	Stone for pulp mills, agricultural limestone.
Leclerc & Day, Rimouski	"	Stone for pulp mills, crushed stone, agricultural limestone.
Gaspesian Fertilizer Co., Port Daniel East.	Port Daniel East	Stone for pulp mills, agricultural limestone.
Fishermen's Co-operative Society, Carleton.	Carleton	Agricultural limestone.
Cercle Agricole de St. Godfroy, St. Godfroy.	St. Godfroy	Agricultural limestone.

TABLE IV—*Continued*

Limestone and Marble Quarries in Quebec

Operator	Location of Quarry	Product
Champlain County		
Heon & Heon, St. Louis de France	St. Louis de France	Quicklime.
Carrière St. Louis Enrg., St. Louis de France.	"	Crushed stone, rubble.
St. Maurice Quarry, Ltd., 307 Alexander St., Three Rivers.	"	Crushed stone, rubble.
Yvon Dontigny, Ste. Thècle	Lake Travers	Quicklime.
Charlevoix County		
Albert Boily, Baie St. Paul	Baie St. Paul	Agricultural limestone, crushed stone.
Boily & Filion	"	Quicklime.
François Villeneuve, Pointe à Pic	Pointe à Pic	Agricultural limestone.
Chateauguay County		
Alfred Bissonette	Ville de Lery	Building stone.
Alphonse Faubert, Ville de Lery.	"	Building stone.
Laberge & Marchand, Chateauguay Basin.	Chateauguay	Crushed stone.
La Carriére Marcil, Ltée, St. Michel Station, Napierville Co.	Ste. Clothilde	Crushed stone.
Chicoutimi County		
Praxède Bouchard, Ste. Anne de Chicoutimi.	Ste. Anne de Chicoutimi	Quicklime.
Paul Vincelette, St. Honoré	St. Honoré	Agricultural limestone.
Hochelaga County		
(*See* Montreal District)		
Hull County		
Canada Cement Co., Phillips Square, Montreal.	Hull	Portland cement, crushed stone, agricultural limestone, asphalt filler.
Laurentian Stone Co., Ltd., 195 Nicholas St., Ottawa.	"	Crushed stone, rubble, quicklime, hydrated lime.
Oscar Noël, 44 Wright St., Hull.	"	Building stone, rubble.
Napoléon Tremblay, 31 Joffre Ave., Hull.	"	Crushed stone, stone for pulp mills, and rough building stone.
Wright Crushed Stone Co., Ltd.	"	Crushed stone, rubble, stone for pulp mills, agricultural limestone.
Jacques Cartier County		
(*See* Montreal District)		

TABLE IV—*Continued*

Limestone and Marble Quarries in Quebec

Operator	Location of Quarry	Product
	Joliette County	
Arnaud & Beaudry, Joliette	Joliette	Quicklime.
J. P. Beaudry, 41 rue Taché, Joliette.	"	Building stone.
Standard Lime Co., Ltd., Joliette	"	Quicklime, hydrated lime, crushed stone, stone for pulp mills, flux, agricultural limestone, asphalt filler.
Guilbault Frères & Cie, Ste. Elizabeth.	Ste. Elizabeth	Crushed stone for making pre-cast concrete blocks.
	Labelle County	
Canada Marble & Lime Co., 630 Cathcart St., Montreal.	L'Annonciation	Terrazzo, stucco dash, poultry grit, pulverized stone for the glass industry, and for making artificial stone.
	Lake St. John County	
J. O. Beaulac, Dolbeau	Dolbeau	Stone for pulp mills.
Emile Gagnon, Jonquière	St. Jérôme	Stone for pulp mills.
Leclerc & Robitaille, Roberval	Roberval	Crushed stone.
Armand Levesque, Roberval	"	Crushed stone.
	Laprairie County	
Baillargeon & Faubert, 62 Union Blvd., St. Lambert.	Caughnawaga	Crushed stone.
	Matane County	
Octave Gagné, St. Ulric	St. Ulric	Quicklime, agricultural limestone.
	Missisquoi County	
Shawinigan Chemicals, Ltd., Power Building, Montreal	Bedford (Lime plant at Shawinigan Falls)	Stone for manufacture of calcium carbide, flux, crushed stone, agricultural limestone, hydrated lime.
Wallace Sandstone Quarries, Ltd., Architects Building, Montreal.	Philipsburg	Marble, terrazzo, stone for pulp mills, stone for whiting substitute, agricultural limestone.
	Montmorency County	
A. A. Baker, Chateau Richer	Chateau Richer	Crushed stone, rubble for building purposes, agricultural limestone.
Edouard Gravel, Chateau Richer	"	Crushed stone, rubble for building purposes.
T. Lacouline, Chateau Richer	"	Crushed stone, rubble.
Quebec Department of Highways, Quebec.	St. Joachim	Crushed stone.
Beaudet & Bergeron, St. Antoine de Tilley.	Beaulieu, Island of Orleans	Riprap.

TABLE IV—*Continued*

Limestone and Marble Quarries in Quebec

Operator	Location of Quarry	Product
	Montreal District *Island of Montreal*	
Matthew Devito Construction, Ltd., 6138 Hamilton St., Montreal.	Pointe Claire.....	Crushed stone, rubble, riprap.
Fuger & Smith Ltd., Pointe Claire	"	Crushed stone, rubble, riprap.
Wilfred Schetagne, 309 Bord du Lac, Pointe Claire.	"	Crushed stone, rubble.
R. H. Miner Co., Ltd., 7411 Delanaudière St., Montreal.	St. Laurent.....	Crushed stone, rubble, riprap.
A. & E. Lapointe, 12034 Lachapelle St., Montreal.	Cartierville, Montreal.....	Building stone.
Quebec Department of Highways, Quebec.	Bordeaux, Montreal.....	Crushed stone.
Aldéric Cousineau & Fils, 5697 St. Urbain St., Montreal.	Villeray St., Montreal.....	Building stone.
Villeray Quarry Co., Ltd., 4740 Iberville St., Montreal.	Villeray St., Montreal..... and Ville St. Michel	Crushed stone.
Delorimier & Rogers Quarries, Ltd., 4901 Iberville St., Montreal.	Iberville St., Montreal.....	Crushed stone.
R. C. Dickson, 5759 Hochelaga St., Montreal.	Sherbrooke St. W., Montreal	Crushed stone, rubble.
Maisonneuve Quarry Co., Ltd., 5750 Iberville St., Montreal.	Rosemont Blvd., Montreal	Crushed stone.
Martineau Fils, Ltée, 517 Marie Anne St. East, Montreal.	Papineau St. and Rosemont Blvd., Montreal.	Crushed stone, rubble.
" "	Masson St. and 13th Ave., Montreal.	Crushed stone, rubble.
Montreal Quarry, Ltd., 1340 Bellechasse St., Montreal.	1340 Bellechasse St., Montreal.	Crushed stone.
Canada Cement Co., Ltd., Phillips Square, Montreal.	Montreal East.....	Portland cement.
Cyrille Durocher, 11021 Notre Dame St. East, Montreal.	"	Crushed stone.
National Cement Co., Ltd., P.O. Box 170, Hochelaga Station, Montreal.	"	Portland cement.
Limoges Fils & Cie, 552 Poupart St., Montreal.	Quarry at Ville St. Michel; kilns at 552 Poupart St.	Quicklime.
Montreal Lime Co., St. Marc des Carrières, Portneuf co.	Ville St. Michel.....	Quicklime.
National Quarries, Ltd., Park Ave. and Beaubien St., Montreal.	Ville St. Michel.....	Crushed stone.
Stinson-Reeb Builders Supply Co., Ltd., 360 Dorchester St. West, Montreal.	Quarry at Ville St. Michel; kilns at Delorimier Ave.	Quicklime, crushed stone, asphalt filler.
Union Rock, Ltd., 1340 Bellechasse St., Montreal.	Ville St. Michel.....	Crushed stone.
	Ile Jesus	
Canadian Lime Products Co., Cap St. Martin.	Kilns at Cap St. Martin; quarry at St. Vincent de Paul.	Quicklime.
Cap St. Martin Quarry, Cap St. Martin.	Cap St. Martin.....	Crushed stone.
Edgar Desormeaux.....	"	Building stone.
Arthur Charron, Village Belanger	"	Building and ornamental stone.

TABLE IV—*Continued*

Limestone and Marble Quarries in Quebec

Operator	Location of Quarry	Product
	Ile Jesus—*Concluded*	
Ubald Chartrand, Cap St. Martin	Cap St. Martin	Building stone.
V. Lecrenier, 8434 De Gaspé St., Montreal.	"	Building and ornamental stone.
Napoléon Lagacé, St. Martin	St. Martin	Crushed stone, rubble.
Jules Petitjean, Cap St. Martin	Village Belanger	Building stone.
Martineau Fils, Ltée, 517 Marie Anne St. East, Montreal.	"	Building stone.
St. Laurent Quarry Co., Ltd.	Cap St. Martin	Crushed stone.
Montreal Crushed Stone, Ltd. c/o General Trust of Canada, 112 St. James St. W., Montreal.	St. Vincent de Paul	Crushed stone.
St. Vincent de Paul Penitentiary, St. Vincent de Paul.	"	Building stone, crushed stone.
Levis Paquette & Co., Cap St. Martin.	St. François de Sales	Building stone.
Quinlan Cut Stone, Ltd., 1165 Greene Ave., Montreal, Que.	"	Building stone.
Stone & Quarry, Ltd., 1340 Bellechasse St., Montreal.	"	Building stone.
	Pontiac County	
White Grit Company, Hurdman Road, Ottawa, Ont.	Portage du Fort	Marble for terrazzo and artificial stone, stucco dash, poultry grit, asphalt filler.
	Portneuf County	
Canada Lime & Stone, Ltd., St. Marc des Carrières.	St. Marc des Carrières	Quicklime, building stone in rough block, crushed stone, agricultural limestone.
Deschambault Quarry Corp., 52 St. Paul St., Quebec.	"	Building stone, crushed stone, stone for pulp mills, agricultural limestone, asphalt filler.
Olivier Gauthier, St. Marc des Carrières.	"	Building stone; stone for pulp mills.
Gingras Frères, Ltée, St. Marc des Carrières.	"	Building stone, stone for pulp mills.
Martineau Fils, Ltée, 517 Marie Anne St. East, Montreal	"	Building stone, stone for pulp mills.
National Stone & Lime Co., 386 Lemoyne St., Montreal.	"	Quicklime.
Standard Lime Co., Joliette	"	Quicklime.
Arthur Boivin, Pont Rouge	Pont Rouge	Quicklime.
	Quebec County	
Carrière Giffard, Ltée, 71 St. Peter St., Quebec.	Giffard	Crushed stone, rubble.
Elzéar Verreault, Ltée, 194 Bridge St., Quebec.	"	Crushed stone, rubble.
Joseph Pagé, Charlesbourg	Charlesbourg West	Crushed stone, rubble, building stone, agricultural limestone.

TABLE IV—*Concluded*

Limestone and Marble Quarries in Quebec

Operator	Location of Quarry	Product
	St. Johns County	
Standard Clay Products, Ltd., St. Johns.	St. Johns.....	Crushed stone, rubble
	Stanstead County	
Eastern Townships Paving & Contracting Co., Sherbrooke.	Burroughs Falls.....	Crushed stone.
	Shefford County	
Canadian Rock Products, Ltd., 2020 Union Ave., Montreal.	South Stukely.....	Crushed stone.
	Wolfe County	
Dominion Lime Co., Lime Ridge	Lime Ridge.....	Quicklime, hydrated lime, crushed quicklime, agricultural limestone, crushed stone, poultry grit, asphalt filler, flux stone.

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CHAPTER IV

LIMESTONES NORTH OF THE ST. LAWRENCE RIVER

It is from the limestone deposits of this area that by far the greater proportion of the limestone production of Quebec is obtained. With the exception of unworked deposits of Silurian limestone on an island in lake Timiskaming at the extreme western part of the province and on Anticosti island in the Gulf of St. Lawrence, all the deposits in this territory are of Precambrian and Ordovician ages. The principal quarries are located in the Ordovician limestones. The resources of the area are described by counties and districts in alphabetical order in the several groups as follows:—

Area between Lake Timiskaming and Charlevoix County

Argenteuil
Berthier
Champlain
Charlevoix
Hull
Joliette
Labelle
L'Assomption
Maskinongé
Montcalm
Montmorency
Montreal
Papineau
Pontiac
Portneuf
Quebec
St. Maurice
Soulanges
Terrebonne
Témiscamingue
Two Mountains
Vaudreuil

Lake St. John Region

Chicoutimi
Lake St. John
Saguenay

Anticosti island

Mingan islands

Northern Quebec

AREA BETWEEN LAKE TIMISKAMING AND CHARLEVOIX COUNTY

Argenteuil County

Limestones of the Grenville series (Precambrian) comprise the major part of the limestone resources of Argenteuil county. They are plentifully distributed in belts having a prevailing northeast-southwest trend throughout the hilly, wooded territory that comprises most of the county. In the lowland bordering Ottawa river, sandy and argillaceous dolomite and magnesian limestone of the Beekmantown formation is found in flat beds with thin interbeds of shale between. The general distribution of the Beekmantown limestone is shown on Map No. 757, but, owing to the irregularity of the Precambrian limestone deposits and to their great number, it has not been found practicable to show all the individual deposits on the map and instead only the larger limestone belts are shown.

Among the deposits of Grenville limestone in this county are some having a chemical composition closely approaching that of magnesite but, owing to crystals of dolomite being present in variable quantity in all the rock, (Plate VI, page 41) it is, properly speaking, a magnesitic dolomite.

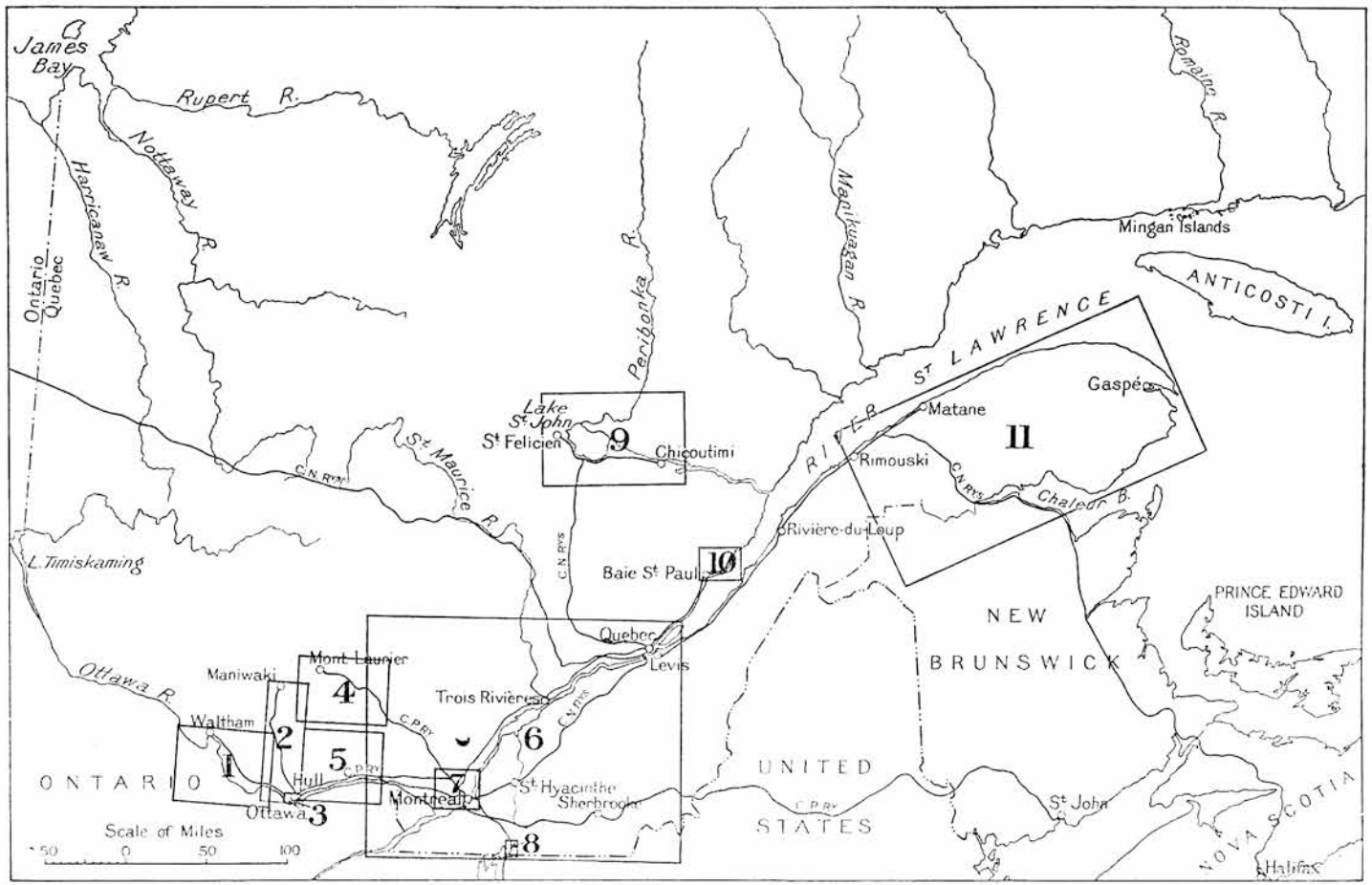

Figure 4. Key map showing areas covered by maps in this report:

1. Pontiac county ..... *See* Figure 10
2. Hull county ..... " " 6
3. Hull-Aylmer district ..... " " 7
4. Labelle county ..... " " 8
5. Papineau county ..... " " 9
6. Southern Quebec ..... *See* Map No. 757 in pocket.
7. Montreal district ..... " " " 756 "
8. Philipsburg district ..... " Figure 12
9. Lake St. John-Saguenay river.. " " 11
10. Charlevoix county ..... " " 5
11. Gaspe peninsula ..... " " 13

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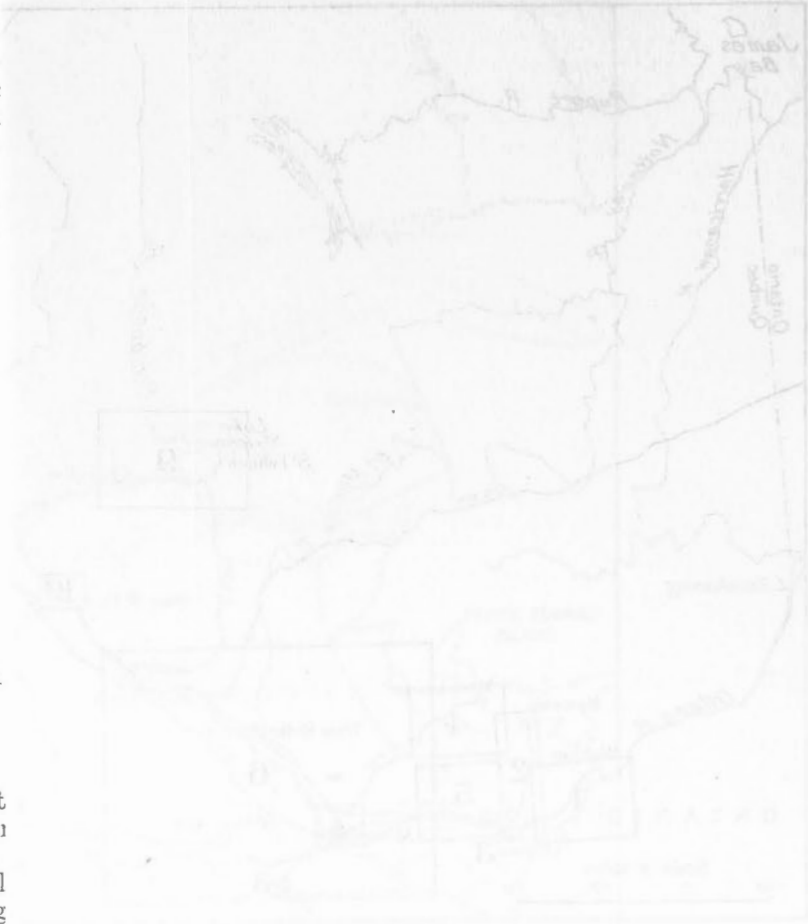

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Deposits of this nature are found in the townships of Grenville and Harrington, 9 to 12 miles north of the village of Grenville where they are being quarried by two companies for the production of refractory materials. Though deposits of Grenville limestone are numerous in the county, comparatively few are close to railway transportation and few have been worked. Calcium limestones predominate but there are also deposits of dolomite and of magnesian limestone in addition to the rare occurrences of magnesitic dolomite. In some of the deposits, impurities such as mica, graphite, serpentine, quartz, and inclusions and dykes of other rock are so plentiful that the limestone is practically worthless for chemical and metallurgical uses; other deposits, however, are relatively free from impurities. A deposit of rather impure Grenville limestone occurring a short distance north of the village of Grenville was at one time quarried for use in the pulp mill at Hawkesbury, Ontario, but it proved unsuitable chiefly owing to the abundance of flakes of graphite and mica present in the stone. Beekmantown limestone is quarried at Lachute for crushed stone, foundation stone, and rubble.

Calumet

There are a number of deposits of Precambrian limestone in the hills a short distance north of Calumet, but most of them contain only impure stone. On the bank of Calumet river, on lot 15, range III, Grenville township, a deposit of compact, grey Grenville limestone containing serpentine was quarried for building stone and for pulp-making many years ago. Part of the limestone is dolomitic and part is nearly free from magnesia. Sample 24 taken from this deposit includes all types of limestone occurring therein.

Farther to the northeast, on lot 13, range IV, Grenville township, very impure Grenville limestone is exposed at the place where the road going north from a point midway between Calumet and Grenville crosses the south branch of the Calumet river.

Impure Grenville limestone is also exposed to the northwest of Calumet in ranges III and IV of Grenville township.

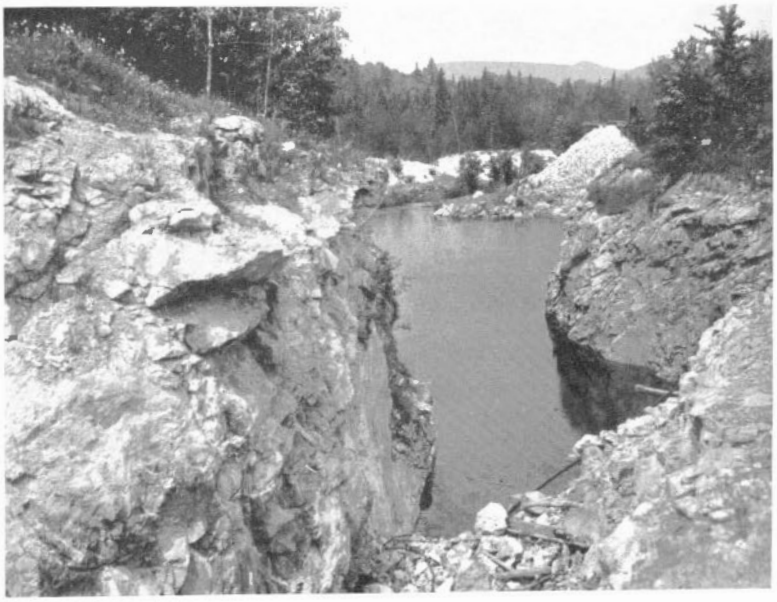
Impure dolomite and magnesian limestone of the Beekmantown formation underlie a large area east of Calumet, but west of the village the Beekmantown limestone occurs only in patches overlying the Potsdam sandstone, in a narrow strip bordering Ottawa river.

Grenville

A deposit of grey Grenville limestone occurs on the west side of Kingham river, 2¾ miles north of the village of Grenville. The stone is fine-grained calcium limestone containing flakes of graphite and mica, and also many grains of silicate minerals. Sample 25 as taken from this deposit. In 1901 a trial shipment of the limestone was made to the sulphite-pulp mill at Hawkesbury, but it proved unsuitable for pulp-making largely because of the presence of flakes of graphite and mica which caused specks in the pulp.

Just east of Grenville village, on lots 6 and 7, range II, Grenville township, exposures of thin-bedded, impure, magnesian limestone of Beekman-

A. Quarry of Canadian Refractories, Ltd., in Precambrian magnesitic dolomite, Kilmar, Argenteuil county.



B. Disused quarry on property of International Magnesite Company, Ltd., Harrington East, Argenteuil county, illustrating the variable width of the band of magnesitic dolomite.

town age are numerous. The stone is fine-grained, hard, dark blue and dark grey in colour on fresh fracture but on exposure it turns to a drab brown. Thin partings of brown shale occur between the beds. Sample 26 was taken from a 3-foot face exposed in a pit on the Arnold property on lot 6. Some of the dark grey Beekmantown limestone in this vicinity when polished becomes nearly black, and as it takes a good polish it has attracted some attention as being a possible source of black marble, but, in general, the beds are too thin and too irregular to render the deposits of value for this use.

Impure limestone of the Beekmantown formation is also exposed along the shore of the Ottawa river east of Grenville, particularly between Stonefield and Cushing.

Kilmar—Harrington East

In the Precambrian rocks of this district are found important deposits of magnesitic dolomite from which, between the years 1908 and 1933, inclusive, refractory products having a value of $6,220,000 have been produced. At the present time two companies are engaged in quarrying and processing this material. The deposits have been examined and reported on by M. E. Wilson of the Geological Survey, and for detailed information his report[1] should be consulted. In a recent article[2] Wilson gives the following summary of his information on these deposits.

The only deposits containing magnesite in Canada that have been mined extensively are masses of magnesite-dolomite found near the southern border of the Canadian Precambrian Shield, in Grenville and Harrington townships, about 10 miles (13 miles by road) north of the village of Grenville, in the county of Argenteuil, Que. The rocks of the district are all Precambrian, and belong chiefly to a basal complex consisting of crystalline limestone, quartzite and sillimanite-garnet gneiss of the Grenville series intruded by gabbro, anorthosite, and other pyroxenic igneous rocks of the Buckingham or Anorthosite series, and by batholithic masses of granite and syenite. Cutting this basal complex is an east-west system of late Precambrian diabase dykes, one of which cuts transversely across the largest of the magnesite-dolomite masses.

The magnesite-dolomite deposits occur in two north-south trending zones arranged in echelon; the south end of the northwesterly zone lying about one mile west of the north end of the southeasterly zone. The southeasterly zone from which most of the magnesite, so far produced, has been obtained, is about one and one-half miles long; the northwesterly zone is one mile long. The magnesite-dolomite occurs within the zones in irregular elongated masses, the largest having a maximum length of about 1,200 feet and a maximum width of 100 feet. The average width of this deposit is about 50 feet. The rocks adjoining the deposits in the southeasterly zone are vertically standing quartzite on the west, and crystalline limestone and gabbro on the east; in the northwesterly zone the adjacent rocks are not well exposed but crystalline limestone, quartzite, gabbro, and granite gneiss all occur nearby.

The deposits do not consist of pure magnesite, but are an intimate intergrowth of dolomite and magnesite. Masses of dark green to pale yellow-green serpentine are also common, forming from one-fourth to one-third of the deposits. The proportion of magnesite and dolomite in the deposits is exceedingly variable, ranging from almost pure magnesite to pure dolomite. The proportion of lime contained in the magnesite varies, of course, with the proportion of dolomite included, but in most of the deposits, leaving the serpentine out of consideration, the average is about 13 per cent. It has been found, however, that material containing 17 per cent lime (magnesite-dolomite) may be used for refractory purposes with satisfactory results.

The character and relationship of the deposits indicate that they have been formed by the replacement of the crystalline limestone of the Grenville series, this transfor-

[1] Wilson, M. E.: Geol. Surv., Canada, Mem. 98 (1917).

[2] Wilson, M. E.: "Magnesite in Canada," Can. Min. Jour., May 1934, pp. 239-241.

mation taking place in two stages, first, by the alteration of the Grenville limestone to dolomite and, second, by the transformation of the dolomite to magnesite. The last stage in replacement was not carried to completion however. The emanations effecting the transformation carried silica as well as magnesia, as shown by the masses of serpentine in the deposits. The intimate association of gabbro with the deposits, and the presence of considerable magnesia in this gabbro, suggest that it is the source from which the emanations were derived.

Most of the magnesite-dolomite produced from the Grenville deposits is now mixed in a finely ground condition with about 3 per cent of waste iron and roasted to a dead-burned state in rotary kilns. The product is used chiefly in lining open-hearth steel-furnaces. A few thousand tons of magnesite were mined from one of the Grenville deposits between 1908 and 1914, but they were not worked on a considerable scale until the World War, when a maximum production of 28,564 tons valued at $1,016,764 was reached in 1918.

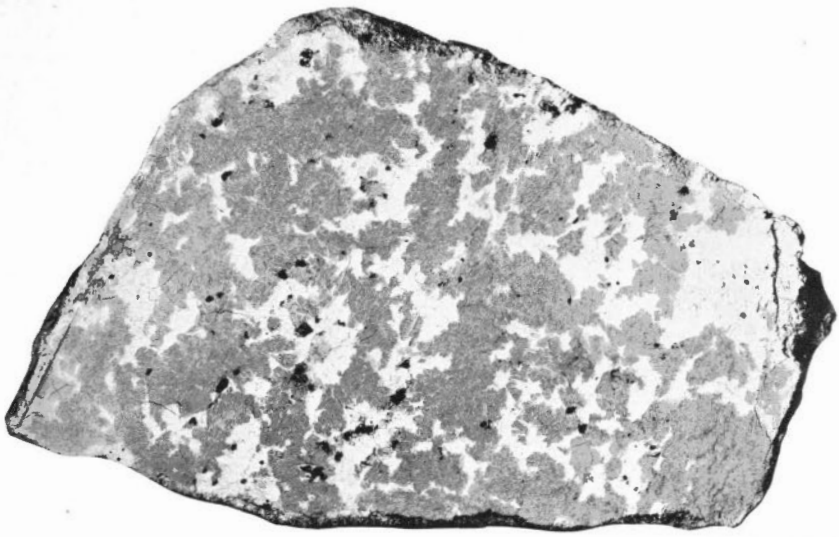
Quarry of Canadian Refractories, Ltd.,[1] *1050 Canada Cement Building, Montreal.* This quarry is on lot 15, range IX, Grenville township, on the east side of White Rock lake. It is near the southern end of the southeasterly zone of magnesitic dolomite deposits referred to by Wilson. In this locality 5 quarries have been opened within a distance of 400 yards along the band of magnesitic dolomite which outcrops in a low ridge striking approximately N. 35° E.[2] along the east shore of the lake. The entire deposit is owned by the above company but only one of the quarries, that next to the southernmost of the series, is being worked at present. It is by far the largest of the series, being 400 feet long and having a maximum width of 190 feet at the surface and 100 feet at the bottom. In 1934 it had been worked to a depth of 185 feet at the south end and to a depth of 150 feet over most of the remainder, and as yet the bottom of the deposit has not been reached. The quarry is roughly semi-circular in plan, the west wall being nearly straight, and the east wall being curved. The outline of the quarry closely corresponds to that of the nearly vertically dipping band of magnesitic dolomite at this place. The ore zone is narrow at both ends of the quarry but is traceable in both directions to the other quarries which have been opened in similar lenses, though in places dykes of basic igneous rock cut across the vein. Less than 100 feet separates the operating quarry from the now disused quarry to the south. This latter excavation is 300 feet long, 75 to 80 feet wide, and is said to be 165 feet deep, but is now nearly full of water. The quarry to the north of the one being operated is 300 feet distant and is quite small, but 60 feet farther north is a quarry 180 feet long, and 60 feet north of this again is the northernmost quarry which is 120 feet long. A band of quartzite extends along the west sides of all these quarries. In each quarry the magnesitic dolomite is associated in an irregular manner with both serpentine and normal dolomite, though a certain zoning of the several types of rock is in evidence.

In the quarry now worked the band of quartzite forms the west wall. Adjoining this to the east is a narrow zone of dolomite and serpentine containing stringers of magnesitic dolomite. Next to this is a band 15 to 40 feet wide consisting largely of fine-grained, snowy white and bluish grey, magnesitic dolomite with some pockets or lenses of dolomite and

[1] A detailed description of the operations of this company is given in a paper "Magnesia Refractories in Canada" by G. M. Carrie and D. W. Stewart, published in Can. Inst., Min. & Met. Bull. Sept. 1933, pp. 541-554. (*See also* Plate V A.)

[2] In this report wherever the strike of a stratum of limestone is given, the bearing refers to magnetic north and not to true north.

PLATE VI



Geological Survey, Canada.

A. Calcined magnesitic dolomite. The dark material is magnesite, the light-coloured material is dolomite. Natural size.

Geological Survey, Canada.

B. Calcined magnesitic dolomite, showing few crystals of dolomite.

serpentine and occasional masses of white and green diopside. This band extends the full length of the quarry and in places yields magnesitic dolomite containing only 1 per cent silica and 8 per cent calcium carbonate, but the average grade of rock obtainable from this band, after the serpentine has been cobbed out, has a somewhat higher content of both silica and calcium carbonate. East of this is a zone of irregular thickness of bluish grey, coarser-grained rock approaching dolomite in composition, but having a higher content of magnesium carbonate than has normal dolomite. This lower grade rock contains occasional crystals of pyrite, sphalerite, magnetite, and some few flakes of graphite, in addition to veins and masses of serpentine. East of this dolomitic rock is a body of nearly white, coarse-grained magnesitic dolomite, associated with serpentine and dolomite, that has a maximum width of 35 feet and averages 2·5 per cent silica and 15 per cent calcium carbonate. It is bounded on the east by a green, siliceous carbonate rock containing biotite, pyrite, graphite and other impurities, and also containing bands of mica schist, serpentine and at least one thin band of gneiss. Near the north end of the quarry this last body of magnesitic dolomite ends abruptly at what appears to be a fault plane, but southward it continues for an as yet undetermined distance, though in this direction it is overlain by 15 to 35 feet of green, siliceous carbonate rock, serpentine, and mica schist, and thus this body of magnesitic dolomite is not traceable on the surface. East of the quarry is a boulder-studded ridge 600 to 800 feet wide, and this is succeeded by a wide swamp. A nearly vertically dipping band (20 feet thick) of impure, rusty calcium limestone, studded with fragments of gneiss and other silicate rocks, forms a wall along the southeast side of the ridge. This limestone is adjoined on the northwest by a band of dark gneiss but no other outcrops of rock in place were observed between the gneiss and the quarry.

Hand-cobbing and sorting are necessary to separate waste from mill rock and to ensure a uniform quarry product. The cobbing and blending are done in the quarry and the quarrymen become very skilful in these operations. The following analysis, supplied by the company, is representative of the main quarry product delivered to the mill:—

	Per cent
Silica	4·0
Ferric oxide and alumina	1·0
Calcium oxide	11·0 to 12·5
Magnesium oxide	38·0
Loss on ignition	45·0

Jackhammers and dynamite are used in quarrying, and the quarry is being deepened in 12-foot benches, though, owing to the irregularity of the deposit, the benches are not always maintained at this height. The broken rock, after being block-holed and sledged to 1-man size, cobbed and graded, is loaded by hand into 1- and 1½-ton skips which are hoisted to the surface by means of 3 high-speed derricks and dumped into 10-ton, two-way, side-dump cars which are hauled in trains of 7 by gasoline locomotives over a standard-gauge track to the mill at Kilmar, 2 miles to the north. At the mill the rock is dumped into a gyratory crusher set to

3-inch opening and is then stock-piled. Waste rock is hoisted out of the quarry by the same means and is dumped into a hopper on the west side of the quarry, from which it is taken by self-dumping cars and piled up on the shore of the lake. The average output of the quarry at the present time (1934) is 500 tons of magnesitic dolomite per day. Quarrying is discontinued in the winter, sufficient being stock-piled to supply the mill during the winter months. Pumps, derricks, and air compressor are driven by electricity.

The calcining plant at Kilmar has a capacity of 100 tons of refractory products per day. The equipment includes, in addition to elevators, screens, and feeding devices, a dryer, 3 gyratory crushers, a jaw crusher, 2 ball mills, 3 tube mills, 3 rotary kilns (each 60 feet long and 5 feet in inside diameter), a rotary cooler, and a set of rolls. Pulverized coal used for fuel is prepared in a Hardinge mill. The main product of the plant is dead-burned magnesitic dolomite, of which two varieties, sold under the trade names of "Basifrit" and "Magnifrit," are prepared. Caustic-calcined magnesitic dolomite, "Grenite", is produced when required. A portion of the dead-burned material is further processed into several products such as finely ground refractory cement and plastic refractory products. Chrome refractories are also manufactured under licence from E. J. Lavino Company of Philadelphia; these include "Plastic K-N," "Wetkrome," "Kromepatch," "A-3 Cement", and "Neutragrog." Storage space of 9,000 tons of manufactured products is available at the plant. The products are shipped in standard railway freight cars which are hauled by gasoline locomotive over 11 miles of track owned by the company to Marelan station on the Canadian Pacific railway. Electric energy for operating both mill and quarry and for lighting purposes is brought from the Belle Falls plant of the Gatineau Power Company on Rouge river, 5 miles distant.

What is apparently the northerly extension of the same band of magnesitic dolomite now being quarried 2 miles south of Kilmar passes close to the mill, and has been quarried in 5 places in that vicinity, but there has been no production from these quarries within the past few years. The band of magnesitic dolomite near the mill is said by the company officials to vary from 35 to 50 feet in width and to be of the same general character and to be associated with the same type of rock as is that in the quarry now being worked.

Quarry of International Magnesite Co., Ltd., Calumet, Quebec. The property of this company is on lot 13, range I, Harrington township. It is near the northern end of the northwesterly belt of magnesitic dolomite deposits referred to by Wilson (page 39) and is 2 miles north of the village of Kilmar. The company is engaged solely in the production of caustic-calcined magnesitic dolomite.

The magnesitic dolomite here occurs in a vertically dipping band, a few feet to 30 feet in width, trending S.8°W. and is exposed in several small quarries for a distance of 400 yards south from the kiln. (Plate VB, page 38). Associated with the magnesitic dolomite in a very irregular way are veins and masses of serpentine, normal dolomite, and also basic igneous rock. Rock containing the highest content of magnesium carbonate is fine-grained and is bluish grey in colour. A blue, medium-grained rock is also found here in which the content of magnesium carbonate is

much higher than that in normal dolomite, which is generally white and coarse grained. Four shallow quarries have been opened along this belt, with the present production coming from the third quarry south of the kiln. This quarry is 100 feet long, 15 to 20 feet deep and 30 feet wide. Drilling is done by means of a steam drill mounted on a tripod, and dynamite is used for blasting. The broken rock is hauled in horse-drawn dump carts to the kiln. The company supplied the following analysis as being representative of the graded rock sent to the kiln:—

	Per cent
Silica	1·75
Ferric oxide and alumina	0·98
Calcium oxide	9·54
Magnesium oxide	38·37
Loss on ignition	49·36

The calcining plant consists of one vertical, externally fired, continuous, steel kiln, 50 feet high and 8 feet in inside diameter. It is of the same type as that employed in modern lime plants. Wood is used for fuel and the capacity of the kiln is 12 tons of caustic-calcined magnesitic dolomite per 24 hours. In the calcined product the dolomite present shows up as light grey spots against the darker colour of the calcined magnesite, as illustrated in Plate VI, page 41. The calcined material is hauled by motor truck to Kilmar and shipped from thence, by arrangement with Canadian Refractories, Ltd., over the privately owned railway of the latter company to the Canadian Pacific railway at Marelan. The caustic-calcined magnesitic dolomite is used principally for fettling the bottoms of open-hearth furnaces in steel plants.

One-half mile south of the property of the International Magnesite Company is a small quarry, known as the Shaw Mine, owned by Canadian Refractories, Ltd., but which has not been operated in recent years. The magnesitic dolomite available here is reported to be similar to that in the quarries of the International Magnesite Company above described.

Carillon

A thickness of 12 feet of the flat-lying, Beekmantown limestone, underlying the country in the vicinity of Carillon, is exposed in the side of the old Carillon canal at the village. The beds range from 2 to 16 inches in thickness, with those less than 6 inches thick predominating. Shale partings are present and one bed of shale 13 inches thick is to be seen. The limestone is fine-grained, hard and brittle, and weathers to a muddy brown colour, though on fresh fracture it is brownish blue. Sample 27 represents the limestone beds only, no shale being included.

Similar impure magnesian limestone, composing the upper part of the Beekmantown formation, is exposed in places along the Ottawa river between Carillon and Grenville.

Lachute

Sandy and argillaceous dolomite of the Beekmantown formation is exposed in a number of places in the vicinity of Lachute and has been quarried for road metal and for building purposes.

Quarry operated by A. Laurendeau & Co., Ltd., 10 St. James St. W., Montreal. This quarry, which is worked for road metal, is opened in a low ridge of limestone immediately south of the centre of the town, on property owned by L. C. Barron. It is roughly 200 feet square and 19 feet deep. The limestone is fine-grained, hard and tough, dark blue-grey to brown-grey in colour, and occurs in even, nearly flat-lying beds 12 to 20 inches thick, two or more of which are in places tightly joined together. A 12-inch bed of sandy shale occurs just beneath the top limestone bed. Beginning 5 feet from the surface, large crystals of opaque white calcite and dolomite are plentifully distributed through several of the beds in a zone 6 feet thick. The analysis of Sample 28A, which is representative of the entire quarry face except the shale bed, shows the stone to be siliceous. Many years ago stone for building culverts along what is now the North Shore line of the Canadian Pacific railway between Montreal and Ottawa was quarried from this property. The quarry is worked by means of jackhammers, and the broken stone is loaded by hand into dump carts for conveyance to the nearby crushing plant, which is of the semi-portable type and has a capacity of 100 tons of crushed stone per 10-hour day. The depth of soil on the ridge does not exceed 2 feet in the vicinity of the quarry.

Quarry operated by the Town of Lachute. This is a very small quarry opened in the same ridge 100 yards east of the quarry on Mr. Barron's land. A very small crushing plant is operated in connection with the quarry, which is worked only occasionally.

Quarry of Adélard Filion, Lachute. On the southeastern outskirts of the town, Adélard Filion produces foundation stone and rubble for building purposes from a shallow quarry 100 feet wide by 200 feet long. The stone is fine-grained, dark grey Beekmantown dolomite in beds 1 to 2 feet thick, dipping at an angle of 3 degrees to the northwest. Seams of sandy shale are present in many of the beds and on the weathered surfaces the seams stand out in relief. Joints are widely spaced and blocks of large dimensions, subject to the limitations of thickness, are available. On weathering, the stone becomes a drab brown colour. The production is small and no mechanical equipment is used in quarrying.

On the farm of George Fraser, ½ mile south of Lachute, on the east side of the highway to Montreal, Beekmantown dolomite was at one time quarried for road metal. At this place 10 feet of flat-lying beds of dark grey, fine-grained, hard, tough, impure dolomite up to 2 feet in individual thickness is exposed in a small pit beneath 1 to 3 feet of soil. Thin partings of sandy shale occur between the beds. Sample 28 represents this stone which, as shown by the analysis, is very siliceous and somewhat argillaceous.

Three-quarters of a mile northeast of Lachute and a short distance north of North river is a large deposit of impure Grenville limestone that was at one time quarried for the building of bridge piers on what is now the North Shore line of the Canadian Pacific railway between Montreal and Ottawa. Lime has also been burned here. The limestone is medium- to coarse-grained and contains inclusions of schist and gneiss, masses of quartz, flakes of mica and graphite, and grains of other minerals.

Over relatively small areas, however, some fairly pure calcium limestone is obtainable, as shown by the analysis of Sample 29, which represents what appears to be the best quality limestone in the deposit.

Brownsburg

From the West Branch of West river, 2 miles north of Brownsburg, a prominent belt of Grenville limestone extends northwards for some miles. It consists in part of calcium limestone and in part of dolomite, but so far as the southern part of the belt is concerned, it is apparently nearly all impure, though there are some narrow bands of fairly pure dolomite available in places. No sample was taken from this deposit.

Weir

In the vicinity of Round lake, a short distance west of Weir, on the St. Rémi branch of the Canadian National railway, are large exposures of impure, coarse-grained, greyish white Grenville limestone, containing much quartz and pyroxene, and also some graphite, mica, and pyrrhotite. An analysis on record at the Mines Branch of a sample obtained from this deposit is as follows:—

	Per cent
Insoluble	16·00
Calcium carbonate	74·71
Magnesium carbonate	3·86

This belt of limestone is shown on Geological Survey Map No. 750 as extending continuously from the northern part of Grenville township across Harrington township to the central part of Montcalm township, over 18 miles in all. Doubtless the purity and composition of the limestone vary widely in different parts of this belt.

Analyses of Argenteuil County Limestones[1]

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
24	7·56	1·14	0·54	0·04	63·93	25·47	98·68	n.d.	35·80	12·69	2·8 : 1
25	15·10	1·13	1·27	0·04	82·29	0·59	100·42	0·26	46·10	0·28	165 : 1
26	5·82	2·10	1·48	0·09	66·25	23·29	99·03	0·22	37·15	11·14	3·3 : 1
27	14·06	1·90	3·41	0·09	58·52	20·42	98·40	0·38	32·82	9·76	3·4 : 1
28	15·84	2·34	3·24	0·07	45·42	33·15	100·06	0·72	25·45	15·86	1·60 : 1
28A	9·20	1·36	3·12	0·09	48·62	35·99	98·38	0·14	27·28	17·21	1·59 : 1
29	4·97	0·65	0·14	0·02	93·48	0·83	100·09	0·21	52·35	0·40	131 : 1

24.	Calumet.	Precambrian limestone on the bank of the Calumet river, lot 15, range III, Grenville township.
25.	Grenville.	Precambrian limestone on west bank of Kingham river, 2¾ miles north of the village.
26.	"	Beekmantown limestone on lots 6 and 7, range II, Grenville township.
27.	Carillon.	Beekmantown limestone exposed in the wall of the Carillon canal at the village.
28.	Lachute.	Beekmantown limestone in quarry on the farm of George Fraser.
28A.	"	Beekmantown limestone in quarry operated by A. Laurendeau & Co.
29.	"	Precambrian limestone in quarry ¾ mile northeast of the town.

[1] Analyses of magnesitic dolomite occurring in this county are given on pages 42 and 44.

Berthier County

Nearly flat-lying beds of Beekmantown, Chazy, and Trenton limestones, forming part of the great limestone belt paralleling the north shore of the St. Lawrence river from Montreal to below Quebec, underlie the southern part of Berthier county. This part of the county lies in the St. Lawrence plain where the soil is generally deep and rock exposures are uncommon except in the river valleys. The villages of St. Cuthbert and St. Barthélémi are situated on this limestone belt, which in this county has a width of 2 to 5 miles between the Archaean escarpment and the shales that overlie the limestone toward the river. The northern part of the county is underlain by Precambrian rocks in which a few deposits of impure calcium limestone are known, none of which appears to be of commercial value.

At St. Barthélémi the Trenton limestone is quarried for road metal, and at St. Cuthbert it is quarried on a very small scale for making lime.

Berthier Junction

Along the valley of Bayonne river, west of Berthier Junction and near the boundary of Joliette county, dark-coloured, thinly bedded, fine-grained, shaly calcium limestone of Trenton age is exposed beneath a heavy covering of soil. Conditions for quarrying are not favourable.

St. Cuthbert

Trenton limestone dipping to the southeast at angles of 5 to 10 degrees is exposed on both sides of Chicot river at the village of St. Cuthbert, and from time to time small quantities of stone for building purposes, for road metal, and for lime burning have been quarried along the river banks. Away from the immediate vicinity of the river though, the rock is apparently deeply covered by soil. At present small amounts of stone are occasionally quarried by Gaspard Defond for making lime in a small field kiln in which wood is used for fuel. The stone used for this purpose is from a series of beds of medium-grained, bluish grey, high-calcium limestone, totalling 20 feet in thickness, that is overlain and underlain by dark-coloured, fine-grained calcium limestone containing many nodules of black chert. The individual beds of the pure stone are irregular but in places are 3 feet thick and are practically devoid of shale seams even in the parting planes. Exposures of the pure limestone are seen at intervals in the river valley for 300 yards above the highway bridge and also for a short distance below it. A small amount of quarrying has been done in several of the outcrops but at present stone is obtained only from below the bridge. Sample 88 is representative of the stone used for making lime. As shown by the analysis of this sample the stone is very pure but large-scale quarrying is scarcely practicable because of the overlying cherty stone and the depth of soil.

St. Barthélémi

In the neighbourhood of St. Barthélémi, rather impure, thin-bedded, dark-coloured limestone of the top of the Trenton formation is exposed

A. Quarry of St. Barthélémi Quarry Co. Note the unusual type of cart used to transport the limestone.

B. Near view of thinly bedded Trenton limestone in quarry of St. Barthélémi Quarry Co.

and has been quarried in several places for making crushed stone At present a quarry is operated in the village. Three miles due west of the village is a water-filled quarry once worked for crushed stone in which the only beds visible are composed of dark brownish blue, fine-grained, hard limestone with shale partings between.

St. Barthélémi Quarry Co., St. Barthélémi. This company is producing crushed stone at a quarry just south of the highway near the centre of the village. The quarry is opened in a hard, dense textured, dark brownish blue, dull-lustred Trenton limestone, and is 700 feet long, 90 feet wide, and the maximum height of face is about 14 feet. A small amount of calcareous shale occurs between the beds, which range from 2 to 6 inches in thickness (Plate VII B, page 48), but several beds are commonly tightly joined. The dip of the strata is southeasterly at an angle of 3 degrees at the southern end of the quarry but is even less at the northern end. Soil covers the stone to a depth of 1 to 5 feet, the greater thickness being at the northern end of the quarry. Sample 89 is from the 14-foot face.

The quarry is worked in two benches of equal height. Broken stone is loaded by hand into box-shaped steel wagons without rear end-gates (Plate VII A, page 48). These wagons are hauled by horses over the smooth floor of the quarry to the foot of the incline leading to the crushing plant, up which the wagon is pulled by a hoist. Just above the crusher the slope of the incline is increased sufficiently to cause the stone to slide out of the wagon into the crusher. The crushing plant has a capacity of 15 tons per hour.

Analyses of Berthier County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
88.....	0·82	0·22	0·53	0·20	98·25	0·86	100·58	0·04	55·13	0·41	134 : 1
89.....	7·40	1·14	2·56	0·22	85·73	2·31	99·36	0·21	48·13	1·10	44 : 1

88. St. Cuthbert. Medium-grained, bluish grey limestone from quarry of Gaspard Defond.

89. St. Barthélémi. Dense-textured, dark brownish blue limestone in quarry of St. Barthélémi Quarry Co.

Champlain County

Flat-lying beds of Trenton limestone, comprising part of the limestone belt that parallels the north shore of the St. Lawrence river from Montreal to below Quebec city, are available over a strip of country 2 to 9 miles wide, immediately south of the Archaean escarpment. At St. Louis de France the limestone is being quarried for crushed stone and for making lime, and was formerly quarried at Radnor for flux, and more recently for use in pulp mills. A few deposits of Grenville limestone occur in the Precambrian rocks that underlie the greater part of the county. Near Ste. Thècle lime is being made from Grenville limestone, and another deposit

nearby was at one time quarried for marble. Three bands of Grenville limestone are reported[1] to occur in the parish of St. Tite, one of which consists of fine-grained, rose-coloured limestone that is said to take a high polish.

St. Louis de France

Three quarries, two of which are worked for crushed stone, rubble and riprap, and one of which is worked in connection with a small lime plant, are situated 1¾ miles northeast of this village, which is on the highway between Three Rivers and Shawinigan Falls and about 6 miles from the former place. A large lime plant (6 kilns) formerly operated by the St. Maurice Lime Company is also situated here but it has not been operated for a number of years. The quarries and lime plants are served by a spur track from the Canadian Pacific railway, and by a paved highway. At present most of the production is being shipped by motor truck.

The limestone in the vicinity is covered by 1 to 3 feet of soil and has a slight dip to the southeast. A generalized section of that exposed in the quarries, all of which are close together, is as follows.

10 feet—Medium-grained, brownish grey, hard limestone in beds, 2 to 12 inches thick, separated by seams of jet black shale. Sample 93 represents this top 10 feet of stone, the full thickness of which is seen only on the south sides of the quarries.

13 feet—Medium- to fine-grained stone in somewhat thinner beds than that above and, as shown by the analysis of Sample 93A, which represents this zone, is also somewhat more siliceous.

7 feet—Fine-grained and thinner bedded brownish grey stone with seams of black shale. Sample 93B represents this stone which is more siliceous than that above.

All the stone is hard and tough and smells strongly of petroleum.

The following quarry companies are engaged in quarrying at St. Louis de France:—

St. Maurice Quarry, Ltd., 307 Alexander St., Three Rivers. This company is producing crushed stone, rubble, and riprap. The quarry is 30 feet deep, 600 feet long and 400 feet wide and is worked in benches by means of jackhammers and dynamite, the bottom bench being 13 feet in height. Blasted stone is loaded by hand to small, steel side-dump cars which are pushed by hand over narrow-gauge tracks to the primary crusher which is set in a pit on the floor of the quarry. From the primary crusher the stone is elevated to the secondary crusher and screening plant, situated at the brink of the quarry. The capacity of the plant is 50 tons of crushed stone per hour. Motor trucks are used to deliver the products. The photograph of this quarry (Plate VIIIA, page 51) was taken in 1930 when a large quantity of rock for use in breakwater construction at Three Rivers was being quarried.

Messrs. Heon & Heon, St. Louis de France, are engaged in the production of lime from the medium-grained stone which constitutes the top 10 feet of the strata exposed in this vicinity and from which Sample 93 was taken. The quarry immediately adjoins the southwest corner of the

[1] Geol. Surv., Canada, Rept. of Progress 1885, p. 54A.
Geol. Surv., Canada, Rept. of Progress 1887-88, p. 31A.

PLATE VIII

A. Quarry of St. Maurice Quarry, Ltd., St. Louis de France, Champlain county.

B. Quarry of Carrière St. Louis Enrg., St. Louis de France.

quarry worked by St. Maurice Quarry, Ltd. The lime plant consists of a vertical, externally fired, continuous, steel kiln having a capacity of 6 tons of quicklime per 24 hours. The lime is light brown in colour and is burned with wood fuel.

Carrière St. Louis Enrg., St. Louis de France. The quarry worked by this company for the production of crushed stone, rubble, and riprap, is 500 feet northeast of the other quarries. It is 400 feet in diameter and 30 feet deep (Plate VIII B, page 51). The same strata are exposed as in the quarry of St. Maurice Quarry, Ltd. and the same general method of quarrying is employed with the exception that the stone is hauled up an incline to the crushing plant, the capacity of which is 20 tons per hour. This quarry was formerly operated by the St. Maurice Lime Co. for the production of lime, but the lime plant, consisting of 6 kilns, has not been in operation since 1925.

Radnor

Rather siliceous and argillaceous, hard, fine- to medium-grained Trenton limestone, in flat-lying beds 2 to 16 inches thick, separated by partings of shale, is exposed near Radnor in the banks of rivière au Lard, and also in a small quarry from which flux was obtained for use in the blast furnace of the Canada Iron Corporation when that company was in operation there. Recently a small amount of limestone was quarried at Radnor for use in sulphite-pulp mills but the stone did not prove so satisfactory as that obtainable elsewhere. Sample 94 is representative of 10 feet of strata exposed in this area. The depth of soil on top of the limestone ranges from 3 to 20 feet or more.

Ste. Anne de la Perade

Impure, fine-grained, dark brownish grey, thinly bedded, shaly Trenton limestone is exposed in the bed of the Ste. Anne river from 2½ miles above the village of St. Anne de la Perade northwesterly to the Portneuf county boundary. Four miles above the village a small quarry for road metal was at one time worked in stone of this character on the east bank of the river. Sample 95 was taken in this quarry and represents 20 feet of limestone exclusive of the shale interbeds. There is 6 feet of soil on top of the stone here.

Ste. Thècle

West of lake Travers and about 4 miles northwest of the village of Ste. Thècle is a deposit of Grenville limestone which, according to Mr. Theo. Denis,[1] has a length of 1,000 feet and a width, in places, of 200 feet. The limestone is enclosed in micaceous rock, bands of which, together with veins and crystals of quartz, flakes of mica, and grains of various other silicate minerals, also occur in the deposit. The limestone varies in colour from pink to white, and in grain from fine to very coarse. It is apparently all of the calcium variety. The following analyses are taken from reports of Howells Fréchette and W. A. Parks. They represent stone comparatively free from impurities.

[1] Dept. Colonization, Mines and Fisheries, Quebec, Rept. Mines Branch 1912, p. 43.

	1 Per cent	2 Per cent
Insoluble	5·40	0·36
Ferric oxide	0·19	0·26
Alumina	0·13	
Calcium carbonate	91·29	96·69
Magnesium carbonate	3·11	2·59
Combined water	Not det.	0·58
	100·12	100·48

1. General sample from the deposit. (Frechette, Howells: Mines Branch, Dept of Mines, Canada, Sum. Rept. 1916, p. 55).
2. Specimen of fine-grained, pink marble. (Parks, W. A.: Mines Branch, Dept of Mines, Canada, Rept. No. 279, p. 200 (1914)).

In 1911 a company known as La Compagnie de Marbre du Canada opened up the deposit with the object of producing marble for interior decorative purposes. A derrick and a small marble mill were erected at the deposit, and an excavation 50 feet square and 6 to 12 feet deep was made by means of a channelling machine, but operations soon ceased and were not resumed. The masses of quartz and foreign rock scattered irregularly throughout the limestone would render it difficult to cut and polish.

Mr. Paul Bouret of the Quebec Bureau of Mines informs the writer that Mr. Yvon Dontigny of Ste. Thècle is producing lime from a deposit of dolomitic Grenville limestone ½ mile north of the old marble quarry. No sample for analysis is available from this deposit.

Analyses of Champlain County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
93	2·90	0·25	0·65	0·26	94·09	1·40	99·55	0·06	52·83	0·67	79 : 1
93A	5·50	0·44	0·36	0·31	91·32	1·39	99·32	0·07	51·31	0·66	78 : 1
93B	6·58	0·38	1·21	0·24	88·98	1·90	99·29	0·09	49·96	0·91	55 : 1
94	4·72	0·88	2·19	0·07	89·71	2·60	100·17	0·21	50·28	1·24	41 : 1
95	9·46	0·61	1·58	0·20	84·71	2·42	98·98	0·20	47·55	1·15	41 : 1

93. St. Louis de France. Top 10 feet of strata in quarry operated by Heon & Heon.
93A. " " Next 13 feet of strata exposed in quarry worked by St. Maurice Quarry, Ltd.
93B. " " Bottom 7 feet in face of same quarry.
94. Radnor. Ten feet of strata formerly quarried for flux by Canada Iron Corporation.
95. Ste. Anne de la Perade. Twenty feet of strata in east bank of Ste. Anne river, 4 miles above the village of Ste. Anne de la Perade.

Charlevoix County

This county lies on the north shore of St. Lawrence river between the island of Orleans and Saguenay river. So far as known the only limestone resources within its boundaries are contained in two outliers of the Trenton formation, one of which occurs at Baie St. Paul and the other at Murray Bay (Figure 5, page 55). The limestone in each of these outliers has a very low content of magnesium carbonate but it is all rather argillaceous. In each locality the limestone is associated with sandstone and shale. At Baie St. Paul small quantities of quicklime and agricultural limestone are produced for local use and the limestone has also been used for local buildings. No use is at present being made of the limestone at Murray Bay though it has been quarried in the past for road metal and for making lime.

Baie St. Paul

The main outlier of Trenton limestone at Baie St. Paul occupies an area about 3 miles in diameter and lies mostly in the valley of Gouffre river at the head of the bay. Small detached areas of limestone are to be found over a greater area. The limestone is all fine-grained to dense in texture, dark brownish grey in colour, and is in relatively thin, steeply dipping beds with shale between. It is commonly underlain by sandstone and shale and is overlain by shale, but in places it rests directly on the granitic Precambrian rocks of the district.

About 1½ miles above the highway bridge over Gouffre river, on the property of Alfé Simorral, a small quarry having a face of 7 feet has been opened in the Trenton limestone exposed in the steep hillside on the east side of the river above the road to Murray Bay. The limestone is fine-grained, dull-lustred, dark brownish blue and is in beds 2 to 8 inches thick, between which are beds of shale up to 4 inches thick, the shale being most prevalent in the upper part of the deposit. The strata strike north and south and dip to the west at an angle of 13 degrees. It is said that the stone for the post office at Baie St. Paul was obtained from this quarry. Sample 127 represents the limestone in the 7-foot face exclusive of the shale interbeds.

Limestone that would underlie that in the quarry is exposed farther up on the hillside at a distance of about 350 yards from the road, and here the strata dip westerly at an angle of 75 degrees and form a ridge about 50 feet wide along the hillside. The beds are very uneven and possibly rest directly on the steeply sloping, uneven granite floor, outcrops of which rock are seen farther up the hill. The limestone is similar

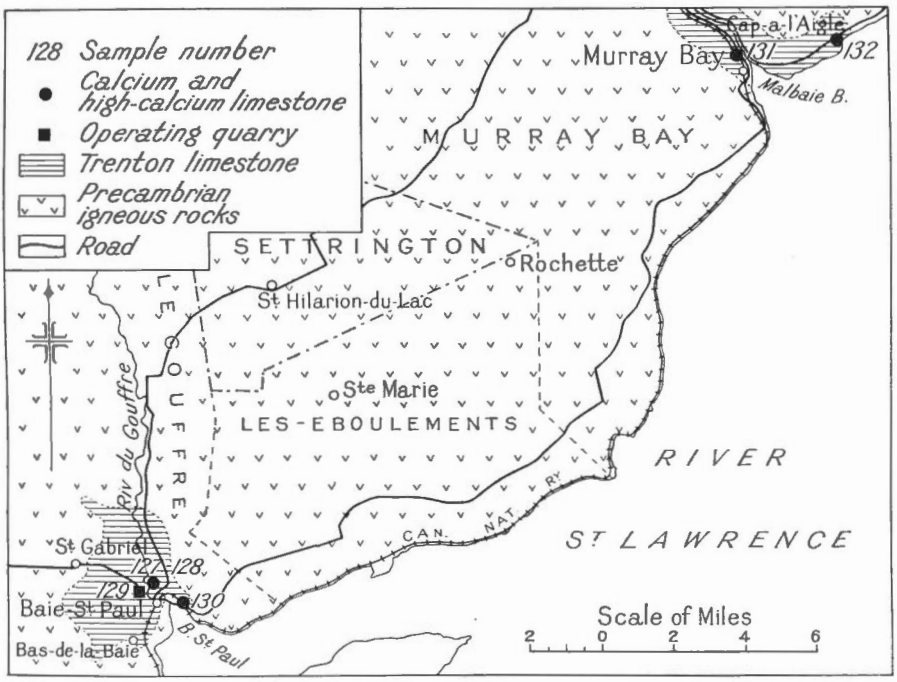


Figure 5. Map showing location of limestone deposits sampled in Charlevoix county.

in appearance to that in the quarry except that it is not so dull-lustred and has less interbedded shale. As shown by the analysis of Sample 128, which was taken across the beds exposed in the ridge, it contains less impurities, but even so it is impure.

Exposures of limestone of the same general type are to be seen along the road ¼ mile north of here and again ¼ mile south, the latter outcrops being on the property of Ernest Simorral.

One-half mile west of the village, on the road to Quebec, Alfred Boily produces agricultural limestone from limestone obtained from the bed of a brook. The limestone used is similar in appearance and probably in composition to that on top of the ridge where Sample 128 was obtained. The limestone is crushed in a small jaw crusher and then passed through

a set of rolls. The capacity of the plant is 2 tons per hour. Messrs. Boily and Fillion also make lime for local use in a small pot kiln at this locality.

In the bed of the river at Baie St. Paul fine-grained, dark brownish blue limestone in uneven beds up to 14 inches thick is exposed. Here the strike is N. 40°E. and the dip is southeasterly at an angle of 35 degrees. Sample 129 represents the stone.

Along the shore east of the village limestone is exposed for 800 feet in the railway cutting. The stone is in fractured beds of variable thickness up to about 12 inches and dips westward at an angle of 40 degrees. (Plate IX A.) Very little shale is present between the beds except toward the base of the section. An almost vertical face of limestone 80 feet in height is visible here. Sample 130 consists of fragments taken at intervals of 10 feet along the cutting.

Small quantities of lime for local use are made in several small field kilns in the neighbourhood of the village.

Murray Bay

The outlier of Trenton limestone at Murray Bay is somewhat larger than that at Baie St. Paul, isolated patches of limestone being observed as far distant as 6½ miles northwest of the village. The limestone resembles the Baie St. Paul limestone in general appearance and in its low content of magnesium carbonate but there is a greater variation in the silica content, some being very sandy and consequently very siliceous, but some contains much less silica than that at Baie St. Paul.

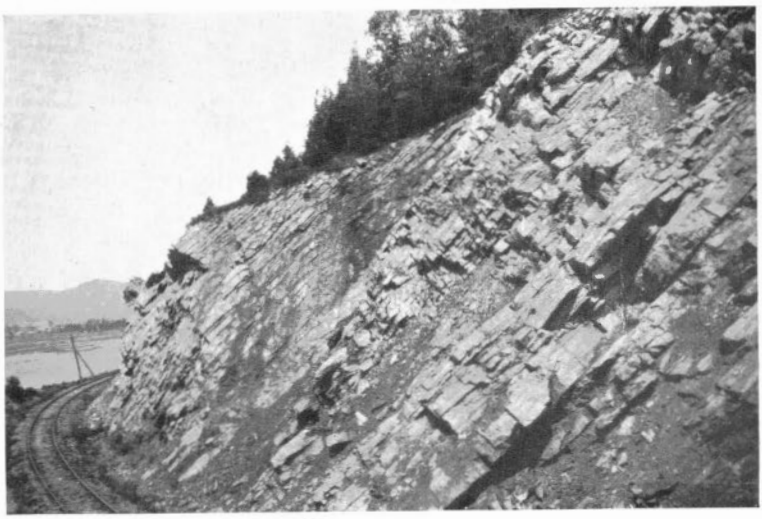
Cliffs of limestone, sandstone, and shale are exposed along the shore of the bay on both sides of Murray river, but the cliffs on the west shore in the vicinity of the pier are mostly sandstone and contain only thin belts of impure limestone. But along Murray river and on the east side of the bay, limestone is the predominant rock.

On the west bank of Murray river about 75 feet of limestone beds are exposed in a railway cutting 350 yards above the highway bridge. The prevailing dip is to the southeast at an angle of 4 degrees. At the base of the section the limestone is dull-lustred and more impure than that above, and in the bottom 25 feet of the section are some beds of shale 16 to 21 inches thick. The remainder of the exposed section is composed of dense-textured, thinly bedded, dark brownish grey limestone with only a small amount of interbedded shale. The hill rises steeply for about 100 feet above the limestone outcrops, but no rock is seen on the upper slopes. Sample 131 represents the top 15 feet exposed; Sample 131A the middle 35 feet; and Sample 131B the bottom 25 feet. No shale is included in any of the samples.

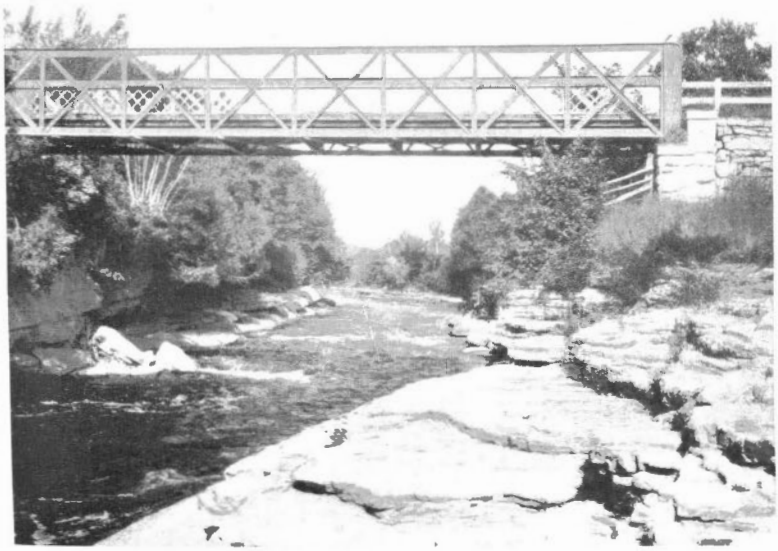
Exposures of limestone are visible along the west side of Murray river for 1½ miles above the highway bridge at Murray Bay.

Along the shore three-quarters of a mile west of Cap l'Aigle post office is a cliff composed of sandy, calcium limestone in the lower part, then above this is a zone of thin-bedded, very fine-grained, shaly limestone, which is overlain by a 25-foot thickness of fine- to medium-grained limestone nearly free from shale; this in turn is overlain by very fine-grained, thinly bedded

PLATE IX



A. Steeply dipping Trenton limestone at Baie St. Paul, Charlevoix county.



B. Trenton limestone at Les Dalles in Ouareau river, Montcalm county.

shaly limestone and finally by shale. All the limestone appears to be siliceous. The strata are undulating but the prevailing dip is toward St. Lawrence river at a low angle.

Inshore from this cliff, at a place about 500 feet north of the road paralleling the river, a small quarry was at one time worked for road metal on the property of Arthur Desmeules. The quarry is opened on the southeast side of a hill in limestone strata that dip to the southwest at an angle of 32 degrees. The stone in the quarry consists of alternate beds of hard, dark .brownish blue, very fine-grained limestone, and shale. The shale beds vary from 6 inches to 9 inches in thickness, and the limestone beds are slightly thicker. The top bed in the quarry face is shale. When freshly broken the limestone smells of petroleum. Sample 132 represents the limestone beds in the quarry face.

Analyses of Charlevoix County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
127.....	15·10	0·69	1·87	0·22	80·45	0·61	98·94	0·11	45·17	0·29	156 : 1
128.....	9·18	0·59	1·21	0·17	86·98	0·63	98·76	0·08	48·80	0·30	163 : 1
129.....	8·86	0·50	1·78	0·22	84·36	2·35	98·07	0·21	47·36	1·12	42 : 1
130.....	9·60	0·48	1·36	0·24	84·79	1·91	98·38	0·17	47·48	0·91	52 : 1
131.....	4·44	0·60	1·40	0·07	91·02	0·86	98·39	0·26	51·01	0·41	124 : 1
131A.....	4·72	0·54	1·44	0·07	91·14	0·82	98·73	0·63	51·08	0·39	131 : 1
131B.....	9·52	0·60	1·14	0·09	87·20	0·74	99·29	0·11	48·88	0·35	140 : 1
132.....	9·32	0·65	1·93	0·20	85·38	1·03	98·51	0·11	47·92	0·49	98 : 1

127.	Baie St. Paul.	Seven feet of limestone in quarry on property of Alfé Simorral.
128.	"	Fifty feet of strata in ridge on hill above the quarry.
129.	"	Bed of river at village.
130.	"	Railway cutting east of the village.
131.	Murray Bay.	Top 15 feet of strata in railway cutting on west side of Murray river, 350 yards above the highway bridge.
131A.	"	Middle 35 feet of strata in railway cut.
131B.	"	Bottom 25 feet of strata in railway cut.
132.	"	Small quarry on property of Arthur Desmeules.

Hull County

Both Precambrian and Ordovician limestones are available in this county. The Ordovician limestones, consisting of those of Beekmantown, Black River, Chazy, and Trenton ages are found only within an area 2 to 4 miles wide and 12 miles long in the southern tip of the county between the city of Hull and the town of Aylmer (Figures 6 and 7). It is from the Trenton limestone at Hull that the entire present production of limestone within the county is obtained. This limestone is being quarried for the making of Portland cement, crushed stone, building stone, for use in the acid towers of local pulp mills, for agricultural use, for asphalt filler, and for the making of lime. North of Aylmer a deposit of very pure high-calcium limestone of Black River age was also recently quarried for making lime but the lime plant is now dismantled.

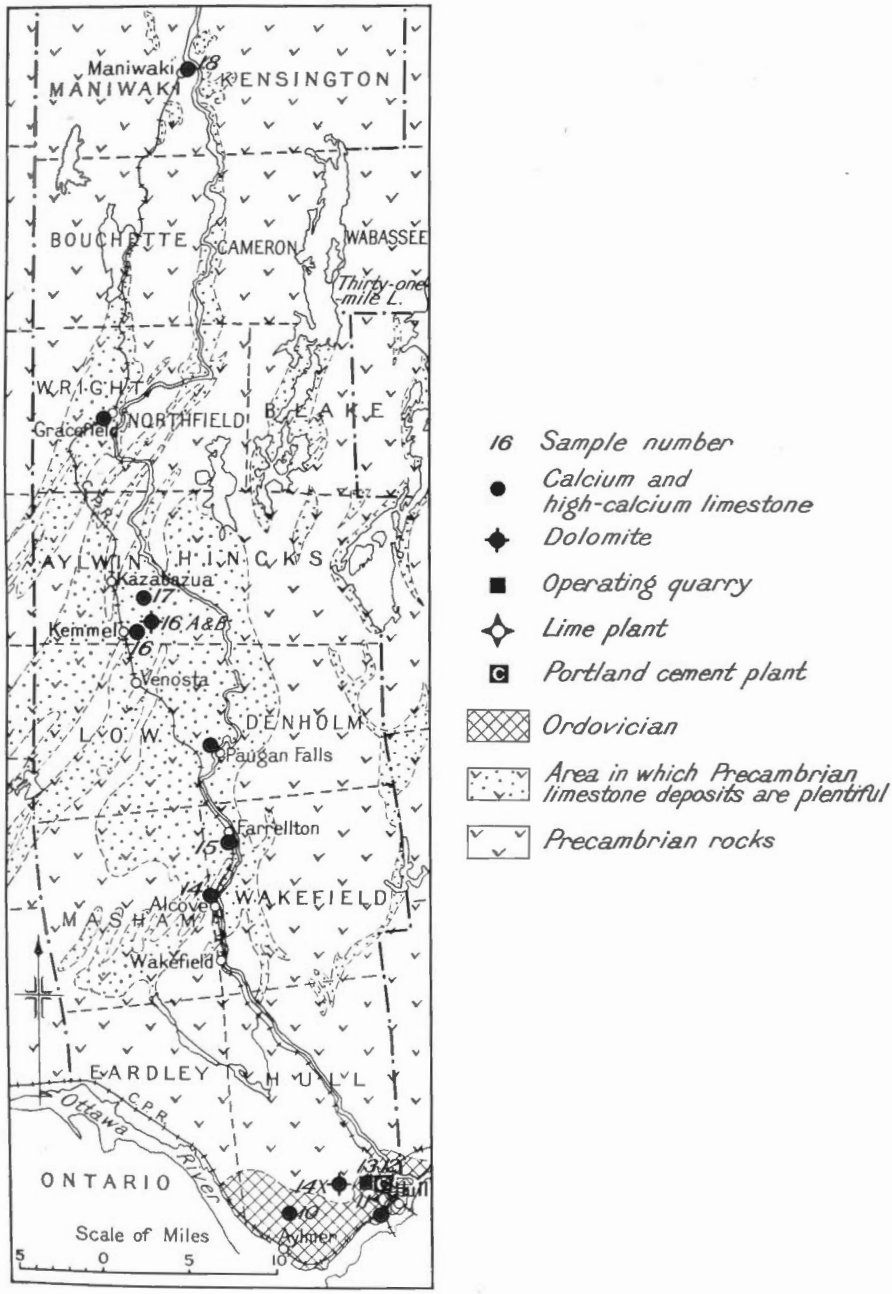


Figure 6. Map showing location of limestone deposits sampled in Hull county.

The remainder of Hull county is underlain by Precambrian rocks in which deposits of metamorphosed Grenville limestone are abundant, but though many small quarries have been worked from time to time in these deposits there is no production at present. The majority of the deposits consist of calcium limestone but deposits of dolomite and magnesian limestone are also available, and some deposits are composed of the three varieties. The Grenville limestones in general as found in this county contain a great variety of impurities, are interbedded with quartzite, gneiss and mica schist, and also are invaded by tongues of igneous rock, though as shown in the succeeding pages, there are some deposits that are comparatively pure. Field work in this area was confined to the immediate vicinities of the Gatineau Valley highway and the Canadian Pacific railway. By no means all of the deposits seen, even in this restricted area, were sampled, but it is believed that the samples taken are representative of the better quality limestone that is readily accessible.

Aylmer

Beginning one-half mile or so north of the town of Aylmer, flat beds of Chazy and Black River limestones are exposed along the Klock road for 4 miles as shown in Figure 7, page 61.

Three miles due north of Aylmer on lot 21, range IV of Hull township, medium-grained, greyish white, fossiliferous, Black River limestone was quarried recently for making lime, but the lime plant is now dismantled. The limestone is thinly bedded, without shale partings and occurs in flat beds beneath only a few inches of soil. It is a very pure, high-calcium limestone, as shown by the analysis of Sample 10 which represents the top 4 feet of strata, and it yields a white lime. This pure limestone is exposed over the central part of the Black River area shown in Figure 7, but probably has no great thickness. It is underlain by a dark grey, very fine-grained, calcium limestone represented by Sample 10A. This latter type of limestone constitutes the remainder of the Black River area, 1 mile in diameter, as shown in Figure 7.

One-half mile north of Aylmer, fine-grained, dark blue-grey Chazy limestone in flat, regular beds up to 14 inches in thickness is exposed in a low escarpment on both sides of the Klock road and has been quarried in small amount for building purposes. Some of the stone here contains patches of brown-weathering, argillaceous and siliceous material similar in appearance to that which characterizes much of the Chazy limestone elsewhere in the province. Sample 10B was taken from a stratum apparently free from the brown-weathering siliceous material, and Sample 10C represents a bed containing considerable of it.

One and a half miles east of Aylmer, sandy dolomitic limestone of Chazy age is to be seen on the north side of the Aylmer road. This type of stone apparently occurs just a short distance above the Chazy shale which in this district comes between the Chazy limestone and the underlying Beekmantown limestone.

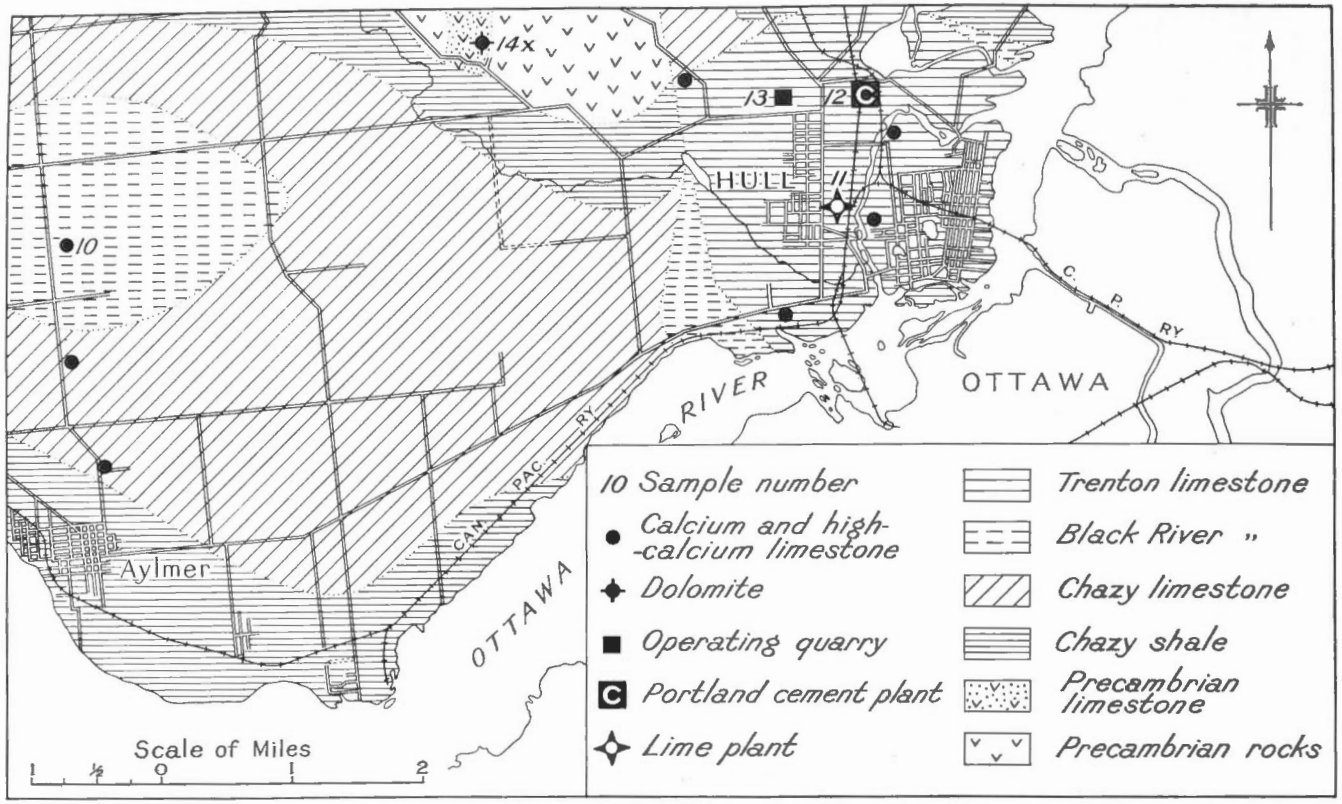


Figure 7. Detailed map showing limestone deposits and quarries in the Hull-Aylmer district.

Hull

Limestones of Grenville, Beekmantown, Black River, Chazy, and Trenton ages are exposed in and near the city of Hull, but quarrying has been confined to the Trenton limestone, which occupies an area roughly 2½ miles square within which area the city is built. (Figure 7, page 61.) This mass of Trenton limestone is part of a down-faulted block, connected on the southeast side with Trenton limestone on the Ontario side of the Ottawa river, but sharply separated by faults from the older rocks on the west, north, and northeast sides. The limestone consists predominantly of calcium carbonate and rarely contains over 3·5 per cent magnesium carbonate. Pure and impure zones alternate, and for the most part the limestone is cherty, though this impurity is scarcely noticeable in certain zones.

Quarries have been worked in the Trenton limestone in Hull since the place was first settled, to obtain stone for building purposes and for making lime, and these products as well as crushed stone, stone for use in acid towers in sulphite-pulp mills, and for the manufacture of Portland cement are still produced. The first hydraulic cement made in Canada was made in Hull by Ruggles Wright about 1835, though the limestone used for making the cement was obtained from a quarry on the Ontario side of the Ottawa river. In 1889 the Wrights established the first Canadian Portland cement plant at Hull, and in this plant the local limestone was used. The present plant of the Canada Cement Company at Hull also uses local limestone.

Quarry of Wright Crushed Stone Co., Ltd., Hull. This company is producing crushed stone and stone for use in the manufacture of sulphite pulp. The quarry (Plate XA, page 67) is situated a short distance west of Brewery creek in that part of Hull known as Wrightville. The top stone to a depth of 10 to 13 feet was in the past quarried off from most of the property and used for building purposes, but this stone is still available along the western edge of the property. The top 3 feet consists of impure, shaly limestone, but beneath is 10 feet of fine- to medium-grained, brown, high-calcium limestone in beds 8 inches to 2 feet thick; these beds were used in the construction of many buildings in the city. Sample 11 represents this pure stone. The quarry at present worked is 400 feet square, and in it an additional 63 feet of flat-lying strata is exposed as follows:—

19 feet—Medium- to fine-grained, dark brown limestone containing a great deal of black chert. The beds are comparatively thin and of irregular thickness and are separated by partings of black shale.

4 feet—Medium-grained, light brown, high-calcium limestone in heavy beds. A few nodules of black chert occur near the top of these beds and near the base are a few nodules of grey chert. Sample 11A was taken from this 4 feet of stone.

20 feet—Heavily but very unevenly bedded, fine- to medium-grained, brown calcium limestone seamed with black shale and containing many nodules of black and of grey chert.

11 feet—Mostly thin-bedded, fine-grained, dark brownish grey calcium limestone containing much chert and with partings of black shale between the beds.

9 feet—Heavily bedded, medium-grained, brown, high-calcium limestone practically free from chert and with only very thin films of black shale between the beds. Sample 11B represents this 9 feet of stone which is quarried for use in pulp mills and formerly was used for lime, together with that of the 4 feet of pure stone near the top of the quarry from which Sample 11A was taken.

The quarry is worked in benches by means of jackhammers. After blasting, the stone is loaded by hand into small steel cars which are pushed by hand over narrow gauge tracks to the foot of the incline leading to the crushing plant where the stone is dumped into a skip which is hauled up the incline by cable to the crusher. The capacity of the crushing plant is 50 tons per hour. A siding from the Canadian Pacific railway serves the plant but most of the crushed stone is used locally and is shipped by truck. The other products from this quarry are stone for use in sulphite-pulp mills, and agricultural limestone. The latter consists of screenings from the crushed stone plant and is of a fineness that 97 per cent passes a 10-mesh screen.

Quarry of Laurentian Stone Co., Ltd., 195 Nicholas St., Ottawa. This company is producing crushed stone from a quarry a short distance south of that of the Wright Crushed Stone Co., and also operates a lime plant adjacent to the quarry. High-calcium stone for the lime plant was until recently obtained from the nearby quarry, but is at present being obtained from a quarry on the Montreal road just east of Ottawa.

The quarry from which crushed stone is obtained is 200 by 400 feet in area and, except for an old pit at the south end, does not exceed 9 feet in depth. The stone quarried is the same as that in the top of the Wright quarry. Jackhammers are used in quarrying and the blasted stone is loaded by hand to trucks for transportation to the nearby crushing plant which has a capacity of 20 tons per hour.

The lime plant consists of one vertical, continuous, externally fired, steel kiln having an output of 10 tons of lime per 24 hours, and a batch hydrator. Wood is used for fuel in the kiln. A grey lime is produced; part of which is marketed in the form of quicklime and part as hydrated lime packed in multi-walled, 50-pound bags.

Quarry of Oscar Noël, Hull. This small quarry is a few hundred feet north of that of the Wright Crushed Stone Company, and is being worked for building stone. The stone quarried is the heavily bedded, fine- to medium-grained, pure limestone at the same geological horizon as are the upper beds seen along the west side of the Wright property. Cross-bedding is evident in the stone and consequently the beds are of irregular thickness, but blocks up to a maximum of 3 feet 6 inches in thickness and from 5 to 10 feet in length are obtainable, though they are not perfectly rectangular. The blocks are sold to cut-stone plants in Ottawa and Hull.

On the east side of Brewery creek and a short distance south of the quarries just described, is a large abandoned quarry in which 15 feet of thinly bedded, cherty calcium limestone is seen overlying 10 feet of heavily bedded, nearly chert-free stone. The chert nodules here contain crinoid stems. The limestone is covered to a depth of 10 to 15 feet with gravelly soil.

Quarry of Canada Cement Co., Ltd., Phillips Square, Montreal. The quarry and plant of this company are on the northern outskirts of Hull. In the quarry, which is 700 feet long and 500 feet wide, a 65-foot section of Trenton limestone is exposed as follows:—

1 foot—Soil.

9 feet—Thinly bedded limestone, many of the beds being composed in part of medium- to coarse-grained, fossiliferous, pure limestone, and in part of fine-grained, non-fossiliferous, cherty, siliceous limestone, the two types being sharply differentiated in a direction parallel to the bedding but nevertheless being firmly joined together. Sample 12 represents the coarse-grained portions of these beds, and Sample 12A the fine-grained portions. This top 9 feet of stone has previously been removed over a large area and is not at present being quarried.

21 feet—Heavily bedded, brown, fine- to medium-grained stone in irregular beds up to 4 feet thick but which tend to split much thinner owing to the presence of thin seams of black bituminous matter which occur roughly parallel to the bedding planes: Grey and black chert nodules occur sparingly through this stone, chiefly in the bottom 11 feet. Sample 12B represents this 21 feet of strata exclusive of chert.

11 feet—Fine-grained, very dark-coloured limestone with numerous seams of shale and an abundance of nodules and large platy masses of black and grey chert. Sample 12C is from this 11 feet of stone exclusive of the chert.

24 feet—Medium- to fine-grained, brown, rather siliceous limestone in heavy beds which, however, tend to split along seams of black bituminous matter which occur at intervals of a few inches all through the stone. Shale partings occur between the beds. Grey chert containing crystals of pyrite is common in this stone. Sample 12D represents this stone exclusive of chert. These are the lowest strata exposed in the quarry.

The following series of analyses of limestone on the property was kindly supplied by the company. The samples were chip samples from each 3-foot section from a well drilled near the company's office by means of a churn drill. Note the uniformly low content of magnesia.

Sample	Depth in feet	SiO_2	R_2O_3	CaO	MgO	Loss on ignition	Total
1	4– 7	27·28	4·28	36·65	0·83	30·00	99·04
2	7– 10	13·56	2·48	46·28	0·62	36·72	99·66
3	10– 13	8·64	1·86	49·22	0·65	39·00	99·37
4	13– 16	3·56	1·00	52·70	0·58	41·62	99·46
5	16– 19	1·54	0·62	54·14	0·80	42·38	99·48
6	19– 22	1·64	0·72	54·32	0·62	42·62	99·92
7	22– 25	4·34	0·90	52·61	0·65	41·34	99·84
8	25– 28	5·28	0·90	51·90	0·62	40·70	99·40
9	28– 31	6·12	0·96	51·18	0·72	40·42	99·40
10	31– 34	6·76	0·90	51·09	0·70	40·30	99·75
11	34– 37	7·60	1·24	50·10	0·69	39·88	99·51
12	37– 40	6·40	1·00	50·45	0·88	40·24	98·97
13	40– 43	3·10	0·88	52·92	0·74	41·94	99·22
14	43– 46	2·03	0·88	53·50	0·70	42 30	99·30
15	46– 49	1·02	0·72	54·24	0·58	42·52	99·42
16	49– 52	1·32	0·64	54·60	0·51	42·78	99·85
17	52– 55	3·96	0·76	52·39	0·70	41·76	99·58
18	55– 58	6·56	0·80	50·89	0·70	40·46	99·21
19	58– 61	5·88	0·76	51·51	0·62	40·70	99·47
20	61– 64	6·80	1·56	50·17	1·15	39·84	99·52
21	64– 67	8·00	1·84	48·78	1·01	39·24	98·87
22	67– 70	5·40	1·80	50·63	0·78	40·24	98·85
23	70– 73	7·00	2·00	48·78	1·10	39·36	98·24
24	73– 76	8·92	2·52	47·12	1·20	38·52	98·48
25	76– 79	6·88	1·36	48·52	1·59	39·72	98·03
26	79– 82	7·32	2·36	47·98	1·74	39·40	98·80
27	82– 85	5·96	2·00	49·30	1·17	39·92	98·35
28	85– 88	3·32	1·20	51·84	0·74	41·56	98·66
29	88– 91	5·56	2·16	49·74	0·91	40·12	98·39
30	91– 94	6·92	2·60	48·43	0·98	39·36	98·29
31	94– 97	10·00	5·00	45·43	0·96	36·28	97·67

Sample	Depth in feet	SiO_2	R_2O_3	CaO	MgO	Loss on ignition	Total
32	97–100	6·00	3·08	48·78	1·11	39·32	98·39
33	100–103	6·76	3·72	48·16	0·97	38·52	98·13
34	103–106	5·08	2·84	49·84	0·88	39·72	98·36
35	106–109	5·08	3·00	49·57	0·90	39·40	97·93
36	109–112	5·60	3·12	49·13	1·03	39·08	97·96
37	112–115	6·32	3·56	48·42	1·05	38·88	98·23
38	115–118	6·00	3·24	48·60	1·11	39·04	97·99
39	118–121	6·16	3·40	48·52	1·03	38·88	97·99
40	121–124	5·72	3·12	49·04	1·04	39·04	97·96
41	124–127	6·94	3·86	47·11	0·94	38·32	97·17
42	127–130	1·04	0·78	53·89	0·45	42·68	98·84
43	130–133	0·78	0·40	54·15	0·46	43·08	98·47
44	133–136	1·06	0·60	53·97	0·62	42·60	98·85
45	136–139	1·24	0·62	53·53	0·55	42·00	97·94
46	139–142	1·60	1·04	53·45	0·61	42·20	98·90
47	142–145	1·40	0·92	53·53	0·59	42·56	99·00
48	145–148	1·00	0·68	53·97	0·52	43·04	99·21
49	148–151	1·00	0·64	54·06	0·54	43·00	99·24
50	151–154	0·88	0·48	54·24	0·59	42·96	99·14
51	154–157	0·80	0·56	54·50	0·51	43·16	99·53
52	157–160	0·73	0·52	54·59	0·48	43·02	99·33
53	160–163	5·35	1·80	50·45	0·78	40·12	98·48
54	163–166	3·16	1·38	52·30	0·61	41·52	98·97
55	166–170	3·84	1·60	51·25	0·91	40·96	98·56
The samples from the next 13 feet were lost.							
56	183–186	9·64	2·04	47·55	0·87	38·48	98·57
57	186–189	9·60	2·08	47·64	0·82	38·40	98·54
58	189–192	11·44	2·40	46·31	0·87	37·32	98·34
59	192–195	14·76	3·00	44·20	0·91	35·56	98·45
60	195–198	8·96	2·08	47·81	0·82	38·76	98·43
61	198–201	14·16	2·78	44·73	0·91	36·00	98·58
62	201–204	21·16	3·88	39·89	1·10	32·28	98·31
63	204–207	19·60	3·96	40·24	1·11	33·16	98·07
64	207–210	16·08	3·56	42·44	1·26	34·92	98·26
65	210–213	15·80	3·02	43·32	1·01	35·20	98·35
66	213–216	6·80	2·68	48·78	1·16	39·20	98·62
67	216–219	10·72	2·72	46·23	0·93	37·68	98·28
68	219–222	14·44	4·08	43·25	1·10	34·52	97·39
69	222–225	26·80	8·00	33·38	1·55	26·80	96·43
70	225–226	15·52	5·16	41·56	1·31	33·40	96·95
71	226–229	10·92	2·84	46·23	0·94	37·28	98·21
72	229–232	4·84	2·24	50·10	0·97	41·20	99·35
73	232–235	4·64	1·32	50·80	0·82	41·52	99·10
74	235–238	12·68	3·64	44·73	0·96	37·12	98·13
75	238–241	10·20	3·44	46·05	0·81	37·48	97·98
76	241–245	7·72	3·76	47·59	1·04	37·84	97·65

The 55-foot face in the quarry is worked as a unit, the holes for the dynamite charges being drilled with electrically operated churn drills. Blasted stone is loaded into 10-ton, steel, side-dump cars by a $1\frac{3}{4}$-yard electric shovel mounted on traction wheels. The cars are hauled by a Plymouth gasoline locomotive to the foot of the incline leading to the primary crusher and are hauled up the incline by a cable hoist. The crushing plant has a capacity of 100 tons per hour. In 1929 the method of making Portland cement at the Hull plant was changed from the dry process to the wet process. One huge kiln, 374 feet long, 12 feet in outside diameter and having a capacity of 2,500 barrels of cement clinker per 24-

hour day, has replaced 10 small kilns. In addition to Portland cement, which constitutes the main product, crushed stone, agricultural limestone and asphalt filler are also marketed. The two latter products are made in a ball mill having an output of 1½ to 2 tons per hour.

A short distance south and east of the quarry of the Canada Cement Company is an abandoned quarry once worked for crushed stone. In it 23 feet of Trenton limestone is exposed above the water. The top 9 feet consists of thinly bedded, cherty limestone similar to the top 9 feet on the property of the Canada Cement Company. Beneath it to the level of the water is heavily bedded, comparatively pure limestone nearly free from chert.

Quarry of Napoléon Tremblay, Hull. This quarry is situated a short distance north of the Mountain road, about ½ mile due west of the quarry of the Canada Cement Company. The products are crushed stone, rubble for building purposes, and stone for use in acid towers in sulphite-pulp mills. The quarry is on higher land than is that of the Cement Company, but, as the dip of the strata is to the east at an angle of 5 degrees, both quarries are opened at about the same geological horizon in the Trenton formation. The quarry is 500 feet long (east and west), 400 feet wide, and 35 feet deep. However, owing to the strata being inclined, there is a thickness of 46 feet of beds exposed within the quarry as follows:—

2 feet—Soil.

13 feet—Medium-grained, brown, high-calcium limestone in beds 18 inches to 3 feet in thickness. A few nodules of black chert occur in the bottom 4 feet of this stone but there is very little in the upper 9 feet. Sample 13 was taken from the top 9 feet. The full thickness of these beds is seen only in the east end of the quarry.

12 feet—Thinly bedded, dark-coloured limestone, in part fine-grained and in part medium-grained, with interbeds of black shale and carrying many nodules and large platy masses of black chert.

14 feet—Medium-grained, brown limestone in beds up to 2 feet thick, containing a few large nodules of grey chert, and separated by films of black shale. This stone is quarried for use in pulp mills. Sample 13A represents this section.

7 feet—Fine-grained, brown limestone containing nodules of black chert in which are many crystals of pyrite. The bottom bed of this section is over 4 feet thick but is seamed with thin films of black shale, as, in fact, is all the stone of this district.

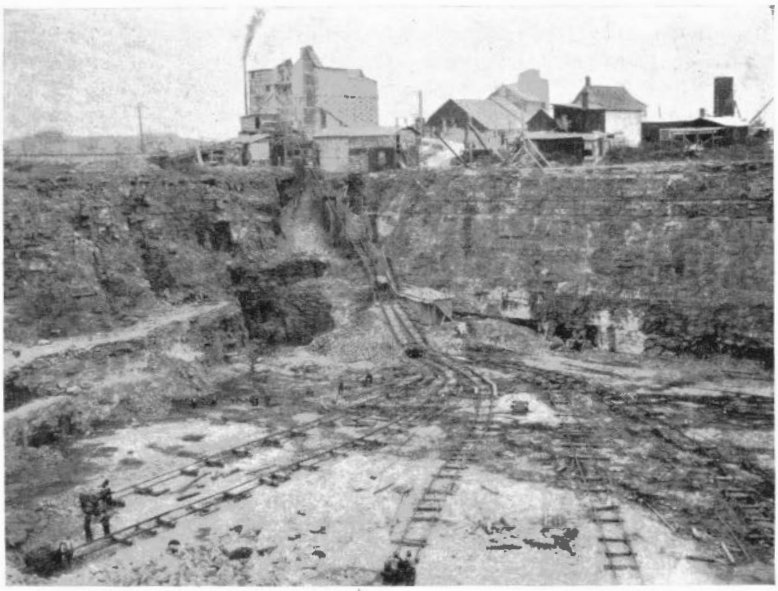
Jackhammers and dynamite are used in the quarry operations. Stone for shipment to pulp mills is loaded directly onto motor trucks which gain access to the quarry by a steep roadway. Trucks are used for transporting stone to the crushing plant at the brink of the quarry but the plant is also served by a stiff-leg derrick by which stone can be hoisted in skips and dumped into the primary crusher. The crushing plant is operated by steam and has a capacity of 20 tons per hour. Motor trucks transport the crushed stone to where it is to be used.

Three-quarters of a mile west of the Tremblay quarry, heavily bedded, pure, Trenton limestone is exposed in a low escarpment on both sides of the Mine road where at one time it has been quarried in small amount on the land of William Dennison on the west side of the road and north of the Hull cemetery.

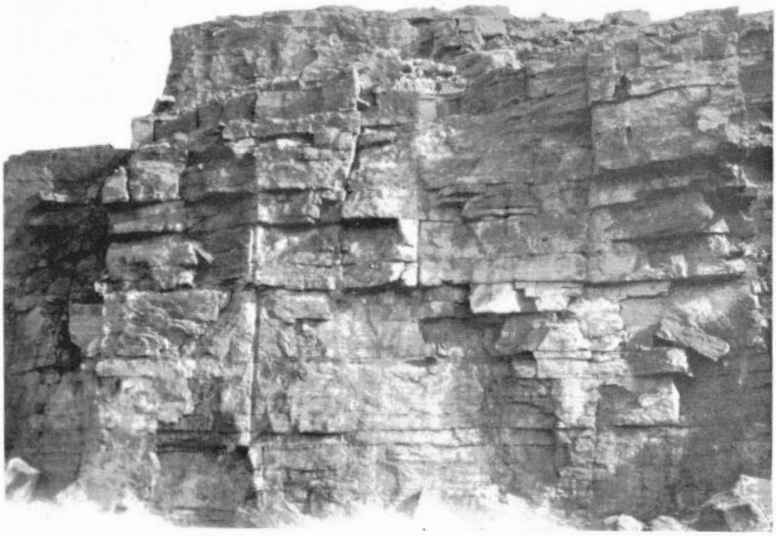
Val Tetreau

Thinly-bedded, rubbly, fine-grained, impure Trenton limestone is exposed in an abandoned quarry in the southwest side of a hill between

PLATE X



A. Quarry of Wright Crushed Stone Company, Ltd., Hull, Que.



B. Heavily bedded Trenton limestone in face of quarry of Canada Cement Company, at Hull, Que.

the Aylmer road and the tracks of the Hull Electric and Canadian Pacific railways. The strata here strike N. 32° W. and dip to the northeast at an angle of 15 degrees. At the base of the quarry some heavily bedded stone, in part fine-grained and in part medium-grained, is exposed and some fairly heavy beds containing chert are seen on the hill back of the quarry face. These again are overlain by thinly bedded limestone interbedded with shale, and in which chert nodules are conspicuous. The limestone is all of the calcium variety but is mostly siliceous.

Mountain Road

Very coarsely crystalline, but nevertheless compact, white Grenville dolomite, containing in places much serpentine and also graphite, mica, and various other impurities, occurs on what is known as the Dawson farm on the north side of the Mountain road, 2 miles in a straight line west of the Hull city limits. Outcrops of the dolomite are to be seen over a large area. In many of the outcrops the dolomite has a greenish colour due to admixture with serpentine, and there are also many intrusions of igneous rock in the deposit. By selective quarrying, however, white dolomite suitable for making white terrazzo chips and for making artificial stone could be obtained. When struck with a hammer some of the dolomite becomes faintly luminous. Sample 14X was taken from outcrops of the better grade stone.

A geological map[1] of this district shows this same belt of limestone to extend northerly for 3 miles from the Mountain road. Where it is crossed by the Mine road, 2 miles to the north, it consists in part of impure dolomite and in part of impure calcium limestone. The same geological map shows another prominent belt of Grenville limestone one-half mile west of the one just mentioned and trending parallel to it. This latter limestone belt is exposed at intervals for 2 miles in the escarpment along the Mountain road and is also seen on the Mine road to the north where, however, it is much narrower. The limestone appears to be all of the calcium type and though in places it is fairly pure, most of it contains masses and crystals of quartz, inclusions of feldspar, flakes of mica and graphite, as well as grains of serpentine. Like the belt to the east, this limestone belt also is intruded by pegmatite dykes and other igneous rocks.

Alcove

Beginning ¾ mile north of Alcove station on the Canadian Pacific railway, exposures of rather impure, coarse-grained, grey calcium limestone of the Grenville series are seen in cuttings and in knolls along the highway to Farrelton. Graphite, pyrite, quartz veins, mica and other silicate minerals are present in quantity in most of the limestone.

On the property of W. J. Mahon, 2½ miles north of Alcove, on the road to Farrelton, greyish white and pink calcium limestone composes the greater part of a broad ridge 100 feet or so high, just west of the highway and railway. Most of the limestone is very coarse-grained—the average grain size exceeding ½ inch. Parts of the deposit are nearly free from visible impurities excepting graphite, which occurs in tiny flakes, but in

[1] Geol. Surv., Canada, Map. No. 714.

other parts there are veins of quartz, large and small clusters of silicate minerals, and small crystals of pyrite. But on the whole the deposit is fairly pure and is in an excellent situation for quarrying. Sample 14 was taken across the top of the ridge and Sample 14A from the lower eastern slopes. In places the limestone weathers to a gravelly mass, but it is mostly compact and massively bedded.

A very coarse-grained, semi-translucent calcite associated with basic igneous rock is exposed a short distance from the road at the south end of lot 5, range IX, Wakefield township. Sample 14B was taken here. The relatively high content of silica is due to the presence of tiny grains of quartz between the large calcite crystals, many of which are over ½ inch in diameter.

Farrelton

Yellowish and grey, very coarse-grained calcium limestone of Grenville age, and in which are many flakes and grains of mica, graphite, quartz, feldspar, pyrite, and other minerals, and also inclusions of gneiss, is exposed along the Canadian Pacific railway a short distance south of Farrelton. The impurities are mostly concentrated in veins and bands leaving some few areas of fairly pure stone as is shown by the analysis of Sample 15 which was taken across 20 feet of what appeared to be the purest stone in the outcrop. The stone gives off a sulphurous odour when struck with a hammer, but on analysis no sulphur was found.

In the railway cutting 1 mile north of the village a similar limestone is exposed, but here bands of quartzite up to 3 feet thick are interbedded with the limestone, which, in addition, contains many grains of silicate minerals.

Low

Extensive deposits of coarse-grained Grenville limestone occur in this vicinity. Most of it, however, is much mixed with granite and with basic igneous rock, and much is full of small grains of silicate minerals and other impurities. At Paugan Falls some magnesian limestone was observed but most of the exposures there, as elsewhere in the district, are of the calcium type. For small-scale operations, hand-picked stone of good quality could be obtained from some of the deposits.

Kemmel

East of this station on the Canadian Pacific railway are many large outcrops of Grenville calcium limestone, but also some of dolomite and magnesian limestone.

On the property of Thos. McCombly, lots 6 and 7, range VI, Aylwin township, is a deposit of coarse-grained, bluish white, compact calcium limestone that has been burned for lime for local use. Large and small masses of mica schist and gneiss are present in the deposit (Plate I B, page 11) as well as disseminated grains of silicate minerals and flakes of graphite. Hand-sorting was necessary when the stone was quarried for making lime. Sample 16 was taken from the best grade of material available.

A deposit of interbanded dolomite and magnesian limestone of the Grenville series is exposed on lots 8 and 9, range V, Aylwin township.

The strike and dip of the deposit vary but the average strike is N. 15° W. and the dip is to the northeast at angles of 65 to 75 degrees. Both types of limestone are coarse-grained, and both contain graphite, pyrite, veins of quartz, flakes and grains of mica, and also grains of various silicates and inclusions of mica schist, but the dolomite is much darker and rougher on the weathered surface than is the magnesian limestone. The contact between the two types is very sharp as shown in Plate IA, page 11. Sample 16A was taken from a band of the magnesian limestone and Sample 16B from a band of the dolomite. These samples are representative of the best grade of stone available in the locality.

Kazabazua

Only impure Grenville calcium limestone was observed in this neighbourhood. On lots 14 to 18, range V, Aylwin township are very large exposures of coarse-grained, bluish white calcium limestone containing much pyrite and graphite in addition to siliceous impurities. On lot 17 a small quarry has been opened in a part of this deposit. Sample 17 taken here shows the stone to be siliceous.

Between these outcrops and the village, and also north of the village, most of the rock is covered by sand. On lots 38 and 39, range VIII, Aylwin township are outcrops of coarse-grained, greyish white, calcium limestone containing much quartz, quartzite and silicate minerals.

Gracefield

A great deal of coarse-grained, greyish and bluish white Grenville limestone is exposed near Gracefield station. It is intruded by granitic rocks and contains interbeds of quartzite as well as graphite, mica, and grains of various other minerals. At the quarry the limestone strikes N. 40° E. and dips southeasterly at an angle of 45 degrees. Some fairly pure stone could be obtained from these outcrops by hand-sorting.

Maniwaki

Many outcrops of Grenville limestone occur in the vicinity of the town but they are much intruded by and contain many inclusions of various igneous rocks. At the eastern edge of the town the Oblate Fathers formerly quarried stone for making lime from a deposit of coarse-grained, blue and white calcium limestone. Graphite, micaceous streaks, quartz veins, and inclusions of mica schist are present in the stone, in addition to small grains of various silicate minerals, and the stone for lime burning had to be hand-picked. It is said that the blue limestone made a better grade of lime than the white, though as shown by the analyses of Sample 18, representing the white stone, and of Sample 18A representing the blue stone, there is practically no difference in chemical composition between the two. These samples are of hand-picked material.

On top of the hill east of the railway station a deposit of similar limestone has been quarried on a small scale. The limestone here is interbedded with dark-coloured quartzite and is intruded by granitic rocks.

Analyses of Hull County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
10.....	0·55	0·23	0·20	0·05	98·15	0·52	99·70	Tr.	54·99	0·25	220 : 1
10A.....	1·00	0·26	0·26	0·04	95·77	2·07	99·40	Tr.	54·01	0·99	55 : 1
10B.....	1·44	0·62	0·92	n.d.	95·68	1·30	99·96	n.d.	53·58	0·62	86 : 1
10C.....	12·72	0·83	2·27	n.d.	80·86	2·01	98·69	n.d.	45·28	0·96	47 : 1
11.....	0·70	0·28	0·12	0·39	96·96	1·72	100·17	0·06	54·51	0·82	66 : 1
11A.....	1·06	0·25	0·01	0·26	96·37	2·21	100·16	0·05	54·11	1·05	52 : 1
11B.....	1·22	0·24	0·08	0·52	96·12	1·70	99·88	0·05	54·11	0·81	67 : 1
12.....	2·62	0·16	0·36	0·28	95·34	1·72	100·48	0·02	53·54	0·82	65 : 1
12A.....	12·98	0·54	1·14	0·22	83·14	0·53	98·55	0·09	46·68	0·25	187 : 1
12B.....	1·34	0·16	0·32	0·33	95·53	2·66	100·34	0·03	53·68	1·27	42 ; 1
12C.....	14·98	0·49	0·61	0·39	79·59	3·50	99·56	0·08	44·78	1·67	26 : 1
12D.....	8·50	0·87	0·67	0·44	85·46	3·80	99·74	0·52	48·10	1·82	26 : 1
13.....	0·80	0·19	0·23	0·28	92·55	6·21	100·26	Tr.	51·98	2·97	18 : 1
13A.....	1·57	0·23	0·29	n.d.	96·28	1·23	99·60	0·02	53·92	0·59	78 : 1
14X.....	2·73	0·31	0·16	n.d.	54·85	43·46	101·51	n.d.	30·72	20·88	1·47 : 1
14.....	3·12	0·29	0·19	0·07	94·57	1·60	99·84	0·07	53·00	0·76	70 : 1
14A.....	4·68	0·42	0·10	0·09	94·04	0·32	99·65	0·04	52·71	0·15	351 : 1
14B.....	2·40	0·33	0·16	0·07	93·79	1·70	98·45	Tr.	52·56	0·81	65 : 1
15.....	2·80	0·31	0·13	0·04	90·00	6·61	99·89	Nil	50·42	3·16	16 : 1
16.....	1·52	0·15	0·20	0·02	91·82	6·31	100·02	Tr.	51·43	3·02	17 : 1
16A.....	3·44	0·31	0·29	0·13	74·72	21·94	100·83	Nil	41·86	10·49	4 : 1
16B.....	5·34	0·41	0·34	0·02	53·64	42·26	102·01	Nil	30·05	20·21	1·48 : 1
17.....	11·94	1·16	1·05	0·11	82·91	1·95	99·12	0·46	46·49	0·93	50 : 1
18.....	1·64	0·13	0·23	0·04	96·50	1·05	99·59	Nil	54·06	0·50	108 : 1
18A.....	2·40	0·22	0·16	0·04	95·37	1·07	99·26	0·05	53·43	0·51	105 : 1

10. Aylmer. Medium-grained, greyish white limestone, on lot 21, range 1V, Hull township.
10A. " Dark grey, very fine-grained limestone underlying the above type of stone.
10B. " Fine-grained Chazy limestone on Klock road ½ mile north of the town.
10C. " Limestone from the same outcrop as Sample 10B but from a bed containing patches of brown-weathering siliceous material.
11. Hull. Wright Crushed Stone Co. property; 10 feet of pure limestone from the uppermost beds exposed.
11A. " Four feet of pure limestone in a band 19 feet from the top of the Wright Crushed Stone Co. quarry.
11B. " Nine feet of pure limestone from the lowest beds exposed in the above-mentioned quarry.
12. " Canada Cement Co. quarry; coarse-grained part of the upper beds in the quarry, which beds consist, in part, of coarse-grained and, in part, of fine-grained limestone.
12A. " Fine-grained part of the beds from which Sample 12 was taken.
12B. " Next 21 feet of stone in Canada Cement Co. quarry.
12C. " Next 11 feet of stone in same quarry.
12D. " Lowest 24 feet of stone exposed in the quarry face.
13. " Tremblay quarry; top 9 feet of stone in the east end of the quarry.
13A. " Tremblay quarry; 14 feet of nearly chert-free stone quarried for use in pulp mills.
14X. " White Grenville dolomite on lot 12, range V, Hull township, just north of the Mountain road.
14. Alcove. Top of ridge of limestone on property of W. J. Mahon, 2½ miles north of the village.
14A. " Lower eastern slope of same ridge from which Sample 14 was taken.
14B. " Very coarse-grained, calcite in deposit on south end of lot 5, range IX, Wakefield township.
15. Farrelton. Railway cutting a short distance south of the station.
16. Kemmel. Calcium limestone on property of Thos. McCombly, lots 6 and 7, range VI, Aylwin township.
16A. " Magnesian limestone on lots 8 and 9, range V, Aylwin township.
16B. " Dolomite in same deposit from which Sample 16A was taken.
17. Kazabazua. Quarry on lot 17, range V, Aylwin township.
18. Maniwaki. White Grenville limestone from small quarry at eastern edge of the town.
18A. " Blue Grenville limestone from the same quarry as Sample 18.

Joliette County

Limestones of Beekmantown, Chazy, Black River, and Trenton formations, comprising part of the belt of Ordovician limestone that extends parallel to and north of St. Lawrence river from Montreal to below Quebec, underlie a strip of country, 8 miles wide, extending across the southern part of the county, in a northeast-southwest direction. The greater part of this belt is composed of Trenton limestone, the other formations being exposed only in comparatively narrow strips along the northern edge of the belt. In and near the town of Joliette, the Trenton limestone has for many years been quarried for the manufacture of lime, crushed stone, and building stone. One of the largest lime plants in the province is in operation here (Plate IVA, page 28). The central and northern parts of the county are underlain entirely by Precambrian rocks, which include some small deposits of Grenville limestone, but none of commercial importance is known.

Joliette

On the east bank of L'Assomption river at Joliette a small quarry is worked for the production of lime, and from another nearby quarry building stone is produced. Two miles southwest of the town is the large limestone quarry and also the plant of the Standard Lime Company. A number of other quarries have been opened in the Trenton limestone in the vicinity of the town, but are not now being worked.

Quarry of Standard Lime Co., Ltd., Joliette. This large quarry is opened in the Trenton limestone 2 miles southwest of Joliette on the north side of the highway to Montreal and a short distance west of the Canadian National railway. The quarry (Plate XIA, page 73) is of the pit type and covers an area of 20 acres, and in it, beneath 2 to 7 feet of soil, the following section of limestone strata, totalling 64 feet in thickness and dipping at an angle of 5 degrees to the southeast, is exposed:—

6 feet—Medium-grained, brownish grey, high-calcium limestone in beds up to 18 inches thick. In the northern part of the quarry these beds have been removed by glaciation.

16 feet—Coarse-grained, grey, high-calcium limestone in beds up to 4 feet thick.

10 feet—Fine-grained, dark brownish grey, calcium limestone in beds of variable thicknesses, separated by partings of black shale, and generally containing many nodules of black chert.

12 feet—Coarse-grained, heavily bedded, grey, high-calcium limestone.

2 feet—Fine-grained, nearly black, siliceous, calcium limestone in thin beds separated by black shale partings.

12 feet—Medium-grained, brownish grey, calcium limestone in beds up to 4 feet thick.

6 feet—Fine-grained, nearly black, siliceous, calcium limestone in thin beds separated by partings of black shale. This is seen only in a pit in the floor of the quarry.

As shown by the above generalized section, the deposit consists of alternate bands of pure and of rather impure stone. These bands do not maintain their relative thicknesses around the face of the extensive quarry, but thicken and thin in an irregular manner. Thus the above section only shows approximately the relative thicknesses of the two types of stone available. Nodules of hard, black chert are characteristic of the band of fine-grained, dark stone beneath the top medium- to coarse-grained

PLATE XI

A. Quarry of Standard Lime Company, Ltd., in Trenton limestone at Joliette.

B. Upper levels of quarry of Standard Lime Company, where stone for making lime is quarried.

pure stone, and, in parts of the quarry, chert occurs in small quantity through nearly all the stone, but in other parts it is practically absent. The pure chert-free stone from the zones of medium- and coarse-grained limestone is used for making lime and for shipment to pulp mills, and the less pure stone is utilized for crushed stone. Sample 84 represents the upper 55 feet of limestone in an area nearly free from chert. Sample 84A is from the same thickness of beds in an area where chert is plentiful, but the chert nodules themselves were not included in the sample. Sample 84B is a composite sample of the bands of chert-free, medium-grained and coarse-grained limestone used for making lime. Sample 84C is a composite sample representative of all the bands of fine-grained, dark-coloured limestone. The company states that the analysis of the 12-foot zone of medium-grained, brownish grey limestone beneath the 2-foot zone of nearly black, siliceous limestone is as follows:—

	Per cent
Insoluble	2·37
Ferric oxide	0·16
Alumina	0·35
Phosphorus pentoxide	0·05
Sulphur trioxide	0·06
Calcium oxide	53·56
Magnesium oxide	1·24
Loss on ignition	42·88
	100·67

This band occurs just above the floor of the quarry. It is sometimes quarried separately for making lime.

The method of quarrying is as follows: the overburden, consisting of 2 to 7 feet of soil, is removed by steam shovel and loaded into motor trucks for conveyance to waste dumps. The pure limestone at the top of the quarry face is quarried separately for making lime, and is usually worked in two benches, each 6 to 10 feet in height, the drilling being done with jackhammers. Narrow gauge tramways are laid along each face and steel, side-dump cars, holding 2½ tons each, are spotted at close intervals along the tracks and loaded by hand with selected stone to be taken to the lime plant (Plate XIB, page 73). The remainder of the quarry face is generally worked in one bench, and electric churn drills are used for drilling. The stone is loaded by steam and electric shovels to 5-ton wooden, side-dump cars, running on a narrow-gauge track which partly encircles the quarry floor. The cars are taken by a locomotive to the foot of the incline leading to the surface, up which they are hauled by an electric hoist. Another locomotive pulls the train of cars to the crushing plant, which is situated adjacent to the lime plant, ¾-mile northeast of the quarry on the road to Joliette.

The lime plant consists of 20 vertical, externally fired, continuous steel kilns in which coal is used for fuel, and which have a combined capacity of 200 tons of lime per 24 hours. A grey lime is produced. Part of the production is marketed as quicklime, which is sold in bulk or in steel drums, and part is hydrated in a Kritzer continuous hydrator run in conjunction with a Raymond mill. Hydrated lime is sold in 50-pound, multi-walled bags. "Limo" is the registered trade name for the lime products marketed by this company.

The crushed stone plant has a capacity of 100 tons of crushed stone per hour. Screenings from this plant are further processed in a Jeffrey hammer mill and sold for agricultural purposes. Pulverized chemical limestone, ground so that all passes a 150-mesh screen, is prepared in 4 Bonnot ball mills. The limestone used for this purpose is the pure variety. It is crushed and dried before being fed to the ball mills. Asphalt filler, ground so that 85 per cent passes a 200-mesh screen, is also made at this plant.

A siding from the Canadian National railway serves both the lime and crushed stone plants, and connections with the Canadian Pacific railway are made at Joliette.

Quarry of Arnaud & Beaudry, Joliette. Stone for making lime in 2 small field kilns is obtained by Messrs. Arnaud & Beaudry from a quarry on the east bank of L'Assomption river, just below the bridge on Boulevard Querbes, in the town of Joliette. In this quarry, which is of the sidehill type, the top 13 feet of stone is medium-grained, grey blue, fossiliferous, high-calcium limestone in rather irregular beds up to 3 feet in thickness. Underlying this is 7 to 9 feet of fine-grained, dark brownish grey, calcium limestone in beds 4 to 10 inches thick, separated by partings of black shale. Nodules of hard, black chert occur plentifully throughout these lower beds. Beneath the cherty stone is seen 6 feet of medium- to coarse-grained, grey limestone in beds up to 2 feet thick, in which chert is practically absent. Sample 85 was taken from the top 13 feet of pure stone, and Sample 85A from 7 feet of cherty stone beneath, but none of the chert nodules were included. All strata in this quarry dip to the southeast at an angle of 5 degrees. Very little lime has been made in these kilns within the past few years and consequently the quarry is worked only occasionally and then only on a very small scale.

South of the Arnaud & Beaudry quarry and practically continuous with it is a quarry from which the ashlar and cut stone for the nearby St. Charles school building were obtained. Practically the same succession of strata is visible here. Sample 85B represents the entire 25-foot face.

Quarry of J. P. Beaudry, Joliette. On the same side of L'Assomption river but on the opposite side of Boulevard Querbes from the quarries just mentioned, J. Pitro Beaudry is engaged in quarrying building stone. The quarry extends for 300 feet along the river bank and has been worked back for a maximum of 100 feet from the river. Soil covers the limestone to depths of 3 to 10 feet near the river and increases in depth away from the river. Some of the same strata as are exposed in the other quarries are visible here, but, on account of the southeasterly dip at an angle of 5 degrees, only 5 to 7 feet of the medium-grained, heavily bedded stone overlying the cherty beds is available and it is from this medium-grained stone that the building stone is being quarried. The complete section exposed in the quarry and in the river bank is as follows:—

3 to 10 feet—Sandy soil.
5 to 7 feet—Medium-grained, heavily bedded, grey-blue, high-calcium limestone quarried for building stone.
9 feet— Fine-grained, dark-grey, calcium limestone in beds of variable thickness (4 to 10 inches) separated by partings of black shale, and in which nodules of black chert are commonly present.

9 feet—	Medium-grained, grey, high-calcium limestone in beds up to 30 inches thick.
10 feet—	Thinly bedded, fine-grained, dark grey calcium limestone, with interbeds of shale, to river level.

The production of building stone from this quarry is small and is entirely dependent on local demand. Aside from hand derricks there is no mechanical equipment employed in this or in the other nearby quarries.

Across the river from the Arnaud & Beaudry quarry a small quantity of limestone was also quarried at one time for crushed stone.

North and east of Joliette town is an area over which the soil is thin and where outcrops of limestone are frequent. About three-quarters of a mile east of the town near the Canadian Pacific railway track is a water-filled quarry formerly worked by the Joliette Stone Quarry Co. Two miles northeast of Joliette a small quarry was at one time worked in the Trenton limestone to obtain stone for making lime. Howells Fréchette[1] describes the limestone in this quarry as follows:

About six feet of strata are exposed in a long, narrow quarry, consisting of thin beds of brownish grey, fine- to medium-grained limestone carrying very little shale. The following is an average sample:—

	Per cent
Insoluble mineral matter	1·62
Ferric oxide	0·19
Alumina	0·09
Calcium carbonate	96·34
Magnesium carbonate	1·25

North and northwest of Joliette, impure dolomite and magnesian limestone of Beekmantown age are exposed in several localities in the bed of L'Assomption river.

Four miles southwest of Joliette along the highway to Montreal, medium-grained, grey, high-calcium Trenton limestone, similar to that in the top beds of the Standard Lime Co. quarry, is exposed in the banks of a small brook on the west boundary of the county a few hundred yards east of the Ouareau river. Beneath the pure stone, as seen near the highway bridge, is fine-grained, dark, cherty limestone.

Ste. Elizabeth

Three miles due south of this village several small quarries have been opened in the Trenton limestone to obtain stone for local buildings, for lime, and for road metal. The limestone is medium-grained to fine-grained, bluish grey, rather thinly bedded and is in level beds. Overburden varies from 1 to 3 feet. Sample 86 was taken from 10 feet of stone exposed in a quarry, 200 feet long and 100 feet wide on the property of Ephrem Lavallée on the south side of Chaloupe river. On the opposite side of the road is a small quarry on land owned by Mme Guilbault.

On the east side road going south from Ste. Elizabeth, about ¾ mile north of Chaloupe river, is a small quarry occasionally worked by *Guilbault Frères* to obtain aggregate for making pre-cast concrete blocks. The limestone is fine- to medium-grained, bluish grey in colour, and is traversed by irregular seams of shale, but definite parting planes are widely spaced. Very little soil covers the limestone in this vicinity.

[1] Mines Branch Sum. Rept. 1916, p. 52.

Trenton limestone is also exposed in the bed of the Bayonne river from a point 1½ miles east of Ste. Elizabeth to the boundary of Berthier county and beyond, but it is everywhere covered by a thick mantle of soil and much stripping would have to precede any quarry operations in this territory.

Three miles east of Ste. Elizabeth, on the south side of the Bayonne river, on the farms of Onésime Richard and Louis Olivier, is a low ridge of impure, magnesian limestone (Chazy?) from which a small quantity has been quarried for road metal. The top 4 feet of this ridge consists of hard, very fine-grained, grey-blue, magnesian limestone. Beneath this is a zone in which are lenses 2 to 19 inches thick of extremely coarse-grained, black magnesian limestone, and at the base is sandy, brownish grey, magnesian limestone which, in places, is more of a calcareous sandstone than a limestone. Sample 87 is from the top 4 feet of the face. Sample 87A represents the extremely coarse-grained, magnesian material that occurs in lenses. Sample 87B represents the purest type of sandy limestone at the base.

Analyses of Joliette County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	CaO_3	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
84.....	1·50	0·28	0·39	0·22	96·66	1·68	100·73	0·08	54·25	0·80	68 : 1
84A.....	2·00	0·53	0·27	0·42	94·66	0·50	98·38	0·12	53·24	0·24	222 : 1
84B.....	0·64	0·18	0·21	0·15	98·05	0·97	100·20	0·05	54·99	0·46	120 : 1
84C.....	4·18	0·38	1·02	0·09	91·66	2·39	99·72	0·12	51·38	1·14	45 : 1
85.....	0·52	0·27	0·15	0·22	98·70	0·29	100·15	0·16	55·39	0·14	395 : 1
85A.....	1·90	0·68	0·78	0·22	94·89	0·92	99·39	0·07	53·26	0·44	121 : 1
85B.....	1·14	0·25	0·26	0·39	96·50	0·82	99·36	0·05	54·25	0·39	139 : 1
86.....	0·93	0·49	0·94	0·24	95·89	1·01	99·50	0·08	53·83	0·48	112 : 1
87.....	7·94	1·67	0·81	n.d.	56·18	33·76	100·36	n.d.	31·47	16·14	1·95 : 1
87A.....	5·00	0·15	1·13	n.d.	62·61	30·55	99·44	n.d.	35·08	14·62	2·4 : 1
87B.....	12·75	0·99	0·81	n.d.	68·36	15·72	98·63	n.d.	38·29	7·52	5 : 1

84.	Joliette.	Quarry of Standard Lime Co., Ltd., top 55 feet of strata in part of quarry nearly free from chert.
84A.	"	Same quarry, top 55 feet of strata in part where chert is plentiful, but no chert is included in the sample.
84B.	"	Same quarry, composite sample of medium-grained and coarse-grained limestone used for making lime.
84C.	"	Same quarry, composite sample of all fine-grained bands in the quarry.
85.	"	Arnaud & Beaudry quarry, top 13 feet of medium-grained stone used for lime.
85A.	"	Same quarry, 7 feet of fine-grained, dark-coloured cherty stone beneath, but excluding the chert nodules.
85B.	"	Clercs St. Viateur quarry, entire 25-foot face.
86.	Ste. Elizabeth.	Ten-foot face in quarry 3 miles south of the village, on land of Ephrem Lavallée.
87.	"	Top 4 feet of ridge of impure magnesian limestone on properties of O. Richard and L. Olivier, 3 miles east of Ste. Elizabeth.
87A.	"	Lenses of extremely coarse-grained material in same ridge.
87B.	"	Purest type of sandy limestone at the base of the ridge.

Labelle County

This county, which lies directly north of Papineau county, is underlain entirely by Precambrian rocks in which deposits of Grenville limestones are numerous, though the majority are too far removed from means of

transportation to be of economic value at the present time. Deposits of both dolomitic and calcium limestone occur, but judging from those examined, the dolomitic deposits predominate. Also all deposits seen contained many impurities.

Quarries have been worked at several places to obtain stone for making lime for local use. At L'Annonciation a white dolomite is quarried and marketed in the form of granules and in pulverized condition for various uses, but particularly for use in the glass industry.

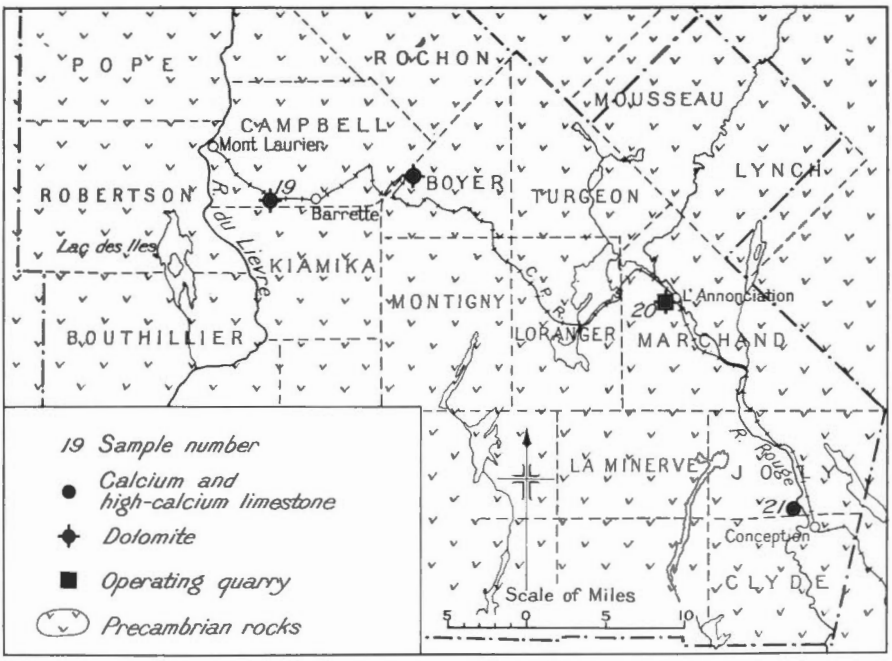


Figure 8. Map showing location of limestone deposits sampled in Labelle county.

Barrette

Along the highway and the railway (Canadian Pacific) in the vicinity of Barrette, coarsely crystalline, white dolomite is exposed in several places, but most of it is siliceous. Sample 19 consisted of several large pieces of white dolomite sent to the Mines Branch and said to have come from an outcrop along the highway 2 miles northwest of Barrette. The Department of Development, Canadian Pacific Railway Company, kindly supplied the following analysis of a sample taken from a deposit on lot 1, range B, Campbell township, 200 yards southeast of the railway.

	Per cent
Silica	7·70
Ferric oxide	Tr.
Alumina	0·80
Calcium oxide	34·50
Magnesium oxide	22·70
Loss on ignition	34·20
	99·90

Guenette

Dr. F. F. Osborne of McGill University informs the writer that a small quantity of stone for monuments was quarried by Henri Provencher in 1931 from a deposit of very coarse-grained, white dolomite, containing mica and scapolite, on lot 21, range VII, Boyer township, about ½ mile southeast of Guenette. The dolomite proved to be too coarsely crystalline for this purpose.

L'Annonciation

Quarry of Canada Marble & Lime Co., 630 Cathcart St., Montreal. This company is quarrying a deposit of white dolomitic Grenville limestone on lot 40, range III, Marchand township, 1 mile southeast of L'Annonciation, but 2 miles by road from the station on the Canadian Pacific railway (Mont Laurier Branch). The dolomite is marketed in a crushed state for use in the glass industry, for the making of artificial stone and for terrazzo, stucco dash, and poultry grit. The dolomite occurs in a belt striking approximately N.15°W. along the hillside southwest of a small brook and dips into the hillside at an angle of 65 degrees. It is all much fractured (Plate XIIA, page 80) and is invaded by tongues of syenite and by at least one dyke of basic-appearing igneous rock. Impurities include serpentine, white diopside, bluish scapolite, and minor quantities of graphite, mica, and chondrodite. The purest rock is bluish white but where serpentine is present in quantity, as it is in much of the dolomite, greenish and pale brown tints prevail. The grain varies from fine to coarse.

Two sidehill quarries, each about 75 feet in diameter, and with 40-foot faces, have been opened in the dolomite at the foot of the ridge—one on either side of the mill building. A third quarry is opened higher up on the ridge about 200 feet from the mill. The dolomite appears to extend for 600 feet or so back on the hillside after which only syenite is seen, and near it the dolomite is very impure.

Jackhammers and dynamite are employed in quarrying. The broken rock is loaded into small tram cars which are pushed by hand over narrow gauge tracks to the mill. Cobbing is necessary to eliminate the more obvious impurities such as serpentine, diopside, and scapolite, but even with careful cobbing the rock sent to the mill is rather siliceous as is shown by the analyses of Samples 20 and 20A representative, respectively, of the average grade of rock available in the two lower quarries, and of the pulverized material as shipped.

The mill is situated on the flat land at the foot of the ridge and is between the two lower quarries. Power for the air compressor and for the crushers, elevators, and screens is obtained from a 60 h.p. gasoline engine. All the rock is crushed and screened and sacked in 100-pound jute bags. The particle size of the products marketed ranges from ¼-inch material for terrazzo, down to material all passing a 40-mesh screen and used for interior stucco. Motor trucks are used for hauling the output to the station.

La Conception

In the vicinity of this village, impure Grenville limestone is exposed in several places along the highway. Dr. F. F. Osborne, of McGill University, engaged in making a geological study of the area north of La Conception

A. Face of Precambrian limestone in quarry of Canada Marble and Lime Company at L'Annonciation, Labelle county.

B. Weathered surface of limestone conglomerate near Beaulieu on the island of Orleans.

for the Quebec Bureau of Mines, kindly supplied the following information on certain of these outcrops.

Grey, coarse-grained limestone containing much pyroxene and other silicates, as well as some graphite, is exposed in a road cut 2¾ miles north of the bridge at La Conception and near mile post 95 of the highway. It strikes N. 70° W. (astronomic) and dips 70° S. Three-tenths of a mile south there is quite an extensive outcrop on the north side of the road, but also impure. At another three-tenths of a mile south there is another extensive outcrop of impure limestone also on the north side of the road. One and a half miles north of the village, granulite forms bluffs close to the river, and the limestone band appears to underlie the sand plain north of Rouge river. The band then appears on the east bank of the Rouge, then swings south and appears on the east side of the highway. The last outcrop of this band observed was 5 miles below La Conception, along the highway. Limestone of similar character is also exposed in road cuts near Duhamel.

In connection with the above notes Dr. Osborne states that they are the result of a hasty inspection of the limestone band and it is possible that more detailed work will result in the finding of limestone of better grade in this belt.

Sample 21, the analysis of which is given below, consisted of a number of fragments collected by Dr. Osborne of McGill University, and by L. H. Cole of the Mines Branch, from the several outcrops of this limestone along the highway north of La Conception.

Labelle

Deposits of Grenville limestone are reported to occur in the neighbourhood of the village of Labelle but no further information is available concerning these limestones at the time of writing.

Analyses of Labelle County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	CaO	MgO	Loss on ignition	Total	S
19	8·75	0·26	0·92	n.d.	30·45	19·81	39·43	99·62	Tr.
20	7·94	0·35	0·40	0·01	31·33	20·18	39·62	99·83	Tr.
20A	5·96	0·12	0·30	0·02	31·46	20·03	41·82	99·71	Nil
21	17·80	0·85	2·95	0·04	44·34	0·60	35·42	102·00	0·24

19. Barrette. Outcrop on Mont Laurier highway 2 miles northwest of the village.
20. L'Annonciation. Quarry of Canada Marble & Lime Co.
20A. " Pulverized material shipped from the quarry of Canada Marble & Lime Co.
21. La Conception. Outcrops on Mont Laurier highway north of the village.

L'Assomption County

The greater part of this county lies in the St. Lawrence plain and is underlain by limestones of the Beekmantown, Chazy, Black River, and Trenton formations comprising part of the limestone belt that parallels the north shore of the St. Lawrence river west of Montreal to below Quebec. The general dip of the limestone is to the southeast at a low angle and in the southeastern corner of the county it is overlain by Utica shale. Soil is deep over most of the limestone area and there are few outcrops. Small

amounts of limestone have been quarried for local use, but there are no quarries in operation at the present time.

Laurentides (St. Lin)

Medium-grained, high-calcium limestone of either Trenton or Black River age is exposed in the bed and banks of the Achigan river for a distance of 1 mile below the village, but overlying it is 15 to 40 feet of soil. Small quantities of stone have been quarried from the river bed for the making of lime, but large-scale quarrying is out of the question. Sample 81 was taken from a 10-foot face of the limestone. In places there is as much as 15 feet of rather heavily bedded limestone visible. The dip is to the south-east at a low angle.

Two and one-half miles due west of Laurentides, on the farm of Ubald Hogue, impure, fine-grained magnesian limestone of the Beekmantown formation has been quarried for foundation stone. In all about 8 feet of flat-lying beds from a few inches to over 1 foot in individual thickness is exposed. On fresh fracture the stone is blue-grey but it weathers to a drab-brown. Sample 80 represents the 8 feet of strata.

In the valley of a creek ½ mile northeast of the Hogue quarry is a small deposit of pink, high-calcium Chazy limestone resting directly on igneous rock. The pink colour is due to many crystals of pink calcite that are seemingly fragmentary fossil remains. It is similar to the bed of red Chazy limestone at Cap St. Martin in the Montreal district (page 120).

St. Roch L'Achigan

Trenton limestone is exposed in the bed of Achigan river beneath the bridge at St. Roch, but the depth of soil is too great to permit of any quarry operations.

L'Epiphanie

In the bed of Achigan river at this village, the thinly bedded, shaly limestone at the top of the Trenton formation is exposed beneath 6 to 10 feet of soil. The limestone is dark grey with a brownish cast, very fine-grained and occurs in beds up to 6 inches thick with layers of shale between. Sample 82 is from the lower limestone beds exposed and no shale is included.

Analyses of L'Assomption County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
80.....	12·10	1·48	2·00	0·11	66·57	17·28	99·54	0·27	37·34	8·26	4·5 : 1
81.....	0·85	0·20	0·32	0·28	97·10	0·86	99·61	0·03	54·54	0·41	133 : 1
82.....	7·66	0·67	2·23	0·15	87·14	1·74	99·59	0·13	48·88	0·83	59 : 1

80. Laurentides. Quarry on land of Ubald Hogue.
81. " Bank of Achigan river below the village.
82. L'Ephiphanie. Bed of Achigan river at the village.

Maskinongé County

Beekmantown, Chazy, and Trenton limestones that form part of the limestone band paralleling the north shore of St. Lawrence river from Montreal to Quebec, underlie a strip of country about 2½ miles in width extending northeasterly across the county just south of St. Justin and Ste. Ursule. To the northwest are the Precambrian rocks, and to the southeast the Utica shale overlies the limestone. Soil is very thick over most of the limestone area and but few exposures are to be seen. Small deposits of Precambrian limestone of the Grenville series are reported to occur near Hunterstown in the township of the same name, and impure limestone of the same age is stated[1] to occur on Lacroix creek. No quarries are in steady operation in this county, though stone for roads has been quarried at St. Justin and also south of Ste. Ursule.

St. Justin

One mile southwest of the village, dense-textured, dark brownish grey, thinly bedded Trenton limestone is exposed in two small quarries that have not been worked for many years. Sample 90 was taken from the stone exposed.

Ste. Ursule

Very hard, brittle, very fine-grained, dark blue Trenton limestone, in beds 6 to 8 inches thick with thin shale partings between, is exposed in the bed of Petite Rivière du Loup south of the village of Ste. Ursule. About ½ mile below the village, stone of this character is quarried occasionally by Joseph St. Louis and crushed in a small gyratory crusher run by water power. Sample 91 was taken from 4 feet of strata exposed in the bed of the river. Soil covers the country to a depth of 30 feet or more except on the east bank of the river where there is a small area over which the overburden does not exceed 10 feet. The beds dip southwesterly at an angle of 3 degrees. When freshly fractured the stone smells of petroleum.

Analyses of Maskinongé County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
90.....	7·93	0·89	2·78	0·20	84·71	2·35	98·86	0·17	47·55	1·12	42 : 1
91.....	7·26	0·66	2·98	0·28	84·99	2·75	98·92	0·13	47·74	1·31	36 : 1

90. St. Justin. Small quarry 1 mile southwest of village.
91. Ste. Ursule. Limestone in river bed ½ mile south of village.

[1] Geol. Surv., Canada, Rept. Progress 1892-93, p. 47A.

Montcalm County

The southern part of this county lies in the St. Lawrence plain and is crossed by the belt of Ordovician limestones that parallels the north shore of the St. Lawrence from Montreal to below Quebec city. Limestones of Beekmantown, Chazy, Black River, and Trenton ages compose this belt but over most of the county these limestones are deeply covered by soil and exposures were seen only in the river valleys. The remainder of the county is underlain by Precambrian rocks in which deposits of highly metamorphosed Grenville limestone occur, but the majority of these deposits are far removed from means of transportation. No quarries are in operation in this county.

St. Liguori

Flat-lying beds of sandy Beekmantown dolomite are exposed in the bed of Ouareau river at this village, but are in a poor position for quarrying. Away from the river the rock is deeply covered by soil.

Rawdon

A narrow band of metamorphosed Grenville limestone striking north and south passes through the village of Rawdon. Small amounts have been quarried in several places for making lime for local use, but inclusions of other rocks and various impurities are so numerous throughout the band that large-scale quarrying of limestone of uniform quality would be extremely difficult and the deposits are of little commercial value. No sample was taken for analysis but the limestone is apparently all of the calcium type.

Les Dalles

A particularly good section of the Black River and Trenton limestones that compose part of the limestone belt paralleling the north shore of the St. Lawrence river from Montreal to below Quebec city, is exposed in the banks of Ouareau river where the road between St. Jacques and Joliette crosses. The river here has cut a gorge 40 feet deep through the limestone and overlying soil. The strata dip to the southeast at an angle somewhat steeper than the gradient of the river and thus successively higher beds are exposed downstream. According to Dr. Parks[1], 189 feet of strata are here exposed of which the basal 59 feet belong to the Black River formation, and the remainder to the Trenton.

The Black River limestone is all fine-grained, brownish blue in colour, and is rather thinly bedded; near the base of the section several sandy magnesian beds occur, but elsewhere the stone is all of the calcium type.

The Trenton limestone is fine- to medium-grained, brownish to bluish grey, is mostly thin-bedded, and certain zones are cherty.

Sample 83 was taken from the 40 feet of stone (mostly Trenton) exposed in the vicinity of the road bridge. In most places away from the immediate channel of the river the limestone is covered with 10 to 30 feet of sandy soil, but below the bridge and on the east side of the river a small quarry could be opened without having to remove an unduly large amount of overburden. However, similar stone in a much more favourable position for quarrying is available a few miles to the eastward.

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[1] Parks, W. A.: Ann. Rept. Quebec Bur. Mines 1930, Part D, pp. 19-21 (1931).

Analysis of Montcalm County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
83.....	2·28	0·49	0·88	0·09	94·20	2·00	99·94	0·09	52·80	0·95	55 : 1

83. Les Dalles. Gorge of Ouareau river at the bridge on the St. Jacques-Joliette road.

Montmorency County

The belt of Ordovician limestone and shale that extends along the north shore of the St. Lawrence from the Montreal district, terminates in Montmorency county a few miles below St. Joachim. In this county the overlying Utica shale covers most of the limestone and is itself in direct contact with the Precambrian rocks in many places, but at Chateau Richer, and north of Ste. Anne de Beaupré and St. Joachim, the Trenton limestone is exposed along the Precambrian hillsides. A small part of another area of Trenton limestone that lies mostly in the adjoining county of Quebec, extends for a short distance into Montmorency county at Montmorency Falls. The limestone, wherever seen, is of the calcium type and for the most part is hard, tough, and rather siliceous. Quarries for crushed stone, rubble, and rough building stone are operated at Chateau Richer and near St. Joachim. Lime is made occasionally from the limestone near St. Joachim and formerly was made at Chateau Richer in small field kilns.

On the island of Orleans, which is part of Montmorency county, are several bands of limestone conglomerate, one of which is being quarried.

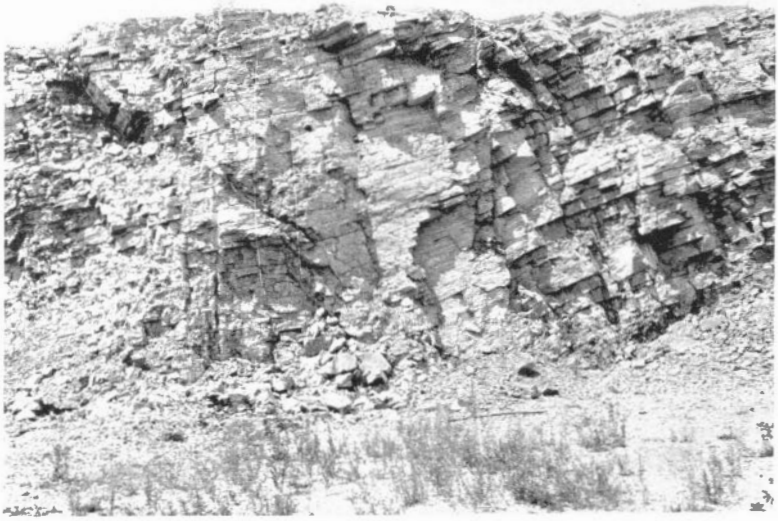
Reports of the Geological Survey state that there are three narrow bands of Grenville limestone (Precambrian) in this county: (1) at the falls of St. Féréol on Ste. Anne river[1]; (2) in a band extending from Cap Tourmente to the parish of St. Tite[2]; (3) at Chateau Richer.[3]

Chateau Richer

The quarries at Chateau Richer are adjacent to the shore of the St. Lawrence river and have supplied stone for buildings and fortifications in Quebec and Levis since the early days of the settlement of the country. They have been opened in an escarpment of thinly bedded, hard, tough, siliceous, dark brownish blue, grey-weathering calcium limestone that faces the

[1] Geol. Surv., Canada, Geology of Canada (1863), p. 46.
[2] Geol. Surv., Canada, Rept. Prog. 1885, Pt. A, p. 54.
[3] Geol. Surv., Canada, Rept. Prog. 1890-91, Pt. L, p. 21.

A. Thinly bedded and faulted Trenton limestone in quarry of E. L. Gravel, Chateau Richer, Montmorency county.



B. Evenly bedded Trenton limestone in quarry of A. A. Baker, Chateau Richer, Montmorency county.

river and rises steeply to a height of 150 feet. The highway and the electric railway of the Quebec Railway, Light and Power Company pass along the foot of this cliff. As shown in Plate XIIIA, page 86, the limestone in places is faulted and folded, but in many other places it lies nearly horizontally. It is exposed for about 1 mile along the shore of St. Lawrence river, beginning at Premont brook in the western end of Chateau Richer and terminating at Sault à la Puce river in the eastern part of the village. It extends back over a plateau about ¾ mile from the shore, beyond which are steep hills of granitic rocks. Southwestward from Premont brook for over 3 miles, exposures of limestone are to be seen in the beds of brooks at a distance of ¾ to 1 mile back from St. Lawrence river, but shale overlies the limestone between these exposures and the St. Lawrence. The lowest beds of the limestone near the contact with the Precambrian are fairly pure, but there is a progressive increase in impurities toward the top of the formation.

Three quarries are at present worked in the village and yield mainly crushed stone, with smaller quantities of rubble for building purposes, and riprap for breakwater construction. Fines from the crushing plants are marketed for agricultural use. The stone has also been made into lime for local use. Shipment of the products may be made by boat, railway, or motor truck. All the quarries are of the side-hill type and are self-draining.

Quarry of Théodore Lacouline, Chateau Richer. This quarry is situated near the western end of the village and is also at the western end of the limestone escarpment; westward from here the cliff face consists of shale. The quarry is about 200 feet square, and a face 80 feet in height is worked in a series of 20-foot benches. The floor being about 40 feet above the highway, access to the quarry is gained by a roadway, 200 feet in length, cut through a very shaly limestone that here forms the face of the cliff. This shaly limestone is separated from the rock quarried by a fault plane trending N. 40° E. and dipping at an angle of 20 degrees to the southeast. The limestone in the quarry proper strikes N. 30° W. and dips to the west at an angle of 4 degrees. It consists of fine-grained, dark brownish blue limestone in beds 2 to 5 inches thick with an occasional bed of 8 inches. Partings of hard, black shale occur between the beds. Overburden consists of 1 to 2 feet of soil and 15 feet of shaly limestone, which is removed prior to quarrying the desirable stone beneath. The stone is very similar to that in the lower face of the Gravel quarry as is indicated by the analysis of Sample 121 which represents the lower part of the face.

Jackhammers are used in quarrying. The broken stone is loaded by hand into motor trucks and taken to the crushing plant across the highway. The capacity of the plant is 300 tons per day.

Just west of the Lacouline quarry a small quarry was formerly worked in the shaly limestone forming the face of the cliff. An analysis of this shaly stone published in Mines Branch Summary Report for 1916, page 59, is as follows:

	Per cent
Insoluble	18·64
Ferric oxide	1·24
Alumina	0·38
Calcium carbonate	74·54
Magnesium carbonate	3·21
	98·01

Quarry of E. L. Gravel, Chateau Richer. The Gravel quarry is situated just behind the village church and is about ⅓ mile east of the Lacouline quarry. It covers an area 600 feet square and the face is about 100 feet in height and will increase as the quarry is worked farther into the cliff. The back of the quarry at present is a fault plane striking east and west and dipping southerly at an angle of 50 degrees. The floor is slightly above the level of the highway and is gently domed. All the stone is fine-grained, hard, dark brownish grey and in thin, even beds with partings of hard, black shale. As shown in Plate XIII A, page 86, the strata are much faulted. A general section of the quarry face is as follows:

2 feet—Soil.
24 feet—Beds 2 to 4 inches thick.
18 feet—Beds 6, 8, and 9 inches thick predominating.
44 feet—Beds 2 to 4 inches thick.
10 feet—Beds 4 to 16 inches thick (seen in pit in floor of quarry).

Sample 122 represents the top 24 feet; Sample 122A, the next 18 feet; and Sample 122 B, the 54 feet of strata comprising the lower part of the quarry face.

The quarry is worked in 20-foot benches with the aid of jack-hammers. Stone from the upper levels is taken by motor truck to the crushing plant, which is situated on the floor of the quarry, and that from the bottom faces is transported in horse-drawn dump carts. At present the 6-, 8-, and 9-inch beds of the upper level are being quarried for use as rough building stone for retaining walls and foundations. The crushing plant has a daily capacity of 250 tons.

Quarry worked by A. A. Baker, Chateau Richer. This quarry, formerly known as Chateau Richer Quarry, Ltd., is at the eastern end of the limestone area a short distance west of Sault à la Puce river, and is owned by A. J. Turner of Chateau Richer. It is opened near the top of the steep escarpment of limestone facing the St. Lawrence river, the floor being 90 feet or so above the highway. It is reached by a steep roadway up the side of the cliff. The quarry extends 800 feet in a northeasterly direction and has been worked back 300 to 400 feet from the edge of the cliff. Sandy soil covers the stone to a depth of 2 to 3 feet and the land rises very gradually beyond the quarry. The southwestern half of the quarry has been worked to a depth of 70 feet, and the northeastern half to a depth of 25 to 30 feet. The stone is all fine-grained, hard, tough, and in beds 2 to 15 inches in thickness with very thin shale partings. The strike is N. 55° W. and the dip is to the southwest at an angle of 15 degrees. Two prominent faults are seen in the quarry face—one at the southwest end striking N. 83° E. and dipping to the north at an angle of 75 degrees, the other 200 feet from the southeast end, striking N. 60° E. and dipping to the northeast at an angle of 50 degrees. This latter fault is visible in Plate XIII B, page 86, which also shows the character of the bedding. The lowest beds—those in the northeast end of the quarry—are very regular and much thicker than the higher beds seen to the southwest. They have been quarried for building purposes as well as for crushed stone. As shown by the analysis of Sample 123A, which represents these beds, they contain less impurities than the thinner beds to the southwest, which are represented by Sample 123.

The quarry is worked in 20-foot benches by means of jackhammers, but a churn drill is used at times. Blasted stone is loaded by hand to horse-drawn dump carts for transportation to the crusher, which is built on the edge of the escarpment. The crushing plant has a capacity of 600 tons per day. The products, crushed stone, rubble, riprap, and screenings used for agricultural purposes are taken from the quarry by motor truck and either delivered by this means or else are transhipped to boats or to cars on the line of the Quebec Railway, Light and Power Company.

One hundred yards northeast of the quarry, near the bank of Sault à la Puce river, underlying beds of pure, medium-grained, brown limestone interbedded with a small amount of fine-grained, blue limestone are seen in a low ridge paralleling the river, the banks of which in this vicinity are of Precambrian rock. Six hundred yards above the quarry the medium-grained, brown limestone in thick beds crosses the river, and the stream has cut a deep gorge through it for nearly ¼ mile. Sample 124 was taken in this gorge. Vugs filled with sticky black petroleum occur in the brown limestone, which is seen to lie directly on the Precambrian rock. It dips to the southwest at an angle of 25 degrees.

Midway between the Baker and Gravel quarries and about ¼ mile back from the edge of the escarpment is a small abandoned quarry from which stone for the church at Chateau Richer was obtained in 1865. In this quarry sound beds up to 12 inches in thickness that turn light grey on exposure are available. The durability of the stone is attested by the good state of preservation of that in the church walls.

Ste. Anne de Beaupré

An area of thinly bedded, dark brownish grey Trenton limestone with partings of brown calcareous shale is exposed along the Ste. Anne river and on its tributary Jean Larose river a short distance north of Ste. Anne de Beaupré. The limestone lies in practically level beds and has been quarried to a small extent in years gone by.

St. Joachim

An area of Trenton limestone of undetermined extent occurs on the steep hillside of Precambrian rock 1 mile north of the village where the road to Murray Bay ascends the cliff. The limestone apparently rests directly on a steep slope of igneous rock and does not extend to the top of the hill as outcrops of granitic rock are seen there; to the east, west, and south it is overlain by shale. The limestone is fine-grained, dark blue, hard and brittle, and occurs in even beds 2 to 12 inches thick separated by thin seams of hard, black shale striking N. 67° E. and dipping southerly, or down hill, at an angle of 28 degrees. Two small adjacent quarries to obtain stone for road metal have been opened on the northwest side of the road about half way up the hill. Sample 125 was taken from the 40 feet of strata there exposed. A small quantity of lime for local use is made from this stone in a small pot kiln on the opposite side of the road. In general the stone resembles that quarried at Chateau Richer but is somewhat more free from shale and is not quite so siliceous.

Island of Orleans

On this island are several deposits of conglomeratic limestone associated with the shales of the Quebec Group of rocks. One of these deposits near Beaulieu at the southern end of the island is being quarried for riprap for the Island of Orleans bridge now (1934) under construction. Many years ago this limestone was used for making lime.

Beaulieu. On the south side of the island, 1½ miles below Beaulieu, a deposit of conglomeratic calcium limestone occupies a synclinal fold in slaty shales of the district. The deposit measures about 1,000 feet east and west, and extends southerly 1,600 feet, or more, down a gentle slope to the top of a cliff along the south shore of the island. On the east side the slate and limestone strike N. 20° E. and dip very steeply to the west. On the west side the strike is the same but the dip is easterly at an angle of 40 degrees. The limestone is not distinctly bedded and rests directly on the slaty shale, the contact between the two being very sharp. In the quarry, which is in the centre of the north end of the deposit, a face of 22 feet of limestone is seen with slaty shale forming the very uneven floor of the quarry. About 100 feet north of the quarry only slaty shale is said to have been found when test pits were dug. The limestone is all fine-grained and grey in colour. As shown in Plate XIIB, page 80, it is composed of rounded fragments of limestone together with an occasional fragment of sandstone and shale. The fragments vary in size from very small pebbles up to those a foot or more in length, and lie with their long dimensions parallel to the strike of the deposit. The paste between the fragments is mostly of the same composition and appearance as the limestone composing the fragments, but in one or two places it appears magnesian and weathers to a rusty brown. Veins of coarse-grained, greyish calcite traverse the limestone and in places hold masses of a black, coal-like substance. Toward the base the limestone is inclined to be sandy and somewhat shaly.

A quarry operated by *Beaudet & Bergeron, St. Antoine de Tilly,* is opened across a width of 200 feet in the south side of a knoll of the conglomeratic limestone and exposes a maximum thickness of 22 feet of limestone resting on slaty shale. No bedding is discernible in the quarry, the limestone being fractured into huge, irregular blocks and the shale floor is very uneven. Sample 126 was taken from the limestone exposed in the face. A jackhammer is used for drilling the stone, which is broken by dynamite into large pieces suitable for riprap. The riprap is loaded into trucks by means of a small stiff-leg derrick driven by a gasoline engine.

At the pier at Beaulieu a band of siliceous, blue-grey, fine-grained, brown-weathering dolomite carrying fragments of calcium limestone and also pebbles of quartz is to be seen along the beach. It strikes N. 75° E. and apparently dips southerly at angles varying from 30 to 60 degrees.

Ste. Famille. The following reference is made on page 229 of the Geology of Canada (1863) to a deposit of limestone conglomerate on the northwest side of the island near Ste. Famille.

"Below Ste. Famille, the black shales are no longer seen on the beach, or in the cliff, which is occupied by the magnesian shales, and occasionally by the lowest band of limestone conglomerate, to within a couple of miles of the lower extremity of the island."

In further reference to this limestone it is described as—

"Grey limestone conglomerate; the rounded masses are chiefly of grey limestone; the matrix in many parts weathers to a brownish colour, and is probably dolomitic. Fossils occur, some of them replaced by silica. . .; the band in some parts appears to break into lenticular patches. Thickness 10 feet."

On page 613 of the Geology of Canada the following analysis of a specimen of dolomite from the island of Orleans is given, but the exact locality from which the specimen was obtained is not stated:—

	Per cent
Insoluble	13·80
Carbonate of iron	10·31
Calcium carbonate	45·06
Magnesium carbonate	31·81
Total	100·98

Analyses of Montmorency County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
121	11·37	0·67	1·47	0·22	81·55	2·87	98·15	0·08	45·79	1·37	33 : 1
122	9·54	0·46	1·25	0·20	84·71	1·64	97·80	0·09	47·55	0·78	61 : 1
122A	10·08	0·55	1·85	0·17	83·14	1·95	97·74	Tr.	46·65	0·93	50 : 1
122B	11·46	0·67	1·52	0·22	81·41	2·78	98·06	0·07	45·71	1·33	34 : 1
123	8·85	0·64	1·34	0·02	84·16	2·83	97·84	0·15	47·14	1·35	35 : 1
123A	7·46	0·40	0·83	0·15	88·13	1·34	98·31	0·11	49·43	0·64	77 : 1
124	3·58	0·60	0·73	0·20	92·75	1·34	99·20	0·10	52·05	0·64	81 : 1
125	5·71	0·78	2·33	0·22	86·82	3·05	98·91	0·15	48·74	1·46	33 : 1
126	6·10	0·87	1·53	0·17	88·36	1·78	98·81	0·15	49·57	0·85	58 : 1

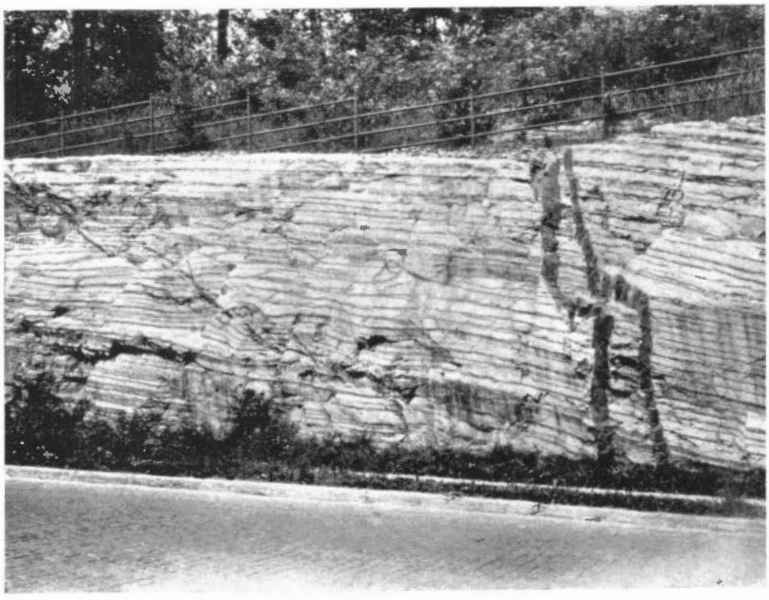
121.	Chateau Richer.	Quarry of Théodore Lacouline.
122.	"	Top 24 feet in E. L. Gravel quarry.
122A.	"	Next 18 feet " "
122B.	"	Bottom 54 feet " "
123.	"	A. A. Baker quarry. Thinly bedded upper beds.
123A.	"	" " Thicker beds at base, used for building stone.
124.	"	Medium-grained limestone in gorge of Sault à la Puce river.
125.	St. Joachim.	Forty feet of strata in quarry 1 mile north of village on road to Murray Bay.
126.	Beaulieu, island of Orleans.	Limestone conglomerate in quarry 1½ miles east of the village.

Montreal District

The term "Montreal district" as used in this report includes the Island of Montreal, Ile Jesus, and Ile Bizard, which territory comprises the counties of Hochelaga, Jacques Cartier, and Laval; the two first-mentioned counties being on the Island of Montreal, and Laval county consisting of Ile

PLATE XIV

A. Black River limestone at Pointe Claire, Island of Montreal.



B. Dykes of trap rock cutting thinly bedded Trenton limestone, Côte des Neiges Road, Montreal.

Jesus. (Ile Bizard forms part of Jacques Cartier county.) With the principal exceptions of a narrow strip of Utica shale along the east shore of the Island of Montreal, the igneous core of mount Royal, and some sills and dykes of igneous rock, practically the entire Montreal district is underlain by the limestones of the Beekmantown, Chazy, Black River, and Trenton formations. Over the greater part of the area the limestone lies in nearly flat beds, though in some places local crumpling has taken place.

The Montreal district is the principal centre of limestone production in the province, and from the numerous quarries stone for road metal, railway ballast, concrete aggregate, flux, building purposes, lime, Portland cement, and for a number of minor uses is obtained. The total capacity of the crushed stone plants is approximately 18,000 tons per 10-hour day and that of the two Portland cement plants, 15,000 barrels per 24-hour day.

Practically the entire production is quarried from the Trenton and Chazy limestones which is in part due to these limestones being readily available near the larger centres of consumption. The distribution of the various formations is shown on the map of the Montreal area in the pocket at the back of this report.

Beekmantown limestone, as may be seen from the map, is to be found in the western parts of each of the three islands. The formation is composed of interbedded, impure dolomite and impure magnesian limestone, the chief impurities being sand and argillaceous material. The stone is fine-grained, unevenly bedded, and is dark grey on fresh fracture but weathers to a drab colour. It is hard and tough and well suited for the production of road metal and has been quarried on a small scale for a number of local uses, but on account of its variable composition it is not suitable for chemical and metallurgical uses. It is quarried only in small quantity. The estimated thickness of this formation is 100 feet.

The *Chazy formation* underlies part of the city of Montreal, the central part of Ile Jesus and is found also in a narrow belt adjoining the Beekmantown limestone near the western end of the Island of Montreal, and in the central part of Ile Bizard. It consists in part of medium-grained, light grey, rather heavily bedded limestone, and in part of fine-grained, thinly bedded, dark grey limestone, the two types being in alternate zones. Locally, as at Cap St. Martin, it is rather shaly, but for the most part the Chazy limestone is comparatively free from shale. The fine-grained stone contains, in general, from 4 to 8 per cent silica and other impurities, but much of the medium-grained stone is comparatively pure. Nearly all the Chazy limestone in the Montreal area, however, is characterized by the presence of mottlings, (Plate IIA, page 16), streaks, and, in some places, interbeds of fine-grained, ferruginous and siliceous magnesian material, which, though scarcely distinguishable from the remainder of the stone on fresh fracture, weathers rapidly to an unsightly yellow colour and finally distintegrates, leaving pits and scars in the stone. In other places this material appears to be disseminated throughout the stone. Where present, even in small amount, this ferruginous, magnesian material renders the stone unsuitable for the making of high-grade lime, and when present in quantity renders the stone undesirable for building stone and for use in the Portland cement industry. In some places in the Montreal area, as in the vicinity of Village

Belanger and in some beds in the St. François de Sales district, this undesirable material is either absent or present only in very minor quantity. Another characteristic feature of the Chazy limestone is the presence of crystals of red and pink calcite, which are apparently fossil fragments. These crystals are so numerous in a bed of the Chazy limestone at Cap St. Martin on Ile Jesus that the stone is quarried for use as red marble.

The Chazy limestone is quarried on a large scale for crushed stone and to a lesser extent for building purposes, the locations of the principal quarries being shown on the map of the Montreal area. In this district the Chazy formation is estimated to have a thickness of 100 feet.

Limestones of the Black River group, viz. the Leray, Lowville, and Pamelia formations, probably occur between the Chazy and Trenton formations throughout the Montreal district, but exposures are relatively few. All three formations are to be seen in the quarries at Pointe Claire; in the Martineau quarry on Papineau Street, Montreal; and in the large quarry at St. Vincent de Paul, formerly worked by Montreal Crushed Stone, Ltd.

The Pamelia formation, the lowest of the three, is composed largely of fine-grained, greyish blue, argillaceous and ferruginous, impure magnesian limestone that on weathering turns rusty and disintegrates to a shaly mass. Until recently the Pamelia formation was believed to be absent in Quebec but Dr. T. H. Clark of McGill University states in a personal communication to the writer that he has definitely established that the band of magnesian limestone occurring beneath the Lowville in the Devito quarry at Pointe Claire and in the large quarry at St. Vincent de Paul, is the Pamelia formation.

The Lowville formation consists mostly of dense-textured, light grey calcium limestone, and the Leray, of dense-textured, dark grey, heavily bedded calcium limestone in which chert is commonly present.

The only use being made of the Black River limestones at the present time is for crushed stone, though formerly the Leray formation was quarried in large amount at Pointe Claire for engineering construction.

Trenton limestone underlies the greater part of the Island of Montreal, the eastern part of Ile Bizard, and is found along the shores of the northeastern part of Ile Jesus. The total thickness of the formation in this area is estimated at 600 feet[1]. Of this the lower 30 feet, or so, closely resembles the Chazy in appearance and consists of alternate zones of medium-grained, light grey, pure limestone, and fine-grained, dark brownish grey, rather impure limestone in beds of variable thickness (up to a maximum of 3 feet) separated by shale partings. The remainder of the formation consists of dark grey, dense- to fine-grained, argillaceous limestone in thin beds with layers of black calcareous shale between, the proportion of shale increasing in the upper part of the formation so gradually that there is no definite break between the Trenton formation and the overlying Utica shale. Some of the medium-grained stone in the lower part of the formation is pure, high-calcium limestone and this is utilized for the making of lime, for foundry flux, and for other purposes demanding a pure limestone. Throughout the formation the content of magnesium

[1] Geology of Canada (1863), p. 139.

carbonate is low. In the shaly beds of the upper part of the formation, the content of silica and alumina combined is such that the stone is suitable for the making of Portland cement with the admixture of but very little other material, and these beds are quarried extensively for the manufacture of this commodity. Crushed stone for use as railway ballast, road metal, and concrete aggregate is obtained from all parts of the formation except the very shaly strata at the top.

In the Montreal area the medium-grained, light grey limestone of both the Chazy and Trenton formations is referred to by the quarrymen as "banc gris" and the dark grey, fine-grained and dense-textured stone is referred to as "banc noir." The term "pierre bâtarde" is applied to certain strata that are composed in part of very fine-grained limestone and in part of coarser grained limestone, the dividing line between the two textures being very sharp but there being no actual parting plane.

Dykes and sills of igneous rocks, related to those composing the core of mount Royal, have, in many places in the Montreal district, invaded the limestone formations. In quarries operated for the production of crushed stone, such dykes and thin sills as may occur are quarried and crushed together with the limestone. Several varieties of igneous rock compose the various dykes and sills, but in this report in the description of the quarries in the Montreal district all varieties are collectively referred to as trap rock.

Island of Montreal

The Island of Montreal, a crescent-shaped island 29 miles long and having a maximum width of 8 miles, lies at the junction of Ottawa and St. Lawrence rivers. On the island is situated the city of Montreal, and the population of the entire island exceeds 1,000,000. As noted on page 93 the island is almost wholly underlain by limestone and many quarries are in operation. The principal centres of crushed stone production are: within the city of Montreal; at Ville St. Michel; St. Laurent; Pointe Claire; and Montreal East. The Portland cement industry is established at Montreal East. Formerly, large amounts of building stone were obtained from quarries within the city of Montreal for the construction of the city buildings, but, although small quantities of building stone are still produced in Villeray ward and at Cartierville, the greater part of the building stone production of the Montreal district is now obtained from Ile Jesus. Three lime plants are situated on the island.

Ste. Anne de Bellevue

Sandy dolomite composing the lower beds of the Beekmantown formation is exposed in several places in this vicinity and has been quarried to a small extent for road metal about ½ mile north of the railway station at Ste. Anne, and again 1½ miles north of Ste. Anne on the Morgan farm. At the latter place beds of sandstone are interbedded with the dolomite. At the northern edge of the village of Ste. Anne a small amount of foundation stone has been obtained from outcrops of the dolomite. The stone in this vicinity is all very impure and of variable composition. No sample for analysis was obtained.

Beaconsfield

Outcrops of limestone occur on a slight elevation along the main highway 1 mile west of Beaconsfield railway station. The upper 3½ feet of stone exposed is possibly of Chazy age. It is fine-grained, dark grey in colour, contains small crystals and veinlets of white calcite, and is heavily bedded without shale partings. The analysis of Sample 33, which represents this stone, shows it to be a fairly pure magnesian limestone. Beneath this, as seen in the 8-foot face of a small quarry a short distance farther west on the north side of the road, is impure dolomitic limestone typical of the Beekmantown formation. The stone in the quarry is very fine-grained, dark grey, hard and tough, and is in beds from 6 to 10 inches in thickness with shaly partings. On exposure it weathers deeply to a muddy brown colour, but does not disintegrate. Sample 33A was taken from all beds exposed in the quarry face.

One-half mile northwest of Beaconsfield station is an exposure of thinly bedded, bluish grey, medium-grained Chazy limestone in flat-lying beds, between which are thin partings of shale. This limestone has been quarried in small amount for road metal and for foundation stone.

One and one-quarter miles north of Beaconsfield station, pure, high-calcium limestone of Black River age (mostly Leray), is exposed in a prominent ridge 25 to 30 feet high extending 600 yards easterly from the junction of the Ste. Marie road with the St. Charles road. The stone is dark bluish grey, fine- to very fine-grained with crystals and veinlets of calcite, and occurs in beds up to 2 feet thick between which there is practically no shale. The strata dip to the southeast at an angle of 2 degrees. Fourteen feet of the stone is exposed in a small quarry on the property of Gédéon Meloche. The top 5 feet is slightly coarser in grain than the remainder and is also somewhat purer, as shown by the analysis of Sample 34. Sample 34A represents the bottom 9 feet of the strata in the quarry. Overburden is practically negligible over most of the broad ridge, and the stone could be easily quarried.

Ste. Geneviève

South of this village, exposures of Chazy limestone are common on the northern slope of a hill that rises to a height of about 100 feet above the river. The stone is medium to coarse in grain, highly fossiliferous, dark bluish grey in colour and occurs in flat beds from a few inches to over 2 feet in thickness, between some of which are thin shale partings. Several small quarries have been opened in the vicinity to obtain stone for highway construction and for foundations for local buildings. Sample 35 represents a thickness of 6 feet of medium-grained, fossiliferous Chazy limestone visible in a small quarry ⅓ mile south of Ste. Geneviève.

On the top of the hill, 1 mile south of Ste. Geneviève, and on the west side of the St. Charles road, 9 feet of flat-lying Chazy limestone is exposed in a small quarry that was once worked for road metal. Overburden here averages about 2 feet in thickness, but outcrops are numerous. Two types of stone are visible in the face. The top 5 feet is of a light grey-blue colour, mostly rather coarse-grained, and is in beds up to 17 inches

in thickness without shale partings. The stone in the lower 4 feet is dark blue-grey, medium-grained, and in beds of the same thickness as those above, but between the beds are partings of sandy shale, and thin shaly seams are visible within the beds themselves. All the stone is highly fossiliferous. Sample 36 was taken from the top 5 feet and Sample 36A from the bottom 4 feet of the face. The percentage of calcium phosphate found on analysing these samples is noteworthy, as the 4·32 per cent of this constituent contained in the lower 4 feet of strata is the greatest amount found in any of the bedded limestones sampled in connection with the present investigation. Search in this locality may disclose beds having an even higher content of calcium phosphate than that already found.

Pointe Claire

A prominent ridge of rather impure Black River limestone rising about 35 feet above the general level of the country extends for over ½ mile in an east-west direction between the village of Pointe Claire and the lines of the Canadian National and Canadian Pacific railways. In places the ridge is 300 yards wide and it presents excellent opportunities for quarrying. Many years ago dimension stone for the construction of bridge piers and culverts was quarried here on a large scale by the Grand Trunk Railway, and a large section of the ridge has been thus removed. At the present time crushed stone and rubble are being produced at Pointe Claire by *Fuger & Smith, Ltd. (address Pointe Claire)* and by *Matthew Devito Construction, Ltd. (address 6138 Hamilton St., Montreal)*. The crushing plant of the former company has a capacity of 10 tons per hour and that of the latter company, 20 tons per hour. The quarries are near each other on the east side of the road between the village and the station and both are working in the same general type of stone. In all, about 40 feet of flat-lying strata representative of the Leray, Lowville, and Pamelia formations is exposed in the vicinity. The Leray, consisting of heavily bedded, dark grey, fine-grained calcium limestone seamed with shale and containing nodules of chert and silicified fossils, is to be seen along the top of the ridge and in the upper part of the old quarry on the west side of the road. The Lowville, consisting of thinner bedded, lighter coloured calcium limestone in which chert is not so conspicuous, comprises most of the stone now being quarried. Veinlets and crystals of secondary calcite are more plentiful in this stone than in the overlying Leray, and, also, the beds are more regular. With the exception of two shaly beds near the base of the formation, each less than 1 foot in thickness, the Lowville is relatively free from shale. The Pamelia formation, consisting of grey-blue, fine-grained, rusty-weathering, impure magnesian limestone is, according to a personal communication from Dr. T. H. Clark of McGill University, exposed at the base of the Devito quarry. Sample 37 is representative of the stone available in the ridge exclusive of chert nodules and the basal magnesian limestone.

Lachine

At the north end of Summerlea Avenue, between the main lines of the Canadian National and Canadian Pacific railways, 8 feet of fine-grained, fossiliferous, very dark blue Trenton limestone in flat beds is exposed in

PLATE XV

A. Quarry of Villeray Quarry Co., in Chazy limestone, Villeray Ward, Montreal.

B. North end of the Papineau Street quarry of Martineau Fils, Ltée, Montreal.

an old quarry formerly worked for road metal and foundation stone. Numerous small crystals of secondary calcite are present in the stone, which is in beds up to 6 inches thick with uneven surfaces and separated by partings of calcareous shale ½ to 1 inch thick. Sample 38 represents the 8 feet of limestone exclusive of the shale partings.

St. Laurent

One-half mile northeast of St. Laurent, several quarries for the production of rubble and crushed stone have been opened in a rather impure Chazy limestone along the Jacques Cartier-Union branch of the Canadian National railway. Considerable water is encountered in quarry operations in this area and much pumping is necessary.

Quarry of R. H. Miner Co., Ltd., 207 St. James St., Montreal. In this quarry, which is on the west side of the Canadian National railway, 46 feet of hard, fine- to medium-grained, blue-grey, Chazy limestone is exposed beneath 4 to 10 feet of soil. The limestone is in flat-lying beds from 1 to 4 feet in thickness though, owing to the presence of very thin seams of black bituminous matter parallel to the stratification, the beds tend to split thinner. Streaks and patches of fine-grained, siliceous, rusty-weathering magnesian material, containing minute crystals of pyrite, or possibly marcasite, occur throughout the deposit, which otherwise consists of calcium limestone nearly free from magnesia. Another noticeable feature is that most of the vertical joints are filled with large crystals of white calcite. Crystals and veinlets of calcite are also present in much of the stone. Sample 39 represents the top 18 feet, and Sample 39A the next 20 feet of strata exposed. Since these samples were taken, the quarry has been deepened another 8 feet but no sample for analysis was obtained from the bottom stone. The lowest bed now visible is softer and somewhat more argillaceous than the remainder.

The quarry is L-shaped and is 600 feet in maximum length at right angles to the railway and 400 feet in maximum width parallel to the railway. Present operations are confined to the southeast corner. Jackhammers are used for drilling. The blasted stone is loaded by hand into small tramcars, which are pushed by hand over narrow gauge tracks to the foot of an incline leading to the crushing plant up which they are pulled by a cable. The crushing plant has a capacity of 50 tons per hour and the entire quarry production is converted into crushed stone of various sizes, most of which is delivered by motor truck.

A short distance north of this quarry is a shallow quarry from which rubble for building purposes has been obtained in recent years. The strata exposed there are the same as those in the upper part of the Miner quarry.

Montreal City

The city of Montreal is very largely underlain by limestone, mostly of the calcium variety, the only other type of rock within the city limits being the igneous rock composing mount Royal, and a narrow strip of Utica shale along the water front. From the limestones enormous quantities of stone for the construction of buildings, as well as for use as crushed

stone and lime, have been obtained. Though the production of building stone from limestone within the city limits has in recent years become less and less until it is now almost negligible, and there is now no stone for the making of lime quarried within the city limits, there is still a large quantity of crushed stone produced within the city at the 8 quarries operated for this purpose, the total capacity of the crushing plants being in the neighbourhood of 8,000 tons per day. The limestone lies in nearly horizontal beds and all the quarries are of the pit type. In addition to crushed stone, some quarries also produce rubble and asphalt filler. The greater part of the production comes from the Trenton limestone, which underlies most of the city, though there is a considerable production from the Chazy limestone in Villeray and Ahuntsic Wards. The stone of both formations in this area is, in general, rather thin-bedded and is of the three types previously described, referred to by the quarrymen as " banc gris," " banc noir," and " pierre bâtarde," with the " banc noir " predominating.

There are two lime plants in the city—one operated by Stinson-Reeb Builders Supply Co., at Delorimier St. just north of the Canadian Pacific railway track, the other at 552 Poupart St., operated by Limoges Fils & Cie. Both plants produce quicklime only. The high-calcium limestone used at these plants is obtained from Ville St. Michel just outside the city boundaries and is brought to the plants by motor truck. The Stinson-Reeb plant consists of two vertical, continuous, externally fired, steel kilns each having a capacity of 12 tons of lime per day. The Limoges plant consists of five batch kilns built of brick, the total capacity of which is 6,000 tons per year.

AHUNTSIC WARD

This ward, which borders on the rivière des Prairies on the northwest side of the island and includes the villages of Cartierville and Bordeaux, is largely underlain by Chazy limestone. A small amount of building stone is quarried at Cartierville, and crushed stone is produced at Bordeaux.

Cartierville. A number of shallow quarries, from which building stone, curbstone, and crushed stone have been obtained, have been opened just southeast of the village on both sides of the St. Laurent road, but all, save one, of the quarries have been idle for a number of years and several have been partly filled in. On the east side of the road a small quarry 9 feet deep is worked by *Joseph Lapointe,* chiefly for the production of rock-face ashlar and sills. The stone in this quarry is representative of that in the other quarries in the vicinity and is a hard, medium-grained, blue-grey, rather impure Chazy limestone occurring in beds up to 2 feet thick. The stone is faintly laminated parallel to the stratification. Sample 40 was taken from the 9-foot quarry face. Mr. Lapointe states that the stone beneath the quarry floor is darker, thinner bedded, and more impure than that above.

Bordeaux. One mile east of Bordeaux and adjacent to the track of the Canadian Pacific railway, the Chazy limestone is being quarried by the Quebec Department of Highways for use as road metal. A number of other quarries, none over 8 feet deep, have been worked at various times in the same locality for building stone, road metal, and, on a very small

scale, for making lime for local use. The strata are in a nearly horizontal position and as shown by the analyses of samples taken here, the top 8 feet of strata is much purer than the remainder.

Quarry operated by Quebec Department of Highways, Quebec. The quarry is at the end of Kelly Street West, Bordeaux, and is close to the Canadian Pacific track. In all, 23 feet of stone is exposed, of which the top 8 feet consists of heavily bedded, medium-grained, grey calcium limestone which has a tendency to split into relatively thin beds along very thin seams of black shaly material. Cross-bedding is quite pronounced in all the strata. On the weathered surface this stone is rough, and in many places has a brownish, ochreous appearance. In the lower 15 feet, beds of fine-grained, hard, brownish grey magnesian limestone alternate with beds of medium-grained calcium limestone. At the base of the quarry the limestone appears somewhat softer and more argillaceous than that above. Sample 41 was taken from the top 8 feet of stone and Sample 41A from the lower 14 feet.

The quarry is 250 by 350 feet in area, and is worked in benches by means of jackhammers. The blasted stone is loaded by hand into horse-drawn dump carts and taken to the foot of the incline leading to the crushing plant. At the foot of the incline the stone is dumped into a small end-dump tram car, which is hauled up the incline by a cable and which dumps automatically into the primary crusher. The plant has a capacity of 35 tons of crushed stone per hour.

VILLERAY WARD

A large amount of limestone has been quarried within the limits of this ward, chiefly from the Chazy formation. In recent years many of the quarries have been filled in to provide building sites. At the time of writing this report (1934), the only quarrying being done was for the production of building stone, though the large crushing plants and quarries of the Villeray Quarry Company are still in commission.

Institution des Sourds-Muets, St. Lawrence Boulevard & De Castelnau St. On the property of this institution a quarry has been worked at intervals for the production of building stone and crushed stone for use in the buildings of the institution. Twenty-four feet of stone is exposed in the quarry face. The top 12 feet consists of fine-grained, hard, brittle, dark blue-grey, brown-weathering magnesian limestone (basal Black River?) in beds up to 3 feet thick. The bottom 12 feet consists of medium-grained, light-grey, fossiliferous calcium limestone (Chazy?) in beds up to 4 feet thick, in which are very thin seams of black shale. A shale bed one-half inch thick separates the two types of stone. Sample 42 was taken from the top 12 feet and Sample 42A from the bottom 12 feet.

Villeray Quarry Co., Ltd., 4740 Iberville St., Montreal. Two quarries have been opened by this company just northwest of the intersection of Villeray and Christopher Columbus Streets. About 100 feet of unquarried stone separates the two quarries. The limestone is in nearly flat-lying beds most of which are rather thick but irregular. It is of Chazy age and, as is the case with most of the Chazy limestone of the district, is mottled and streaked with fine-grained, ferruginous and siliceous magnesian

material, and therefore rather impure. The limestone has an uneven glaciated surface, also the stone varies somewhat in its characteristics from place to place even at the same horizon. A generalized section of the 40 feet of stone exposed in the quarry beneath 2 to 5 feet of soil is as follows:—

7 to 11 feet—Thick, irregular beds, of which in places, the top 4 to 8 feet consists of fine-grained, blue-grey magnesian limestone, and in others the whole section consists of medium-grained, light-grey, high-calcium limestone which in places is mottled and streaked with drab-weathering magnesian material. Sample 43 was taken from these beds and includes all types of stone.

13 feet—Fine- to medium-grained, blue-grey calcium limestone in beds up to 30 inches thick, mottled and streaked with the fine-grained magnesian material. Sample 43A represents this part of the face.

12 feet—Medium-grained, grey limestone in beds of about the same thickness as those immediately above but much more heavily mottled and streaked with magnesian material. Sample 43B represents the stone from this part of the face.

Beneath this exposed section the limestone is finer grained, thinner bedded and more siliceous and argillaceous, and has thin interbeds of shale. Several sills and dykes of trap rock occur in the limestone, one prominent sill 14 inches thick occurring about 20 feet from the surface along the north and west sides of the larger quarry.

Both quarries are fan-shaped. The larger of the two is 750 feet long and 500 feet in width at the widest part, and is being worked in a southerly direction toward Villeray Street. The other is 500 feet long and 300 feet in maximum width, and is being worked in a northerly direction. Churn drills and jackhammers are used in quarrying. Broken stone is loaded into end-dump tram cars, which in each quarry are pushed over narrow-gauge tracks to the foot of a two-compartment elevator in which they are run one car at a time, raised above the surface. (Plate XVA, page 98.) When at the top of the elevator the cage (with the car locked in it) tips, and the stone is discharged to the primary crusher. The elevators are so worked that when the full car is ascending an empty car is descending. The crushing plant at the larger quarry has a capacity of 120 tons per hour and that at the other quarry has a capacity of 60 tons per hour. Crushed stone is delivered by motor truck.

In 1934 these quarries were not being operated by the Villeray Quarry Co. but *Alderic Cousineau* had a large number of men employed in quarrying and dressing stone for building purposes from the top beds on the property; the main product being rock-face ashlar.

On the south side of Villeray Street, opposite the quarries of the Villeray Quarry Company, are some shallow quarries, also in Chazy limestone, which, until very recently, were worked for building stone. A generalized section of the stone exposed in these quarries is as follows:—

2 to 7 feet—Soil.

0 to 8 feet—Fine-grained, drab-weathering, dark grey magnesian limestone not used for building stone. Sample 44 represents this stone. In places this type of stone has been entirely removed by glaciation.

4 feet—Medium-grained, light-grey, calcium limestone, one bed of which is 2 feet thick. Sample 44A was taken from this stone, which was utilized for cut stone.

3 feet—Fine-grained, dark-grey magnesian limestone in beds 4 to 6 inches thick, from which rock-face ashlar was produced. Sample 44B represents this stone.

One-third mile to the northeast of the Villeray quarries or at the corner of De Lanaudière and Everett Streets is a small abandoned quarry also in the Chazy limestone, in which 8 feet of medium-grained, light grey high-calcium limestone is seen overlying a similar thickness of fine-grained, dark grey calcium limestone, blotched with drab-weathering magnesian material. Sample 45 was taken from the top 8 feet, and Sample 45A from the bottom 8 feet.

MONTCALM WARD

In this ward, which lies between Villeray and Rosemount Wards, Trenton limestone is being quarried for crushed stone by Martineau Fils, Ltée. Close by is another large quarry owned by Montreal Quarry, Ltd., and from which crushed stone is also produced, but which is not at present in operation.

Papineau Street Quarry of Martineau Fils, Ltée (Morrison Quarry Company), 517 Marie Anne St. East, Montreal. This company operates two quarries within the city of Montreal, the other being in Rosemount Ward and described on page 104.

The Papineau Street property, 30 acres in area, is southwest of Papineau Street and north of the Canadian Pacific railway tracks. It covers most of the area between Carrière, Garnier, Marquette, and Beaubien Streets. Originally the quarry had a length of 1,800 feet parallel to Papineau Street, but recently Rosemont Boulevard has been extended across the quarry, and the fill required for this road has divided the quarry into two parts. The southeastern end is not being worked at present and quarry operations are being confined to the northwestern end, which is 1,000 feet long (northwest-southeast), 200 to 300 feet wide and 60 feet deep. (Plate XVB, page 98). The quarry can be extended for 400 feet to the northwest before the property limit is reached. Formerly this quarry was extensively worked for building stone, but now the entire output is converted into crushed stone.

Both Trenton and Black River limestones are exposed in this quarry, the Trenton comprising the upper part of the face and the Black River the lower part. The strata have a prevailing dip to the southeast at an angle of 2 or 3 degrees and, as the land surface is level, there is a considerable thickness (at least 35 feet) of strata exposed in the extreme southeastern end of the quarry that is not present in the part now being worked. This 35-foot section is composed largely of dark grey, fine-grained to medium-grained, calcium limestone in thin beds separated by shale partings. Below this is a band 8 to 10 feet thick, composed mostly of medium-grained, light grey, high-calcium limestone in beds up to 2 feet thick, with which is interbedded some fine-grained, dark grey, thin-bedded limestone. The thick beds of this zone were formerly utilized for building stone. These beds are seen in places at the top of the face in the part of the quarry now being worked. Beneath them the following succession of strata is exposed:

25 feet—Medium-grained, light grey and fine-grained, dark grey limestone seamed with shale and mostly thin-bedded. Sample 46 was taken from this part.

1 foot—Sill of trap rock, and about midway along the quarry a vertical dyke of the same rock crosses the quarry from north to south.

5 feet 6 inches—Thinly bedded, very dark blue, dense-textured, hard, brittle, rather impure calcium limestone, in beds 2 to 7 inches thick with thin shale partings. (Black River?)

1 foot 6 inches—Sill of trap rock.
2 feet—Similar stone to that immediately above the sill. Sample 46A includes this 2 feet of limestone together with the 5 feet 6 inches of limestone above the sill of trap rock.
13 feet—Dense-textured, hard, brittle limestone containing much secondary calcite and generally in heavy beds up to 31 inches thick with no shale between. This stone is very similar to the Black River limestone of the Pointe Claire district.
8 feet—Very similar limestone to that above but in thinner beds and some is slightly coarser in grain. Sample 46B is representative of this 8 feet and the 13-foot section immediately above.
4 feet—Sill of trap rock.
3 feet—Very siliceous and argillaceous, very dark grey, fine-grained, brittle magnesian limestone (Pamelia).

A sample taken by Parks from the medium-grained stone formerly used for building purposes had the following analysis[1]:—

	Per cent
Insoluble	0·46
Ferric oxide and alumina	0·46
Calcium carbonate	96·96
Magnesium carbonate	0·87
	98·75

The quarry is worked in 10- to 15-foot benches, with jackhammers being used for drilling. After blasting, the stone is loaded by hand into motor trucks and horse-drawn dump carts, and hauled up an inclined roadway to the crushing plant, which is situated at the eastern side of the quarry near the north end. The plant has a capacity of 80 tons of crushed stone per hour. The product is delivered by motor truck to various parts of the city.

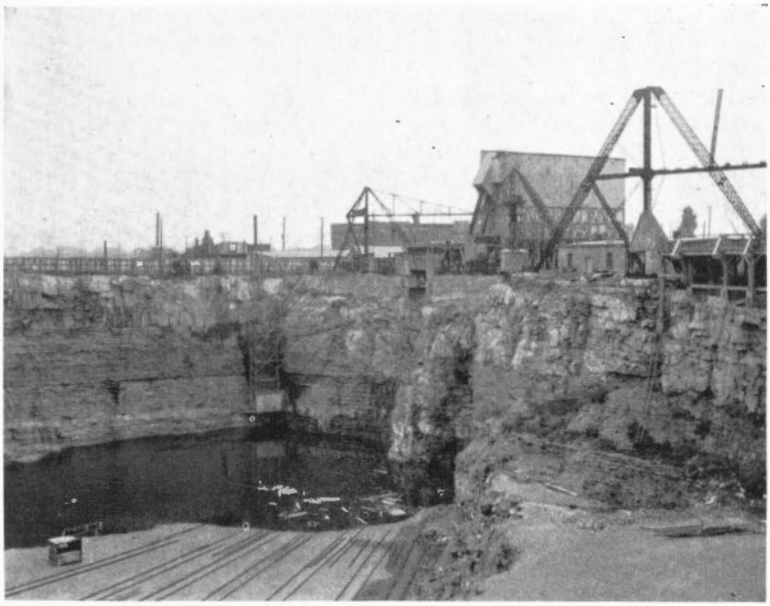
Montreal Quarry, Ltd., 1340 Bellechasse St., Montreal. The quarry owned by this company is only a short distance to the west of the Papineau Street quarry and practically the same strata are exposed in both quarries. When examined in 1934 this quarry was not in operation and was partly full of water. The crushing plant has a capacity of 100 tons per hour.

ROSEMOUNT WARD

This ward, which is in the northeastern part of the city, is largely underlain by the thin-bedded argillaceous limestone that forms the upper part of the Trenton formation. In many places the limestone is overlain by a thick sill of trap rock (Plate IIB, page 16), which is quarried together with the limestone for making crushed stone.

Masson Street Quarry of Martineau Fils, Ltée, 517 Marie Anne St. East, Montreal. The quarry (Plate XVI A, page 105), is a short distance south of Masson Street at 13th Avenue. In it 45 feet of siliceous and argillaceous, thin-bedded, dense-textured, very dark-coloured, dull-lustred calcium limestone is exposed beneath a 25-foot sill of trap rock and 2 feet of soil. The limestone is in flat, fractured beds, 2 to 8 inches thick, separated by thick partings of dark, calcareous shale. Another sill of trap rock 3 to 5 feet thick occurs 35 feet below the top sill, and several thin, vertical dykes of trap cut across the quarry in a westerly direction. Sample 47 represents the entire face of limestone exclusive of the interbeds of shale.

[1] Mines Branch, Dept. of Mines, Canada, Rept. No. 279, p. 34.



A. Masson Street quarry of Martineau Fils, Ltée, Montreal, showing thinly bedded Trenton limestone overlain by a sill of trap rock.

B. Part of the quarry of National Quarries, Ltd., Ville St. Michel, Island of Montreal.

The quarry is 300 by 500 feet in area and is worked in benches by means of jackhammers, though a churn drill has been employed for drilling at times when a high face is to be blasted. Broken stone is loaded into wooden skips set on trucks which run on tracks converging beneath the four derricks used to hoist the skips to the two crushing plants at the brink of the quarry. The derricks are of special design and consist of a vertical mast fitted with a horizontal boom 60 feet long. A trolley carrying the hoisting cable moves along the boom. The mast is pivoted and can be revolved on its vertical axis. Two of these derricks serve each crushing plant. The combined capacity of the two plants is 150 tons of crushed stone per hour. In addition to crushed stone a small quantity of rubble is marketed. Shipments are made by motor truck and by electric car over the lines of the Montreal Tramways Company. The quarry was not in operation in 1934.

Delorimier & Rogers Quarries, Ltd., 4901 Iberville St., Montreal. The quarry and plant of this company are situated just back of the office on Iberville Street. The quarry is 400 by 500 feet in area and 50 feet deep. In places a sill of trap rock 12 to 18 feet thick overlies the limestone and is quarried together with the limestone for making crushed stone. The limestone is very similar in appearance and composition to that in the Masson Street quarry of Martineau Fils, Ltée (Morrison Quarry Co.). After blasting, the stone is loaded by a 2-yard shovel (driven by a Diesel engine) into motor trucks that haul the stone out of the quarry to the crushing plant. The capacity of the plant is 50 tons per hour. Motor trucks are used for shipping the crushed stone to its destination in the city.

Maisonneuve Quarry Co., Ltd., 5750 Iberville St., Montreal. This company is quarrying Trenton limestone on the south side of Rosemont Boulevard at 26th Avenue. Formerly the limestone here was overlain by a thick sill of trap rock, but this trap rock has been quarried off from a large area and is now seen only at the east end of the quarry, and present operations are carried on in the limestone exclusively, of which a thickness of 40 feet is exposed in the quarry as follows:—

20 feet—Thinly bedded, argillaceous, fine-grained, dark calcium limestone in irregular beds with thick shale partings between and also with seams of shale in the beds. Some few beds of medium-grained limestone occur also.

2 feet—Sill of trap rock. In the west end of the quarry another sill occurs about 10 feet down from the top of the limestone.

17 feet—Thinly and irregularly bedded, impure, fine-grained, shaly limestone interbedded with medium-grained, pure, fossiliferous, light grey limestone. Some beds consist in part of fine-grained and in part of medium-grained limestone, the sharp line of distinction between the two types being parallel to the bedding.

An analysis of the upper 15 feet of limestone, published by Howells Fréchette[1] is as follows:—

	Per cent
Insoluble	15·06
Ferric oxide	0·74
Alumina	1·36
Calcium carbonate	79·47
Magnesium carbonate	1·21
	97·84

[1] Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1916, p. 42.

The stone in the lower part of the face is somewhat purer, as is shown by the analysis of Sample 48 which is representative of the bottom 17 feet of limestone exposed. The strata dip to the eastward at an angle of 3 degrees.

The quarry is 700 feet long, parallel to Rosemont Boulevard, and is 600 feet wide. It is worked by means of churn drills and jackhammers. The blasted stone is loaded into 10-ton Mack trucks, by a 2-yard, Link-Belt shovel mounted on caterpillar treads and driven by a Diesel engine. Two steam shovels are also owned by the company. The trucks carry the stone to the primary crusher, which is set in the floor of the quarry at the east end. The crushing plant, which is also built on the floor of the quarry, has a capacity of 200 tons per hour. The crushed stone is shipped by motor truck.

MERCIER WARD

This ward includes the extreme northeastern end of the city. It is underlain by the thinly and unevenly bedded, siliceous and argillaceous limestone that comprises the upper part of the Trenton formation. Most of the stone is dense-textured, but occasional beds of highly fossiliferous, medium-grained limestone also occur. One quarry is worked in this ward for the production of crushed stone.

Dickson Quarry Reg'd., 5759 Hochelaga St., Montreal. This quarry was not examined by the writer, but the following information was supplied by Mr. R. C. Dickson:—

The quarry is on the north side of Sherbrooke Street between Dickson and Monsabre Streets. It is 350 by 185 feet in area and has been worked to a maximum depth of 35 feet. The stone is very fine-grained, dark blue limestone in thin beds separated by seams of shale. Crushed stone and rubble are produced, the capacity of the crushing plant being 10 tons per hour.

Fréchette[1] states that the analysis of the stone in this quarry is as follows:—

	Per cent
Insoluble	12·22
Ferric oxide	0·21
Alumina	0·81
Calcium carbonate	83·75
Magnesium carbonate	2·52
	99·51

Ville St. Michel

This locality, which is on the northern outskirts of the city of Montreal, is an important crushed stone producing centre. A small lime plant is also in operation at Ville St. Michel, and the two lime plants in the city of Montreal obtain their limestone here. Small quantities of pure limestone are also marketed for foundry flux. The limestone quarried is that comprising the lower part of the Trenton formation. It is mostly fine-grained and rather siliceous, but near the top of the quarries is a 13-foot band of pure, coarse-grained high-calcium limestone that provides the pure

[1] Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1916, p. 43.

stone for lime burning. Formerly a considerable quantity of building stone was quarried from this pure band, but there has been no production of this commodity in this district within recent years. All shipments from this district are made by motor truck, none of the quarries being provided with railway shipping facilities.

Property of Villeray Quarry Co., Ltd., 4740 Iberville St., Montreal. The quarry on this property is ¾ mile southwest of the cross-roads at Ville St. Michel and was formerly worked by Varin & Barbin, Ltd. for the production of crushed stone and of stone for sale to the lime plants in Montreal. The quarry has not been operated by the present owners, though, as noted below, stone for making lime is obtained from the southeast end of the quarry by the Montreal Lime Company, which operates a kiln here. The quarry is 600 feet long, 150 feet wide, and in all about 23 feet of stone is exposed beneath 4 to 7 feet of soil. The strata dip to the north at an angle of 3 degrees, whereas the land surface slopes very gradually to the northwest. Limestone of the following types is exposed.

1 to 4 feet	—Dark blue, dense-textured, thinly bedded, impure calcium limestone with partings of black shale.
13 feet	—Coarse-grained, bluish grey, high-calcium limestone in beds 1 to 3 feet in thickness. Near the top, however, is a 16-inch bed of dark, shaly limestone, and another bed of similarly impure stone occurs near the middle of this section.
6 feet	—Heavily bedded, fine- to medium- grained, dark-coloured calcium limestone containing many thin seams of black shale.

Sample 49 is representative of the 13-foot band of pure stone exclusive of the two impure beds. In places throughout the long quarry face the 13-foot band of pure stone has much more shaly, impure limestone interbedded with it than it has at the south end of the quarry where the above section was measured and sampled.

A crushing plant consisting of two units having a total capacity of 140 tons of crushed stone per hour is erected at the quarry. When in operation the stone for crushing was loaded by a gasoline-operated shovel to Mack trucks, which delivered it at the crusher. Stone for sale to lime plants was hand-picked.

Montreal Lime Company, Address, St. Marc des Carrières, Portneuf County, Quebec. This company is quarrying stone for use in its lime plant from the 13-foot band of pure stone near the southeast end of the above quarry. The lime plant is located adjacent to the quarry and consists of one vertical, externally fired, continuous, steel kiln which produces 6 to 7 tons of lime per day when using coal for fuel. Stone for burning is loaded into a small car which is pulled by cable up an inclined track to the top of the kiln and there dumped. The lime, which is light grey in colour, is shipped in lump form packed in steel barrels, and delivered by truck.

On the property adjoining the Villeray Company's quarry to the west, medium-grained, high-calcium limestone, similar in analysis to that of Sample 49, is being quarried to supply the lime plant of Limoges Fils & Cie. The quarry is very small. The stone is trucked to the plant.

Quarry of Union Rock, Ltd., 1340 Bellechasse St., Montreal. This quarry is about midway between that of the Villeray Quarry Co. and the

cross-roads at Ville St. Michel and is worked for the production of crushed stone. It was opened in 1930 and is now 600 feet long and 300 feet wide. When visited in 1934 it was nearly full of water and a section of the limestone exposed could not be seen, but presumably the stone is similar to that in the other quarries in the vicinity. Quarry equipment includes a churn drill, jackhammers, and a steam shovel mounted on caterpillar treads. The blasted stone was transported from the face to the crusher by Mack trucks. The crushing plant is reported to have a capacity of 250 tons per hour.

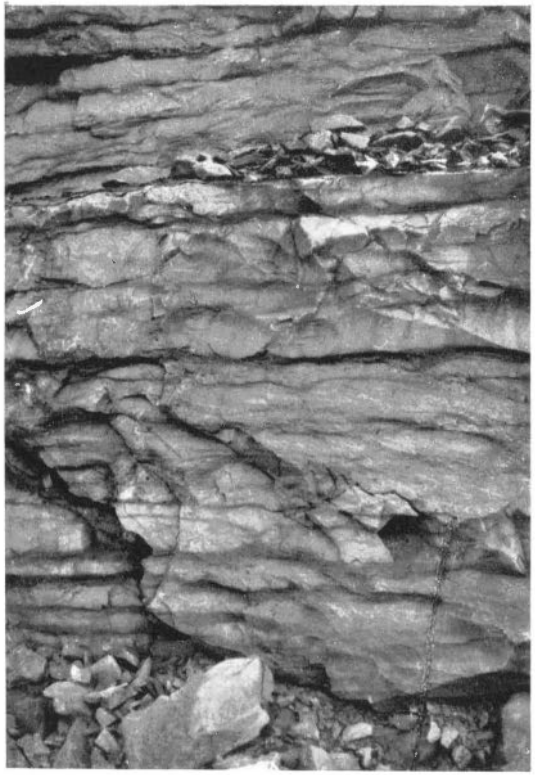
Quarry of Stinson-Reeb Builders Supply Co., 360 Dorchester St. West, Montreal. The quarry, formerly known as the Duquette & Biron quarry, is ¼ mile northwest of the cross-roads at Ville St. Michel. The products are crushed stone, asphalt filler, and stone for making lime in the company's lime plant in Montreal. The quarry covers an area of approximately 200 feet by 300 feet, and in all about 30 feet of limestone is exposed as follows:—

5 feet	—Soil.
3 feet	—Thin-bedded, impure calcium limestone with shaly partings.
2 to 4 feet	—Sill of trap rock, which, however, is not seen in all parts of the quarry.
9 feet	—Thinly bedded, fine-grained, impure calcium limestone with shale seams every 2 to 3 inches. The composition of the limestone in this top 12 feet of limestone is probably similar to that of Sample 50.
1 foot	—Sill of trap rock.
11 feet	—Medium-grained, grey high-calcium limestone in beds up to 18 inches thick and similar in analysis to that of Sample 50A.
6 feet	—Thinly bedded, fine-grained and medium-grained calcium limestone of lesser purity than that immediately above.

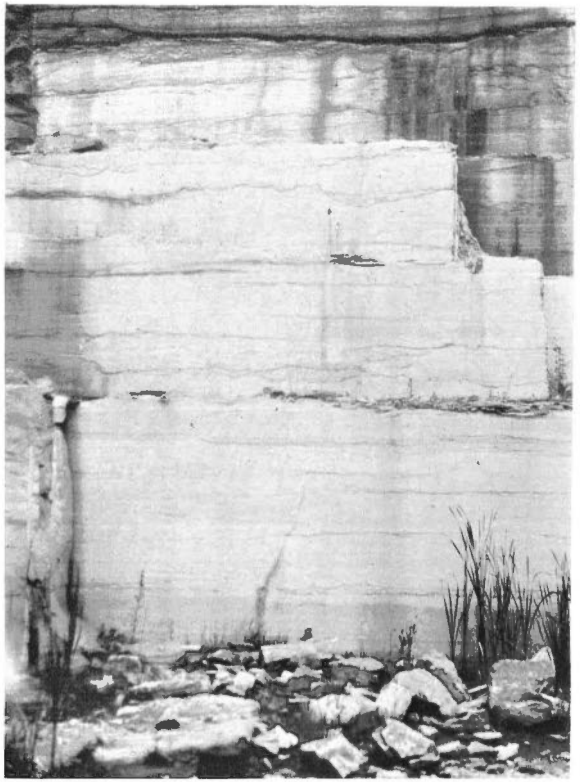
The section does not apply exactly to all parts of the quarry, as many of the beds are not continuous. Also the trap sheets vary in thickness and in position in different parts of the quarry. In one place on the south side there is 8 feet of trap rock on top of the limestone.

The stone is quarried with jackhammers, the pure stone in the 11-foot band near the base of the quarry being quarried separately for use in the lime plant. Stone for crushing is loaded by hand to horse-drawn dump carts and taken to the crushing plant alongside the quarry. This plant has a capacity of 50 tons per hour. Fines from the crushed stone plant after passing through a rotary drier are utilized for making asphalt filler in a Giant Griffin mill, which has a capacity of 60 tons per day of material so pulverized that 85 per cent will pass a 200-mesh wire sieve. The filler is packed in jute and paper sacks and shipped by truck.

National Quarries, Ltd., Park Ave. & Beaubien St., Montreal. The property of this company is ¼ mile north of the cross-roads at Ville St. Michel, a short distance east of the Stinson-Reeb quarry. It includes the quarries formerly operated by Arthur Dupré and St. Michel Quarries, Ltd. The Dupré quarry has been greatly enlarged until it now extends 1,500 feet in a northwesterly direction and is 275 feet wide. (*See* Plate XVIB, page 105). A face 50 to 60 feet in height is worked, and the entire production is converted into crushed stone. The strata dip to the northwest at a low angle and, as the ground surface is level, an entirely different section



A. Argillaceous Trenton limestone streaked with shale; quarry of Canada Cement Company, Montreal East.



B. Irregular and discontinuous seams in heavily bedded Chazy limestone on Ile Jesus.

of stone is exposed in the northwest end of the quarry to that exposed in the southeast end. A generalized section of the southeast part of the property is as follows:

4 feet	—Soil.
4 feet	—Fine-grained, thin-bedded, dark blue calcium limestone, interbedded with shale.
1 to 3 feet	—Sill of trap rock.
14 feet	—Fine-grained, thinly bedded, dark calcium limestone, seamed and interbedded with shale.
12 feet	—Medium- to coarse-grained, grey high-calcium limestone in beds up to 2 feet in thickness with occasional thin beds of fine-grained, darker-coloured shaly limestone. Sample 50A represents the pure limestone only of this band.
12 feet	—Fine-grained and medium-grained, dark grey limestone streaked with shale.
1 to 2 feet	—Sill of trap rock.
4 feet	—Thinly bedded, medium-grained, brownish grey limestone with shale partings between the beds.
1 to 3 feet	—Sill of trap rock underlain by fine-grained, thin-bedded limestone.

The sills of trap rock do not invariably follow bedding planes in the limestone but often cut across the beds, and thus are found at different horizons in different parts of the quarry. Several thin vertical dykes of trap rock also traverse the limestone.

In the northwest end of the quarry, because of the dip, the stone exposed is practically all the fine-grained, dark-coloured variety seen at the top of the face in the opposite end. Sample 50 represents the entire face at the northwest end. At this end of the property there is a greater depth of soil than elsewhere.

In the quarry operations the soil is removed by a gasoline-driven shovel mounted on caterpillar treads and is loaded on motor trucks to be disposed of where it will not interfere with future quarrying. Churn drills are used for drilling and the entire face is blasted as a unit. The stone is loaded by a 2-yard, electric shovel into 6-yard, side-dump motor trucks for conveyance to the crushing plant, which is set on the quarry floor at the southeastern end of the excavation. The plant has a capacity of 240 tons per hour. Trucks are used to transport the crushed stone to its destination in the city.

Montreal East

Limestone available in this vicinity is the argillaceous, thin-bedded, nearly black calcium limestone of the upper part of the Trenton formation. Much of it has practically the composition desired in a raw mix for the manufacture of Portland cement and it is being extensively quarried for that purpose by the Canada Cement Company. The National Cement Company also has a plant in Montreal East but it has been idle since 1931. Crushed stone is produced in Montreal East by one company.

Canada Cement Company, Ltd., Phillips Square, Montreal. The limestone quarry operated for Plant No. 1 of this company is on the north side of Sherbrooke Street East, just east of George V Street. Plant No. 1 is on the opposite side of Sherbrooke Street. From the plant to a shipping pier on the St. Lawrence river is slightly more than ½ mile.

The quarry property is 204 acres in extent, of which about 70 acres have been quarried to a depth of 50 feet. A new face of 20 feet is being developed in the floor of the quarry near the crushing plant. All the limestone is thinly bedded, brittle, dull-lustred, fine-grained, very dark in colour, and is interbedded with shale at intervals of 3 to 8 inches. (*See* Plates XVIIA and XVIIIA). The dip is to the eastward at an angle of 3 degrees. Owing to the high content of argillaceous matter most of the limestone disintegrates to a shaly mass on prolonged exposure, though some beds are more resistant than others. Several sills and dykes of trap rock from 2 to 6 feet thick occur in the limestone and are quarried and mixed with the latter to bring up the silica and alumina content to the desired proportions. The average depth of soil over the quarry area is about 2 feet. As shown by the following analyses supplied by the company, there is a small variation in composition of the stone in the different levels of the quarry, that of the middle 20-foot section being somewhat more pure than the remainder; this is due largely to the presence of numerous crystals of secondary calcite in this section of the face.

—	1	2	3	4	5	6
SiO_2	12·86	11·30	12·80	10·66	20·49	13·16
Fe_2O_3	1·15	1·20	1·17	1·09	} 10·40	} 6·04
Al_2O_3	4·45	4·10	4·38	3·77		
CaO	42·35	43·25	42·45	44·14	35·00	41·48
MgO	2·00	2·10	2·00	1·99	2·20	2·32
Loss on ignition	36·00	36·70	36·12	37·08	29·80	35·20
	98·81	98·65	98·92	98·73	97·89	98·20

1. Top 30 feet of strata in quarry.
2. Middle 20 " "
3. Bottom 20 " " as exposed in new face in floor of quarry.
4. General sample of limestone nearly free from shale.
5. General sample of shale interbeds.
6. Raw mix as sent to kilns.

The company also kindly supplied the following analyses made from a core obtained from a drill hole located 400 feet north of the present quarry. This series clearly shows the variation in chemical composition of the strata composing the upper part of the Trenton formation in this district.

Depth from surface (feet)	SiO_2	Fe_2O_3+ Al_2O_3	CaO	MgO	Loss on ignition	Total
0- 10	11·22	4·40	44·60	2·07	38·30	100·59
10- 20	11·14	4·46	44·50	2·11	37·20	99·41
20- 30	18·46	7·86	36·38	2·69	32·22	97·61
30- 40	20·52	10·42	34·83	2·25	29·84	97·86
40- 50	12·26	5·26	42·61	2·17	36·42	98·72
50- 60	11·62	5·22	43·65	2·21	36·84	99·54
60- 70	8·66	4·36	45·87	1·66	38·14	98·69
70- 80	10·12	4·86	44·76	1·94	37·52	99·20
80- 90	10·58	4·84	44·21	2·28	37·04	98·95
90-100	11·30	5·14	42·52	2·92	36·48	98·36
100-110	10·72	4·94	44·21	2·18	36·78	98·83
110-120	8·14	4·44	46·28	1·98	38·58	99·42
120-130	8·08	4·42	45·50	2·88	38·90	99·78
130-142½	9·16	4·80	45·57	2·26	38·10	99·89

The quarry is worked in two levels, the upper level (with a face of 50 feet) extending around the entire quarry, and the lower face (20 feet in height) being opened in the floor. Electrically operated churn drills are used for drilling. Tracks are laid along both levels and the broken stone is loaded by electric shovels into 2-way, side-dump, steel cars holding 13 tons each. These cars, in trains of 4 to 6, are pulled by gasoline locomotives to the foot of the incline leading to the primary crusher, up which they are pulled two at a time by a cable. The primary crusher is a No. 54 gyratory with a capacity of 700 tons per hour of material broken to 6 inches and under.

The wet process of making Portland cement is employed, and the four 350-foot rotary kilns in use have a combined capacity of 12,000 barrels per day.

Longue Pointe, 2 miles southwest of Plant No. 1, was the site of the former Plant No. 2 of the Canada Cement Company. The plant, however, has been dismantled and the quarry filled in. The limestone here is of the same general type as that at Plant No. 1.

National Cement Company, Ltd., P.O. Box 170, Hochelaga Station, Montreal. The plant and quarry of this company are situated 1¼ miles north of Plant No. 1 of the Canada Cement Company. They have not been operated since 1931. The quarry is 60 feet square and in it a section of 30 to 45 feet of limestone similar to that in the quarry of the Canada Cement Company is exposed beneath 2 to 4 feet of soil. Sample 51 is from the entire face inclusive of the shale interbeds. A 3-foot sill of trap rock forms a large section of the quarry floor. The dip of the strata is to the eastward at an angle of 3 degrees.

When in operation the quarry is worked in a single bench by means of churn drills. The blasted rock is loaded by steam shovel into end-dump, steel cars which run on tracks laid on the floor of the quarry. The cars are taken by gasoline locomotive to the foot of the incline leading to the primary crusher and are hauled by cable up the incline, at the end of which they dump automatically to the primary crusher. The plant is equipped to make Portland cement by the dry process and has a capacity of 3,000 barrels per day.

Quarry of Cyrille Durocher, 11021 Notre Dame St. East, Montreal East. This quarry, which is worked for the production of crushed stone, is ½ mile southeast of the National Cement Company property. It is 250 feet square and 55 feet deep. The same type of dense-textured, dull-lustred, thin-bedded (2 to 6 inches) dark limestone, with shale interbeds, that is exposed in the cement companies' quarries is to be seen here. The limestone dips at a very slight angle to the eastward and is covered by 1 to 2 feet of soil. A vertical dyke of trap rock striking N. 50° W. cuts across the quarry near the southwest wall. Sample 52 represents the limestone exclusive of the shale interbeds.

The quarry is worked in benches by means of jackhammers. Hand-picked stone is loaded into small cars, which are pushed by hand over narrow-gauge tracks to the foot of an incline leading to the crushing plant at the edge of the quarry. The cars are hauled up the incline by a cable and dumped to the crusher. The capacity of the crushing plant is 20 to 25 tons per hour.

PLATE XVIII

A. Top bench in quarry of Canada Cement Co., Montreal East.

B. Faulted, thinly bedded, argillaceous Trenton limestone in quarry formerly worked by Dufresne Construction Company, at Rivière des Prairies, Island of Montreal.

Rivière des Prairies

Thinly bedded, argillaceous calcium limestone typical of the upper part of the Trenton formation is exposed in a number of places near this village, which is situated on the north shore of the Island of Montreal near its eastern end. Two quarries have been worked near here, one for road metal for use on the local roads, the other for riprap shipped by water to Sorel for breakwater construction.

The quarry from which road metal was obtained is ½ mile east of the village and is known as the Desjardins quarry. It is now nearly full of water, but above the water level the stone seen is mostly fine-grained with a lesser amount of interbedded, medium-grained, fossiliferous stone all of which is thin-bedded, dark in colour, and apparently impure.

Quarry of Dufresne Construction Co., Ltd., 1832 Blvd. Pie IX, Montreal. Three-quarters of a mile northeast of the Desjardins quarry is the large quarry worked for riprap until 1933 by the Dufresne Construction Company. The riprap was hauled by truck over a concrete road, ⅓ mile in length to the dock on rivière des Prairies and thence shipped by water to Sorel. The quarry is about 500 by 300 feet in area and is said to be fairly deep. When examined in 1934 the quarry was full of water to the level of the road leading to the river, but above the water level a thickness of 55 feet of thinly bedded, dense-textured, hard, brittle, dark grey limestone seamed with shale was exposed. The continuity of the strata is broken by a fault which strikes N. 72° W. across the quarry from a point midway along the eastern wall. The fault plane dips to the south at an angle of 70 degrees. Plate XVIIIB, page 114, shows both the fault and the general character of the strata. Sample 53 was taken from the strata above water exclusive of the shale interbeds.

Ile Bizard

This small island, west of Ile Jesus and north of the western end of the Island of Montreal, is underlain almost entirely by limestone. Beekmantown limestone similar to that on the Island of Montreal underlies the western part; Chazy limestone forms a belt ½ to 1 mile in width crossing the central part of the island from north to south; and Trenton limestone occupies the eastern end. Small quarries have been worked, chiefly in the Chazy formation, for road metal, building stone, and in connection with small lime kilns, but none have been in operation within recent years.

On the farm of Joseph Théoret, on the height of land near the centre of the island, a small quarry, 75 feet square and 6 feet deep, was opened many years ago in the Chazy limestone to obtain stone for construction purposes, some stone from here being used in the building of the Carillon canal on the Ottawa river. The limestone is coarse-grained, bluish grey, highly fossiliferous and occurs in heavy beds. Toward the bottom of the face the stone contains many crystals of pink calcite, apparently fragments of fossils. The weathered face has a rather rusty appearance due to the presence of much iron oxide, which weathers to an ochre. The strata dip to the northeast at an angle of 3 degrees. Many outcrops of similar limestone are to be seen in the vicinity as the overburden is every-

where thin. Some of the uppermost beds exposed near the road contain streaks of shale. Sample 54 is representative of the 6 feet of stone in the quarry face.

Three-quarters of a mile west of this quarry similar limestone is extensively exposed on the farm of Albert Théoret and to a lesser extent on the farm of Raoul Théoret. On the latter property is also a small deposit of marl underlain by a blue calcareous clay.

Near the north shore of the island on the property of A. Proulx is a disused quarry in the Chazy limestone from which stone was also obtained for the Carillon dam and canal. The stone is heavily bedded, highly fossiliferous, coarse-grained and lies nearly horizontally. The fresh stone is blue-grey in colour but on weathering much of it becomes brownish grey owing to the presence of iron oxide. Fragments of pink fossils are plentiful in some of the beds. Sample 55 was taken from the 8 feet of stone exposed.

Chazy limestone of the same character is also exposed in a low cliff along the shore just north of the quarry, where it has also been quarried to a small extent.

At the north end of Ile Bizard, Trenton limestone of a rather impure type is exposed at Dutchman rapids. The beds are thin, being rarely over 7 inches thick, and for the most part are composed of very fine-grained and dark blue limestone, but in many are streaks of medium-grained, lighter coloured, fossiliferous limestone. Thin seams of shale occur between the beds. Sample 56 was taken from a 6-foot face of this stone on the shore just west of the old mill. Overburden is over 10 feet thick in this area.

Ile Jesus (Laval County)

Ile Jesus, 21 miles long and 7 miles across at the widest part, lies to the northwest of the Island of Montreal and is separated from it by rivière des Prairies and from the mainland by rivière des Mille Iles. Both of these rivers are extensions of the Ottawa river. The island is entirely underlain by limestones of the Beekmantown, Chazy, Black River, and Trenton formations. The Beekmantown formation, consisting of impure magnesian limestone and impure dolomite, underlies only a narrow strip of land about 1 mile in width along the northwest shore between Ste. Rose Station and the southwestern tip of the island. Chazy limestone underlies all the central portion of the island and also parts of the shoreline, as shown on Map No. 756, and the limestones of the Trenton formation and Black River group underlie the remainder of the island.

The Trenton limestone is all of the calcium and high-calcium types. The Black River group consists mostly of calcium limestone but the thin basal formation of this group consists of impure magnesian limestone. Most of the Chazy limestone is also of the calcium type but in places it contains many streaks and masses and beds of ferruginous magnesian material, and thus is variable in chemical composition. At Cap St. Martin and Village Belanger, however, pure Chazy limestone practically free from magnesian material is available.

Many quarries are operated in the central and northeastern parts of the island, the products being crushed stone, building stone, rubble, and lime.

Ste. Dorothée

Near the southwestern tip of Ile Jesus, exposures of impure Trenton limestone, of the same type as that seen on the opposite shore of Ile Bizard, extend for ¼ mile along the shore at Dutchman rapids.

One mile northwest of the village of Ste. Dorothée, shaly, very fine-grained Trenton limestone is exposed and has been quarried for road metal. It is mostly impure.

Abord-à-Plouffe

Small exposures of Chazy limestone are to be seen near the shore on both sides of this village. Small amounts have been quarried for road metal.

St. Martin

One mile east of this village and on the south side of the road to Village Belanger, a number of quarries have been opened in the Chazy limestone but all except one have been abandoned for many years. The quarry now in operation is worked by Napoléon Lagacé for the production of crushed stone and rubble. The other quarries, which are all of small extent, were formerly worked for the production of curbstone, rubble, and, in one one instance, for crushed stone.

The Chazy limestone in this area is mostly impure and also somewhat magnesian owing to irregular streaks and patches of yellow-weathering, fine-grained, ferruginous, magnesian material. Where free from this material the limestone is of the calcium type, but is everywhere characterized by an abundance of pyrite. The beds are slightly undulating with a prevailing dip to the southeast at a low angle. In the southeast part of the area, the top 8 to 12 feet of limestone is heavily bedded, medium-grained and bluish grey in colour, but in many places these top strata have been removed by glaciation; it was in these heavily bedded strata that the curbstone quarries were opened. Beneath is 9 feet of thinly bedded, medium-grained limestone, which in places contains large platy masses of hard, blue chert in addition to other impurities, and then comes fine-grained, impure, thinly bedded, dark-coloured limestone with many lenticular beds of shale. The following series of samples was taken to show the composition of the limestone in this vicinity. Sample No. 57 is representative of 5 feet of the heavily bedded top strata exposed in a small quarry on the property of Maxime Bigras. Sample 58 is from 4 feet of magnesian stone at a lower horizon than the above, as exposed on the property of Mme. Alma Gauthier. Sample 59 is from the 6½ feet of strata above water in an abandoned quarry once worked for crushed stone, also on the property of Mme. Alma Gauthier. These beds are at about the same geological horizon as those included in Sample 58. Sample 60 represents the top 8 feet of strata exposed in the southeast corner of the Lagacé quarry (described below). These beds are apparently equivalent to those in Sample 57. Sample 60A is from the lowest 10 feet of strata worked in the Lagacé quarry and represents the shaly, impure, fine-grained limestone. The analyses of these samples illustrate the wide variation in chemical composition of the Chazy limestone of this vicinity.

Lagacé Quarry, St. Martin. This quarry is just south of the St. Martin road and a little more than 1 mile east of the village of St. Martin. The products are crushed stone and rubble. The excavation is 500 by 300 feet in area and averages 30 feet in depth. The top 10 feet, as seen in the southeast corner of the quarry, consists of medium-grained, bluish grey calcium limestone in beds, 14 to 22 inches thick, in which is considerable pyrite, and the weathered surfaces are usually rusty. Sample 60 was taken from this part of the face. Beneath this is 9 feet of thinner bedded, medium-grained, bluish grey limestone containing black chert and also mottlings and streaks of fine-grained, ferruginous and argillaceous magnesian material. The bottom 10 feet consists of impure, fine-grained, dark grey calcium limestone, interbedded with which, especially in the lower 5 feet, are some lenticular beds of shale and impure magnesian limestone. Sample 60A represents the bottom 10 feet.

The quarry is worked in benches by means of jackhammers. After blasting, the stone is loaded by hand into trailers that hold 2 tons. These trailers are hauled by truck to the crushing plant and there dumped automatically. The crushing plant has a capacity of 30 tons per hour. Shipments are all made by motor truck.

One and a half miles north of the Lagacé quarry and on the south side of the St. Elzéar road is a small abandoned quarry, now partly full of water, on the property of Godfroi Lecavalier, from which building stone and road metal were at one time obtained. The stone is of Chazy age and is in flat beds. The 8 feet showing above the water is rather soft, medium-grained, highly fossiliferous, brownish grey stone in beds up to 2 feet thick. In some places crystals of red calcite, apparently fragments of fossils, are so plentiful as to impart a pink tint to the stone. Overburden does not exceed 2 feet in depth. The stone is free from shale, but, as shown by the analysis of Sample 61, which is representative of the top 8 feet of strata, it is rather impure.

Cap St. Martin

A number of quarries have been opened along the slopes of the hill on which this village is built, immediately east of St. Martin Junction on the Canadian Pacific railway. The railway line to Quebec passes just north of the quarries, and the highway to Montreal via Pont Viau passes through the quarry area. The stone quarried is all of Chazy age. The highest strata exposed, totalling 15 feet in thickness, consist of light grey, medium-grained, high-calcium limestone in beds up to 2 feet in thickness. Most of this type of stone is cross-bedded and consequently the thickness of the beds varies from place to place. Beneath is less pure, thinner bedded, darker limestone, which in some localities is mottled and streaked with fine-grained, rusty-weathering, magnesian material. At the west end of the hill the limestone is more shaly than at the east end. The top beds are worked for building stone and the lower beds for crushed stone.

Carrière du Cap St. Martin, Enrg., 636 Querbes St., Outremont. This quarry, until recently worked by the Laval Quarry Co., is situated in the northwest side of the hill at Cap St. Martin and is served by a spur track from the Canadian Pacific railway. Trucks are also used for shipping the crushed stone which is the principal product. The quarry is about 300 feet

square, and is being advanced southward into the hillside, in which direction the beds dip at a low angle. The following section of strata is exposed:—

2 to 8 feet—Soil.
15 feet—Medium- to coarse-grained, light-grey, oolitic, high-calcium limestone in beds up to 3½ feet thick but which split readily into 6-inch and 12-inch beds along the very thin seams of black shale that occur in the stone. The analysis of this stone is similar to that of Sample 62.
22 inches—Shale and shaly limestone.
9 inches—Siliceous limestone containing many grains of sand.
15 feet—Medium- to coarse-grained calcium limestone in beds up to 20 inches thick, between which are partings of shale ½ to 1 inch thick. Toward the base, patches of fine-grained, rusty-weathering, siliceous magnesian material are noticeable.

The stone is quarried by means of jackhammers and after blasting it is loaded by hand to horse-drawn dump carts for transportation to the crushing plant nearby which has a capacity of 20 tons per hour.

At the northeast end of this quarry a small quarry is worked by *Edgar Desormeaux* for the production of rough and squared rubble for building purposes.

South of the Cap St. Martin quarry, on the opposite slope of the hill, the same heavily bedded stone as is seen in the above quarry has been quarried in the past for building stone. Sample 62 is representative of the 15 feet of stone exposed in these old quarries, which are quite extensive. Crystals of pink calcite are present in much of this stone.

Plant of Canadian Lime Products Co., Cap St. Martin. This company has recently built two stone lime kilns of the batch type at Cap St. Martin on the east side of the highway to Montreal, and nearly opposite the property of Carrière du Cap St. Martin. Just back of the kilns the same strata as are seen in the crushed stone quarry are exposed, and it was the original intention to use this stone for making lime but it was found to give an inferior dark-coloured lime that air-slaked very readily. Stone from the old building stone quarries on the opposite slope of the hill (Sample 62) gave the same results, and at present stone for burning is obtained from the Trenton formation at the village of St. Vincent de Paul. Twenty tons of lime is obtained at each burning.

On the north side of the hill at Cap St. Martin, ¼ mile east of the village and a short distance south of the Canadian Pacific railway, a large quarry for the production of crushed stone was until recently worked by St. Laurent Quarry, Ltd., on the south side of the road going easterly from Cap St. Martin. Another quarry formerly worked by this company for the same purpose is a short distance to the northwest on the opposite side of the road. St. Laurent Quarry, Ltd. is at present operating at Village Belanger (page 123). The abandoned quarry on the north side of the road is about 500 feet square and was worked southeasterly into the hillside exposing 45 feet of limestone beneath 4 to 7 feet of soil. The stone in the upper part of the face varies from fine to coarse in grain and is blotched in places with drab-weathering, fine-grained, impure magnesian material. The beds range up to 12 inches in thickness, and in places several are joined tightly together. Prominent partings occur at vertical intervals of 5 to 7

feet. In the lower part of the face the stone, in general, is finer grained, darker in colour, and shale partings are thicker. At the base the beds are all thin. Sample 63 represents the entire face. The strata dip slightly into the hillside. In the southwest end of the quarry a vertical dyke of trap rock 14 inches thick cuts across the strata in a southeasterly direction.

On top of and on the southern slope of the same hill in which the above quarry was worked, building stone is being produced from the 15 feet of medium- to coarse-grained, high-calcium limestone that occurs immediately above the strata exposed in the quarry just described. One bed, 6 to 20 inches in thickness, that occurs near the top of this 15-foot section is reddish in colour owing to the presence of many crystals of red calcite. The remainder of the section, however, is of a light bluish grey colour and is decidedly oolitic. The red stone is quarried, cut and polished, for use as monumental stone. Other than for the red bed, the stone in these quarries is similar in appearance and probably in composition to that in the abandoned quarry on the opposite side of the highway where Sample 62 was taken. At the present time quarries are being worked by *Messrs. Victor Lecrenier, Arthur Charron,* and *Ubald Chartrand.* Messrs. Charron and Chartrand are quarrying the red stone mostly, but in the Lecrenier quarry, which is the largest of the three, only the grey stone is available and it is being quarried for building stone.

Quarry of Victor Lecrenier, 8434 De Gaspe St., Montreal. The quarry is on the southern slope of the hill and only a short distance east of the highway to Montreal. Twelve feet of medium-grained, bluish grey limestone, in beds 6 inches to 2 feet thick, is exposed beneath 4 to 6 feet of soil. The beds dip southward at a very low angle. The beds in the top 5 feet of the face are much fractured and are discarded, but from the bottom 7 feet fairly large blocks are obtainable. All stone is dressed at the quarry and shipped by motor truck to its destination.

On the crown of the hill north of these small building stone quarries is a large, shallow quarry worked in the past for both crushed stone and building stone but it is at present idle. The same beds as are exposed in the shallow quarries to the south are seen in the above quarry.

Village Belanger

At this village, which is on the highway to Montreal and 1 mile southeast of Cap St. Martin, the Chazy limestone is being quarried for building stone and for crushed stone. Some of the limestone in this locality is practically free from the patches of impure magnesian material that is characteristic of much of the Chazy limestone of the Montreal district.

Quarry of Martineau Fils, Ltée—(Morrison Quarry Co.), 517 Marie Anne St. East, Montreal. In 1932 the above company opened a building stone quarry in heavily bedded, Chazy limestone ½ mile east of Village Belanger. The quarry (Plate XIX A, page 122) is referred to as the Pont Viau quarry by the company. By 1934 the excavation was 250 feet square and 26 feet deep and the following section was exposed:—

5 to 7 feet—Soil.

5 to 7 feet—Medium-grained, bluish grey limestone in irregular beds up to 18 inches in thickness, the top bed of which is mottled with rusty weathering, fine-grained, magnesian material. These beds are used for making squared ashlar.

7 feet—Medium-grained, bluish grey limestone in beds 30, 41, and 13 inches thick but which in places tend to split thinner along stylolitic seams.

6 feet—Similar limestone in two well-defined beds, the top bed being 12 to 18 inches thick and the lower bed 4½ to 5 feet thick; but in the lower bed are several thin, discontinuous seams that, in places, constitute parting planes.

7 feet—Similar limestone in two beds, the upper one 3½ to 5 feet thick and the lower 1 to 3 feet thick. The lower bed is coarser in grain, harder, and darker coloured than the remainder of the stone in the quarry and also is mottled with siliceous and argillaceous, fine-grained, magnesian material. It is not used for building stone. The bed beneath this in the floor of the quarry also contains the magnesian material.

Sample 66A is representative of all the beds exposed excepting the bottom bed. Sample 66B is a grab sample from the bottom bed and the analysis clearly shows the presence of the magnesian material.

The strata dip to northeast at an angle of about 7 degrees and all the stone is cross-bedded to some extent. The main joints strike northwesterly and are spaced at intervals of 1 to 6 feet. They are crossed at right angles by less closely spaced joints. Sound blocks, 3 to 5 feet thick, 9 to 13 feet in length and 2 to 5 feet wide can be obtained. The stone is cut in strips by a channelling machine driven by compressed air, and individual blocks are detached from these channelled strips by means of small powder charges placed in holes drilled with a jackhammer. A stiff-leg derrick capable of lifting 10 tons removes the blocks from the quarry; these are placed on trucks for transportation to the company's cut-stone plant in Montreal. Small, irregularly shaped blocks and stone from top beds are made into squared ashlar at the quarry. Although it has only been available for a short time, stone from this quarry has been used in a number of prominent buildings, among which may be mentioned the Neurological Building of McGill University, the extension to the Montreal City Hall, and the branch of the City and District Savings Bank at the corner of St. Lawrence Boulevard and Mount Royal Avenue, in Montreal, and the addition to the City Hall at St. Hyacinthe.

Jules Petitjean is producing building stone from a small quarry a very short distance northwest of the Martineau quarry. The same beds are being worked. All stone is dressed at the quarry and is shipped by motor truck.

Four hundred feet west of the Petitjean quarry is an abandoned quarry in which is exposed 17 feet of strata at the same geological horizon as are those in the Petitjean quarry. Sample 66 was taken from this 17-foot face.

Quarry formerly operated by John Quinlan & Co., Montreal. This quarry, worked for building stone, but which is now abandoned, is opened near the top of a high ridge of Chazy limestone 750 feet east of Village Belanger, or between the village and the quarries just described. It was worked to a depth of 80 feet by means of channelling machines. At

A. Heavily bedded Chazy limestone quarried for building stone by Martineau Fils, Ltée, Village Belanger, Ile Jesus.

B. Heavily bedded Chazy limestone in quarry at St. François de Sales, formerly worked by Kennedy Construction Company, Ltd.

present there is 40 feet of water in the quarry but the following section was measured when the quarry was in operation:

5 feet—Hard, fine-grained, dark blue-grey, drab-weathering calcium limestone not used for building stone.

8 feet—Very coarse-grained, thin-bedded, calcium limestone interbedded with shale. Masses of very fine-grained limestone occur in the beds of coarse-grained stone.

8 feet—Coarse-grained, light grey limestone in which are many crystals of pink calcite. Very thin, irregular, stylolitic seams occur through this stone at intervals of 4 inches or so, but the bedding in general is heavy. At the base of this is a band varying in thickness from 6 inches to 1 foot 6 inches in which fragments of pink fossils are so plentiful that the stone has a decided pink colour. Sample 64 represents this 8 feet of stone.

18 feet—Medium-grained, heavily bedded, grey, high-calcium limestone with occasional zones of coarse-grained stone. Much of this is decidedly oolitic and contains occasional crystals of pink calcite. Sample 64A was taken from the 18 feet of strata.

40 feet—Medium-grained, heavily bedded, high-calcium limestone somewhat darker and harder than that above, and containing a slightly greater amount of impurities. Sample 64B represents the bottom 40 feet of strata.

St. Laurent Quarry, Ltd., Cap St. Martin. In 1934 this company abandoned the quarry formerly operated at Cap St. Martin (page 119) and commenced operations immediately west of the Quinlan quarry just described. The crushing plant has a capacity of 30 tons per hour.

In the flat ground between this quarry and the highway are several quarries formerly worked for building stone and curbstone in which 15 feet of grey, coarse-grained, pure high-calcium limestone in beds up to 3 feet thick is exposed. These strata are the same as those exposed in the lower part of the upper half of the Quinlan quarry. Sample 65 was taken here.

One mile east of Village Belanger and 1 mile south of the Canadian Pacific railway line between Montreal and Quebec, is a group of abandoned quarries that were not examined by the writer. It is said they were once worked for building stone.

St. Vincent de Paul

Chazy, Black River, and Trenton limestones are exposed in the vicinity of St. Vincent de Paul, and a number of quarries have been worked here for the production of crushed stone and building stone. One of the largest crushed stone quarries in the province was in operation near the village until 1931, but, at the present time, aside from a small production of building stone from the quarry worked in connection with St. Vincent de Paul Penitentiary, and a very small quantity of Trenton limestone quarried for use in the lime plant at Cap St. Martin, there is no production in this neighbourhood.

Quarry formerly worked by Montreal Crushed Stone, Ltd. This very extensive quarry from which crushed stone was produced is just south of the Canadian Pacific railway, 1 mile west of St. Vincent de Paul, and is served by a spur track. It was worked in 1931 by Quarries Limited of Montreal but has not been in operation since. The quarry is 400 to 600 feet wide, averages 30 feet in depth, and extends for ½ mile southerly from the railroad, and in it limestones of Trenton, Black River, and Chazy ages are exposed—the Trenton in the south end, the Black River in the

central part, and the Chazy in the north end. The strata dip southerly at a low angle and are covered to a depth of only 2 feet or so by soil. The Trenton limestone is medium-grained, grey in colour, and in beds up to 1 foot in thickness with no shale partings. Sample 67 represents a thickness of 20 feet of this stone.

The underlying Black River formations, seen in the central part of the quarry, comprise 35 feet or so of cherty calcium limestone and 10 to 12 feet of impure magnesian limestone. The calcium limestone is fine-grained to dense, dark bluish grey in colour, and contains many nodules and plates of bluish black chert. A sill of trap rock, in places 9 feet thick, occurs in this section. The magnesian limestone is fine-grained, greyish blue, argillaceous and ferruginous, and on exposure becomes rusty in colour and disintegrates to a shaly mass. Dr. T. H. Clark of McGill University has identified this magnesian limestone as being the Pamelia formation, and states that the Leray and the Lowville formations are represented in the upper 35 feet. Sample 67A is representative of the upper calcium limestone, exclusive of the chert nodules, and Sample 67B was taken from the magnesian Pamelia limestone. The lowest beds seen in the quarry (at the northern end) are those of Chazy age and they consist of medium-grained, blue-grey, calcium limestone, mottled and streaked with fine-grained, argillaceous and siliceous, ferruginous magnesian material, and also veined with white calcite. Sample 67C was taken from a 20-foot thickness of this stone. In addition to the above-mentioned sill, several thin dykes of trap rock are to be seen in the quarry.

In working the quarry, churn drills were used, and the blasted stone was loaded by steam shovel into 8- and 13-ton electric cars, operated by the Woodford remote control system, for transportation to the crushing plant situated at the north end of the quarry. This plant has a capacity of 300 tons of crushed stone per hour.

About 2 miles southwest of St. Vincent de Paul, a good section of Trenton limestone is exposed in a bluff about 100 feet high overlooking the river. The upper 50 feet is thin-bedded, shaly, dark grey calcium limestone. Then comes a zone 12 feet thick of medium-grained, high-calcium limestone in beds 6 to 20 inches thick. Below this to the level of the river is thin-bedded, very fine-grained, dark blue calcium limestone. Formerly the beds of medium-grained stone were quarried for building stone. Parks[1] gives the following analysis as being representative of the stone that was quarried:—

	Per cent
Insoluble matter	1·00
Ferric oxide and alumina	0·86
Calcium carbonate	93·17
Magnesium carbonate	1·25

Quarry operated in connection with St. Vincent de Paul Penitentiary. One and one-half miles northwest of the penitentiary and connected with it by a narrow gauge tramway is the quarry from which building stone for use at the institution is obtained. The stone quarried is medium- to fine-grained, bluish grey Chazy limestone occurring in beds up to 2 feet

[1] Parks, W. A.: Building and Ornamental Stones of Canada, vol. III, Mines Branch, Dept. of Mines, Canada, Rept. 279, p. 65 (1914).

9 inches in thickness, through which very thin seams of black bituminous matter occur parallel to the bedding. The quarry is in the form of a semicircle of 250 feet radius, and 8 feet of stone overlain by 4 to 10 feet of soil is exposed. In places, particularly on the east side, many small patches of fine-grained, yellow-weathering magnesian material occur in the stone, but the stone in other parts of the quarry is practically free from this material. Sample 68 is representative of the stone in which the magnesian material is not noticeable.

Northwest of here along the road to Côte des Perron are many outcrops of Chazy limestone, and several small quarries from which building stone has been obtained.

Sample 69 was taken from a 10-foot face of brownish grey limestone, in beds up to 6 inches thick, exposed in a small quarry northeast of the junction of the Côte des Perron and St. François de Sales roads. This limestone varies in grain from coarse to very fine and in places it is rather shaly.

Sample 70 is from 6 feet of limestone exposed in an old quarry on the property of J. Charbonneau, ¼ mile west of the school at Côte des Perron. The stone varies from coarse to very fine in grain, and partings of shale occur between the beds. These shale seams were not included in the sample.

St. François de Sales

A mile south of St. François de Sales the ridge of limestone forming the backbone of Ile Jesus ends in a low escarpment, and in the flat-lying strata exposed therein a number of quarries have been opened to obtain crushed stone and building stone, and, for a short time, a small plant making Portland cement was also in operation here. Several quarries have also been opened on top of the ridge along the Terrebonne road. The Canadian Pacific railway passes along the southeast side of the ridge and spur tracks have been laid to some of the larger quarries.

The limestone in this vicinity is variable in appearance and composition. Some is light grey in colour, medium-grained, high-calcium limestone and some is dark grey, fine-grained, and contains over 8 per cent total impurities. Largely because of the presence of mottlings and streaks of fine-grained magnesian material distributed irregularly through many of the beds, the content of magnesium carbonate is, in some places, considerable over a quarriable thickness of stone.

Quinlan Cut Stone Co., Ltd., 1165 Greene Ave, Montreal. This company has recently re-opened one of the old building stone quarries on the south side of the Terrebonne road, 2 miles southwest of St. François de Sales. Medium-grained, heavily bedded, brownish grey, Chazy limestone is exposed in the old excavation. Mottlings of fine-grained magnesian material are present in some of the beds.

Félix Labelle Quarry. On the northeastern end of the escarpment is the large quarry known as the Félix Labelle quarry, which has been worked by several companies for both building stone and crushed stone. The quarry is roughly 800 feet square and at the highest part of the face 36

feet of limestone is exposed, but the average depth is 25 feet. It is served by a spur track from the Canadian Pacific railway. The beds vary in thickness up to 4 feet 6 inches. In general, the top 10 feet is medium-grained, grey, fossiliferous, high-calcium, oolitic limestone containing very thin, stylolitic seams of black bituminous matter parallel to the bedding, but nearly free from patches of magnesian material, though in some small openings nearby, the magnesian material was observed in strata that are at the same geological horizon as the top beds in the main quarry. Sample 71 represents this top 10 feet. Most of the stone beneath is slightly finer in grain, darker in colour, somewhat less pure, and contains streaks and mottlings of fine-grained, ferruginous, yellow-weathering magnesian material; it is also heavily bedded and oolitic. Sample 71A was taken from the bottom 26 feet of strata.

A small quantity of building stone is produced from the upper beds in the southwest end of the Labelle quarry by *Lévis Paquette & Co.* This company maintains a small stone-cutting plant nearby and all stone is shipped in the finished state. Until 1932, De Sales Quarry, Ltd. was working the Labelle quarry for the production of crushed stone.

Stone & Quarry, Ltd., 1340 Bellechasse St., Montreal. Across the Terrebonne road from the Labelle quarry the above company operates a building stone quarry, a full description of which is given on pages 60-63 of Mines Branch Report No. 733. The quarry is about 150 by 100 feet in area and is of the side-hill type. A face of 16 feet is worked in three benches of 5, 6, and 5 feet. The stone is all medium-grained, bluish grey, highly fossiliferous and is in beds of irregular thickness up to 3 feet. In the top bench much drab-weathering, fine-grained, magnesian material is visible in the form of streaks and mottlings, but this material is much less noticeable in the middle bench and is practically absent in the bottom beds of the quarry. Samples 72, 72A, and 72B are from the top, middle, and bottom benches respectively.

Jackhammers and guy derricks are used in quarrying. A cut-stone plant is operated in connection with the quarry and the dressed stone is shipped by motor truck.

Quarry formerly worked by Kennedy Construction Co., Ltd., 407 McGill Ave., Montreal. This quarry (Plate XIXB, page 122), which was formerly worked for building stone and for crushed stone by the Kennedy Construction Co., is 500 feet northwest of the property of Stone & Quarry Ltd., and is served by a siding from the Canadian Pacific railway. It is opened on the north edge of the escarpment and extends for 800 feet southerly into the hillside and has a width of 175 feet. Near the entrance an opening about 200 feet square has been made in the east wall of the quarry. The stone varies in appearance and in thickness of bedding along the face, but in general the 20 to 25 feet of stone exposed in the face is medium-grained, grey stone much mottled and streaked with drab-weathering, fine-grained magnesian material. In some places entire beds, 15 inches thick are composed of this material, but these beds are not continuous. Parts of the face consist entirely of thick beds, some being 4 feet thick, but in other parts the beds are all much thinner and much fractured. The floor of this quarry is in shaly, thin-bedded, dark grey limestone, a thick-

ness of 5 feet of which is visible near the entrance. In order to show the variation in the composition of stone in the quarry, two samples, each representative of the entire face exclusive of the shaly stone in the floor, were taken. Sample 73 was taken half way in from the entrance, and No. 73A at the southern end of the excavation.

The quarry has not been operated since 1930 when it was worked for crushed stone, and the crushing plant is now dismantled.

Quarry formerly operated by Unic Cement Co., Montreal. This quarry is 800 feet northwest of the Kennedy quarry and is opened on the southeast side of a low ridge. It was worked only for a very short time and is very small. The limestone is very fine-grained, dull-lustred and in thin, nodular beds with shale between, the shale composing about 30 per cent of the face. The dip is to the north at an angle of 4 degrees. Sample 74 represents the limestone beds only, none of the shale being included. Clay soil obtained nearby was mixed with this limestone for the making of cement. The soil is only 6 inches deep at the quarry but is much deeper farther north.

Analyses of Montreal District Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
Island of Montreal											
33	2·28	0·67	0·13	0·04	82·80	14·14	100·06	0·06	46·39	6·76	7 : 1
33A	10·88	0·94	2·42	0·09	49·84	34·94	99·11	0·21	27·96	16·71	1·73 : 1
34	1·28	0·22	0·20	0·02	97·93	0·63	100·28	0·08	54·85	0·30	183 : 1
34A	1·96	0·40	0·52	0·02	93·71	2·08	98·69	0·20	52·49	0·99	53 : 1
35	1·92	0·44	0·24	n.d.	94·64	1·88	99·12	0·06	53·00	0·81	65 : 1
36	4·67	0·69	0·59	1·27	89·98	1·32	98·52	0·08	51·08	0·63	81 : 1
36A	6·72	0·85	1·07	4·32	84·36	1·13	98·45	0·14	49·58	0·54	92 : 1
37	6·38	0·58	1·50	0·09	89·16	1·03	98·74	0·16	49·98	0·49	102 : 1
38	2·02	0·65	0·51	0·17	93·05	2·56	98·96	0·12	52·20	1·22	43 : 1
39	5·44	1·55	1·31	0·31	85·57	4·92	99·10	0·20	48·09	2·35	20 : 1
39A	4·86	1·43	1·85	0·17	85·91	5·25	99·47	0·16	48·20	2·51	19 : 1
40	3·86	0·71	1·17	0·48	91·48	1·18	98·88	0·06	51·49	0·56	92 : 1
41	4·50	0·73	1·71	0·20	90·07	1·74	98·95	Tr.	50·55	0·83	61 : 1
41A	11·14	2·17	4·61	0·26	65·55	14·26	97·99	0·44	36·85	6·82	5·4 : 1
42	2·64	1·96	0·90	0·13	69·52	23·69	98·84	0·15	39·00	11·28	3·5 : 1
42A	1·82	1·02	0·18	0·37	94·39	1·62	99·40	Nil	53·06	0·77	69 : 1
43	1·50	1·20	1·20	0·09	85·43	9·37	98·79	0·09	47·89	4·48	10·7 : 1
43A	2·36	0·67	0·57	0·04	92·93	3·12	99·69	0·19	52·05	1·49	35 : 1
43B	3·04	1·14	0·76	0·11	82·07	12·11	99·23	0·19	46·02	5·79	7·9 : 1
44	1·66	0·90	0·72	0·09	86·04	10·50	99·91	0·10	48·23	5·02	9·6 : 1
44A	1·80	0·60	0·76	0·09	91·11	5·42	99·68	0·24	51·07	2·59	20 : 1
44B	1·26	0·81	0·31	0·04	86·71	11·05	100·18	0·09	48·59	5·28	9·2 : 1
45	1·18	0·47	0·35	0·17	96·50	0·82	99·49	0·03	54·13	0·39	139 : 1
45A	1·64	0·75	0·51	0·07	90·80	5·76	99·53	0·06	50·98	2·73	19 : 1
46	1·55	0·35	1·09	0·17	94·73	0·92	98·81	0·10	53·14	0·44	121 : 1
46A	4·76	0·33	1·07	0·13	91·90	1·03	99·22	0·25	51·53	0·49	105 : 1
46B	7·78	0·54	1·56	0·02	88·30	1·76	99·96	0·20	49·46	0·84	59 : 1
47	15·42	1·41	6·05	0·22	70·48	4·16	97·74	0·29	39·59	1·99	20 : 1
48	10·06	1·01	4·37	0·16	81·57	1·67	98·84	0·21	45·70	0·80	57 : 1
49	0·56	0·31	0·25	0·17	97·88	1·03	100·20	Tr.	54·90	0·49	112 : 1
50	5·52	0·74	2·00	0·31	96·86	2·89	98·32	0·28	48·81	1·38	35 : 1
50A	0·68	0·33	0·19	0·17	97·71	0·99	100·07	Tr.	54·81	0·47	117 : 1
51	11·40	1·93	3·98	0·17	77·44	3·01	97·93	0·15	43·47	1·44	30 : 1
52	10·32	0·91	3·23	0·17	81·14	2·56	98·33	0·18	45·53	1·22	37 : 1
53	6·64	0·90	2·18	0·15	85·46	3·20	98·53	0·15	47·94	1·53	31 : 1

Analyses of Montreal District Limestones—*Concluded*

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
					Ile Bizard						
54	1·91	0·95	0·52	0·17	94·73	1·92	100·20	0·12	53·14	0·92	58 : 1
55	1·70	0·91	0·73	0·11	94·84	1·79	100·08	0·04	53·17	0·85	63 : 1
56	5·84	0·91	2·35	0·17	87·48	2·17	98·92	0·18	49·08	1·04	47 : 1
					Ile Jesus						
57	2·10	1·41	0·31	0·39	88·39	6·69	99·29	0·11	49·71	3·20	16 : 1
58	4·40	1·36	0·78	0·33	79·04	13·56	99·47	0·03	44·44	6·48	7 : 1
59	7·90	1·76	0·48	0·97	80·20	7·49	98·80	0·09	45·43	3·58	13 : 1
60	2·14	0·52	0·39	0·42	94·48	1·85	99·80	0·14	53·14	0·88	60 : 1
60A	31·60	2·08	2·16	2·10	55·75	4·71	98·40	0·44	32·36	2·25	14 : 1
61	3·72	1·57	1·37	0·48	89·68	2·33	99·15	Tr.	50·48	1·11	46 : 1
62	0·66	0·79	0·31	0·09	96·32	1·39	99·56	0·09	53·99	0·66	82 : 1
63	3·37	1·35	0·34	0·44	92·64	1·87	100·01	0·10	52·12	0·89	59 : 1
64	1·18	0·63	0·51	0·15	95·75	1·95	100·17	0·11	53·70	0·93	58 : 1
64A	0·90	0·35	0·45	0·07	96·25	1·81	99·83	0·03	53·94	0·86	63 : 1
64B	2·18	0·62	0·70	0·35	94·14	1·11	99·10	0·10	52·91	0·53	100 : 1
65	0·68	0·90	0·40	0·13	96·11	1·38	99·60	0·12	53·89	0·66	82 : 1
66	0·64	0·72	0·36	0·30	96·65	1·44	100·11	0·03	54·30	0·69	79 : 1
66A	0·86	0·69	0·50	0·07	92·70	4·64	99·46	0·11	51·95	2·22	23 : 1
66B	4·78	1·43	3·02	0·11	81·54	9·47	100·35	0·48	45·72	4·53	10 : 1
67	1·90	0·80	0·72	0·31	93·89	1·28	98·90	0·10	52·75	0·61	87 : 1
67A	2·74	0·52	0·28	0·02	94·71	1·72	99·99	0·06	53·05	0·82	65 : 1
67B	16·12	2·71	3·74	0·57	50·12	27·08	100·34	0·09	28·38	12·95	2 : 1
67C	2·50	0·65	1·23	0·26	91·93	2·66	99·23	0·18	51·62	2·66	20 : 1
68	1·51	1·02	0·38	0·13	95·00	1·51	99·55	0·06	53·27	0·72	74 : 1
69	1·48	1·10	0·72	0·09	95·34	0·53	99·26	0·03	53·44	0·25	214 : 1
70	2·30	0·19	0·37	0·11	96·35	0·84	100·16	Tr.	54·02	0·40	135 : 1
71	0·68	0·96	0·27	n.d.	97·87	0·84	100·62	0·12	54·42	0·40	136 : 1
71A	1·14	0·98	0·70	0·07	93·34	3·82	100·05	0·19	52·31	1·83	29 : 1
72	1·08	1·17	1·43	n.d.	84·99	10·32	98·99	0·20	47·75	4·94	9·7 : 1
72A	0·97	0·73	1·01	n.d.	93·33	2·59	98·63	0·22	52·43	1·24	42 : 1
72B	0·52	0·49	0·87	n.d.	94·98	2·30	99·16	0·15	53·36	1·10	49 : 1
73	2·50	1·77	1·05	0·09	84·54	9·20	99·15	0·30	47·39	4·40	11 : 1
73A	4·68	1·30	1·80	0·09	79·86	11·61	99·34	0·27	44·77	5·55	8 : 1
74	5·78	0·73	1·99	0·17	89·93	1·58	100·18	0·16	50·45	0·75	67 : 1

33.	Beaconsfield.	Upper 3½ feet of limestone in outcrop on highway 1 mile west of the railway station.
33A.	"	Small quarry a short distance west of the above.
34.	"	Top 5 feet in quarry 1¼ miles north of the village.
34A.	"	Bottom 9 feet in same quarry.
35.	Ste. Geneviève.	Quarry ⅓ mile south of village.
36.	"	Top 5 feet in quarry 1 mile south of the village.
36A.	"	Bottom 4 feet in same quarry.
37.	Pointe Claire.	Ridge of Black River limestone between the village and the station.
38.	Lachine.	Quarry at north end of Summerlea Avenue.
39.	St. Laurent.	Quarry of R. H. Miner Co., Ltd., top 18 feet.
39A.	"	" " next 20 feet.
40.	Cartierville.	Top 9 feet of stone in quarry worked by Joseph Lapointe.
41.	Bordeaux.	Quarry of Quebec Dept. of Highways; top 8 feet.
41A.	"	" " next 14 feet.
42.	Montreal.	Top 12 feet in quarry on property of Institution des Sourds-Muets, St. Lawrence Blvd. and De Castelnau St.
42A.	"	Bottom 12 feet in same quarry.
43.	"	Top 10 feet in Villeray quarry, at corner of Villeray and Christopher Columbus Streets.
43A.	"	Next 13 feet of strata in the same quarry.
43B.	"	Next 12 feet " "
44.	"	Top 8 feet of stone in small quarries on the south side of Villeray St. opposite the Villeray quarry.

44A.	Montreal.	Next 4 feet of stone in the small quarries.
45.	"	Top 8 feet of limestone in abandoned quarry ⅓ mile northeast of the Villeray quarry.
45A.	"	Bottom 8 feet in same quarry.
46.	"	Papineau Street quarry of Martineau Fils, Ltée: top 25 feet.
46A.	"	Papineau Street quarry; next 7½ feet.
46B.	"	" " next 21 feet.
47.	"	Masson Street quarry of Martineau Fils, Ltée; 45 feet of limestone exclusive of shale interbeds.
48.	"	Maisonneuve Quarry Co.; 17 feet of limestone in second bench.
49.	Ville St. Michel.	Thirteen feet of pure limestone in quarry on property of Villeray Quarry Co., Ltd.
50.	"	National Quarries, Ltd.; entire face of quarry at the northwest end.
50A.	"	Twelve-foot band of medium-grained, pure limestone near top of quarry at southeast end.
51.	Montreal East.	Quarry of National Cement Co.
52.	"	Quarry of Cyrille Durocher; limestone exclusive of shale interbeds.
53.	Rivière des Prairies.	Dufresne Construction Co. quarry, limestone exclusive of shale interbeds.
54.	Ile Bizard.	Small quarry on property of Joseph Théoret near centre of the island.
55.	"	Small quarry on property of A. Proulx on north shore of the island.
56.	"	Six-foot face of limestone on the shore of the island at Dutchman rapids.
57.	St. Martin.	Heavily bedded stone in small quarry on property of Maxime Bigras, 1 mile east of the village.
58.	"	Magnesian limestone on property of Mme. Alma Gauthier, 1 mile east of the village.
59.	"	Top 6½ feet of strata in abandoned quarry on property of Mme. Gauthier.
60	"	Top 8 feet of strata in the Lagacé quarry.
60A.	"	Bottom 10 feet of strata in the Lagacé quarry.
61.	"	Top 8 feet of stone in quarry on property of Godfroi Lecavalier, 1½ miles north of the Lagacé quarry.
62.	Cap St. Martin.	Fifteen feet of limestone exposed in old quarries on top of the hill south of the village.
63.	"	Forty-five feet of stone in face of quarry on south side of the Canadian Pacific railway, ¼ mile east of the village.
64.	Village Belanger.	Eight-foot section of coarse-grained stone above the bed of red limestone in the deep quarry formerly worked by John Quinlan & Co. for building stone.
64A.	"	Next 18 feet of strata below the red bed in the same quarry.
64B.	"	Next 40 feet of strata.
65.	"	Fifteen-foot face in an old quarry just east of the village.
66.	"	Seventeen feet of strata in an abandoned quarry ⅓ mile east of the village.
66A.	"	Upper 23 feet of strata in the quarry of Martineau Fils, Ltée.
66B.	"	Lowest bed at present quarried in the Martineau quarry.
67.	St. Vincent de Paul.	Twenty feet of Trenton strata exposed in south end of the quarry formerly worked by Montreal Crushed Stone, Ltd.
67A.	"	Thirty-five feet of Black River limestone underlying the Trenton limestone in the same quarry.
67B.	"	Ten-foot band of impure, rusty-weathering magnesian limestone, in the same quarry.
67C.	"	Twenty feet of Chazy limestone in the northern end of the quarry.
68.	"	Quarry operated in connection with St. Vincent de Paul Penitentiary.
69.	"	Quarry at junction of Côte des Perron and St. François de Sales roads.
70.	Côte des Perron.	Quarry on property of J. Charbonneau, ¼ mile west of the school.
71.	St. François de Sales.	Félix Labelle quarry; top 10 feet.
71A.	"	" " bottom 26 feet.
72.	"	Property of Stone & Quarry, Ltd.; top 5 feet.
72A.	"	" " middle 6 feet.
72B.	"	" " bottom 5 feet.
73.	"	Entire face of quarry formerly worked by Kennedy Construction Co., Ltd., at a point midway along the length of the quarry.
73A.	"	Entire face at southern end of the above quarry.
74.	"	Limestone, exclusive of shale interbeds, in quarry formerly worked by Unic Cement Co.

Papineau County

With the exception of a narrow strip of Ordovician rocks, consisting principally of impure Beekmantown dolomite, along the shore of Ottawa river on the south boundary of the county, this county is almost entirely underlain by rocks of Precambrian age in which are found numerous deposits of metamorphosed Grenville limestone. The locations of deposits sampled are shown on Figure 9, below. The great majority of the deposits of Grenville limestone are far removed from railway transportation and from good highways and consequently were not examined. The deposits examined in the vicinity of the Ottawa river are all impure and are unsuitable for making high-grade lime or for chemical use. Several small quarries have been opened in the Grenville limestone in this county, but there has been no large-scale production for any purpose.

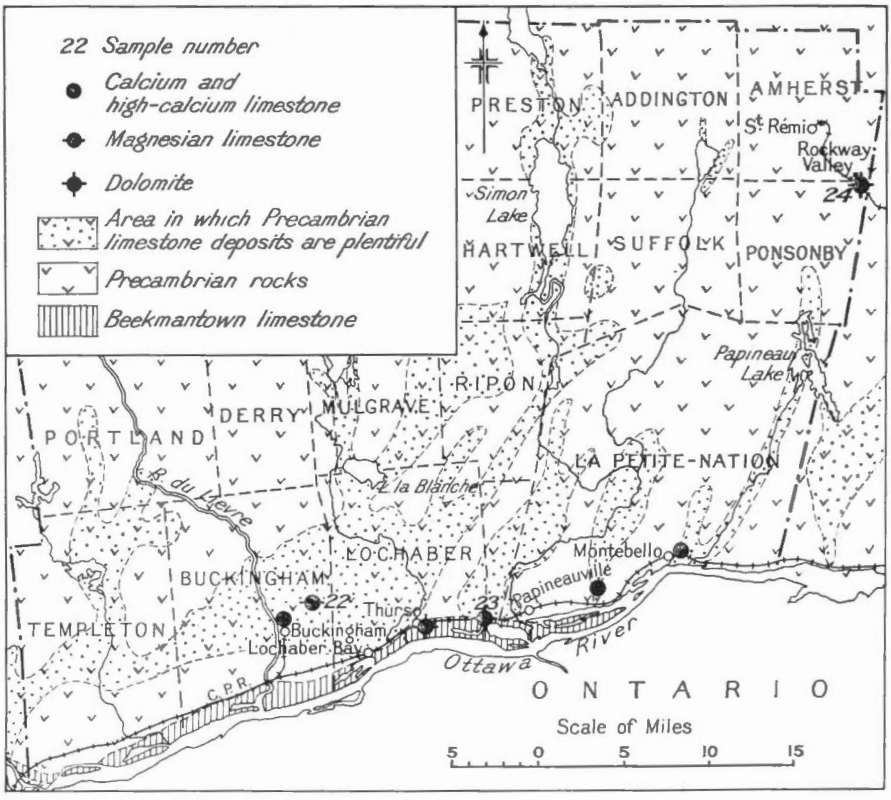


Figure 9. Map showing location of limestone deposits sampled in Papineau county.

The Beekmantown limestone along the north shore of the Ottawa river occurs in flat beds from a few inches to 30 inches in thickness. It is everywhere impure, containing sand grains and argillaceous matter, and, in many localities it contains flakes of mica. In the neighbourhood of Thurso.

stone for building culverts along what is now the North Shore line of the Canadian Pacific railway between Ottawa and Montreal was quarried from the Beekmantown deposits when this line was under construction, but there has been no activity since. Large blocks of stone suitable for engineering construction are obtainable from this formation, but, owing to its hardness and to the unattractive drab-brown shade it assumes on exposure to the weather, the stone is not favoured for general construction.

Buckingham

Many exposures of Grenville calcium limestone occur in the vicinity of Buckingham, but all seen were very impure, the limestone containing much iron, graphite, quartz, mica and various other silicate minerals, as well as inclusions of gneiss and intrusions of granite.

Two miles northeast of the town, on the property of V. T. Doherty, lot 5, range VI, Buckingham township, is a large deposit of red, magnesian limestone of Grenville age, in which crystals of apatite are sufficiently abundant to impart a very phosphatic character to the limestone. The deposit trends northwest-southeast along the southwest side of McNaughton brook and is exposed at intervals for 1,100 feet parallel to the brook and in a pasture for a distance of 400 feet southwest of the brook. It is associated with gneiss and schist and is intruded by one or more igneous dykes. The limestone is fine- to medium-grained and most is of a brownish red colour, though in places it is of a greenish tint, owing to the many crystals of apatite. At both ends of the deposit, particularly at the southeast end, the limestone contains masses of quartzite and also fragments of fine-grained, slaty, calcareous rock of a deep red colour, but in the central part the limestone is nearly free from siliceous impurities, as is shown by the analyses of three samples taken across the line of outcrops. Sample 22 consists of chips taken across the band near the northwest end over a width of 200 feet. Samples 22A and 22B were taken midway along the band; Sample 22A representing outcrops over a width of 175 feet on the southwest half of the deposit, and Sample 22B representing the outcrops over a similar width on the northeast half of the deposit. Though this is a decidedly phosphatic limestone it must be noted that phosphate in the form of apatite is not water-soluble and therefore the deposit is of no greater value for the production of agricultural limestone than are deposits devoid of apatite.

Lochaber

North and west of the railway station at Lochaber are several outcrops of impure, coarse-grained Grenville limestone. The stone is too impure for any use except as a local source of limestone or lime for agricultural purposes.

South of Lochaber flat beds of impure Beekmantown dolomite underlie the area between the highway and the Ottawa river. It is apparently similar in composition to that sampled 4 miles east of Thurso.

Thurso

Impure, brown-grey and blue-grey Beekmantown dolomite underlies a narrow strip of country along the Ottawa river both east and west of

Thurso. The dolomite lies in nearly flat, regular beds up to 30 inches thick, and has been quarried on a small scale in the past for building stone at Thurso and also eastward of the village.

Four miles east of Thurso on the south side of the highway, on lot A, range I, Lochaber Gore, Beekmantown dolomite was quarried for building culverts on what is now the North Shore line of the Canadian Pacific railway between Montreal and Ottawa. The stone is fine-grained, dark grey in colour and occurs in flat beds up to 30 inches thick beneath about 1 foot of soil. Streaks of sandy shale containing tiny flakes of mica stand out in relief on the weathered surfaces of the outcrops in this vicinity. Sample 23 is representative of 10 feet of strata exposed in the old quarries.

Papineauville

A belt of coarse-grained Grenville limestone and interbedded gneiss and quartzite extends northerly for nearly 10 miles from Papineauville. Only the southern part of this belt was at all closely examined, but here the limestone, which is of the calcium type, contains much mica, graphite and other minerals, and, judging from the rusty appearance of some of the outcrops, it has a fairly high content of iron. Interbeds of gneiss are also very numerous. No sample for analysis was obtained.

Montebello

Impure, coarse-grained calcium limestone of Grenville age is exposed on the east side of the village and to the northeast thereof. It is much intermixed with granitic rocks.

Rockway

At this village, which is in the northeastern corner of the county, a deposit of white, siliceous, Grenville limestone occurs immediately north of the St. Rémi branch of the Canadian National railway, and a small quarry was one time worked here. The deposit is at least 200 feet wide and strikes N. 45° W. and dips vertically; it consists of medium- to coarse-grained, white calcium limestone interbedded parallel to the strike with bands of coarse-grained, white dolomite. The dolomite is easily recognizable on the weathered outcrop because it stands out in relief and weathers nearly black in contrast to the light grey of the calcium limestone. The calcium limestone in places is filled with small grains of a pale yellow silicate mineral but is free from mica and graphite. Sample 24A includes both dolomite bands and calcium limestone across a width of 50 feet exposed at the quarry. The analysis of this sample is as follows:—

	Per cent
Silica	13·88
Ferric oxide	0·99
Alumina	0·06
Phosphorus pentoxide	0·17
Calcium oxide	28·38
Magnesium oxide	23·91
Carbon dioxide	28·96
Water	4·16
Sulphur	Nil
	100·51

The high content of magnesia is due in large part to the presence of magnesium silicates.

Analyses of Papineau County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
22.....	0·40	1·44	0·38	12·13	72·95	13·12	100·42	Tr.	47·54	6·27	7·6 : 1
22A.....	0·44	0·96	0·20	11·88	77·57	9·18	100·23	Tr.	50·06	4·39	11·4 : 1
22B.....	0·58	1·25	0·61	13·74	66·00	18·11	100·29	Tr.	44·40	8·66	5·1 : 1
23.....	11·32	1·53	2·03	0·09	48·77	36·83	100·57	0·40	27·36	17·61	1·55 : 1

22. Buckingham. Sample across 200 feet of outcrops of Grenville limestone near northwest end of deposit on property of V. T. Doherty, lot 5, range VI, Buckingham township.

22A. " Sample midway along the same deposit from outcrops on the southwest half of the band over a width of 175 feet.

22B. " Sample midway along the same deposit from outcrops on the northeast half of the band over a width of 175 feet.

23. Thurso. Beekmantown limestone from old quarry 4 miles east of this village.

Pontiac County

The greater part of the limestone of this county consists of highly metamorphosed Grenville limestone (Precambrian), though small areas of impure Beekmantown magnesian limestone occur along the shore of the Ottawa river in several places, as noted later. Beekmantown, Chazy, and Black River limestones also occur on Allumette island, but outcrops are infrequent.

Grenville limestone, in irregularly shaped masses and bands, is found in the southern part of the county in many places between the eastern boundary of the county and Black river. Deposits are particularly abundant along the Ottawa river between Bryson and Bristol and it is in this area that the purest limestone is found. The limestone is all light-coloured, some being white, and is commonly banded. It is mostly medium- to coarse-grained, though some is fine-grained. Many of the deposits consist of dolomite and there is a considerable amount of magnesium carbonate in practically all of the limestone examined. The usual impurities—mica, graphite, grains and masses of silicate minerals and veins of quartz—and also interbedded quartzite, gneiss and schist, and intrusions of basic igneous rocks, occur to some extent in nearly all of the deposits, though the deposit of white dolomite being quarried at Portage du Fort is remarkably free from these materials. Northwest of Bryson the few deposits of Grenville limestone seen are all impure. The locations of the deposits sampled in this county are shown in Figure 10.

Campbell's Bay

Just north of the village of Campbell's Bay a prominent ridge of siliceous Grenville dolomite, 150 feet wide and 30 to 60 feet high, occurs on the bank of the Ottawa river and extends for 500 yards parallel to the river. The dolomite is coarse-grained and white but contains a great many streaks of fine-grained, light yellow, siliceous material, which render it useless as a source of lime and for chemical purposes. No sample was taken.

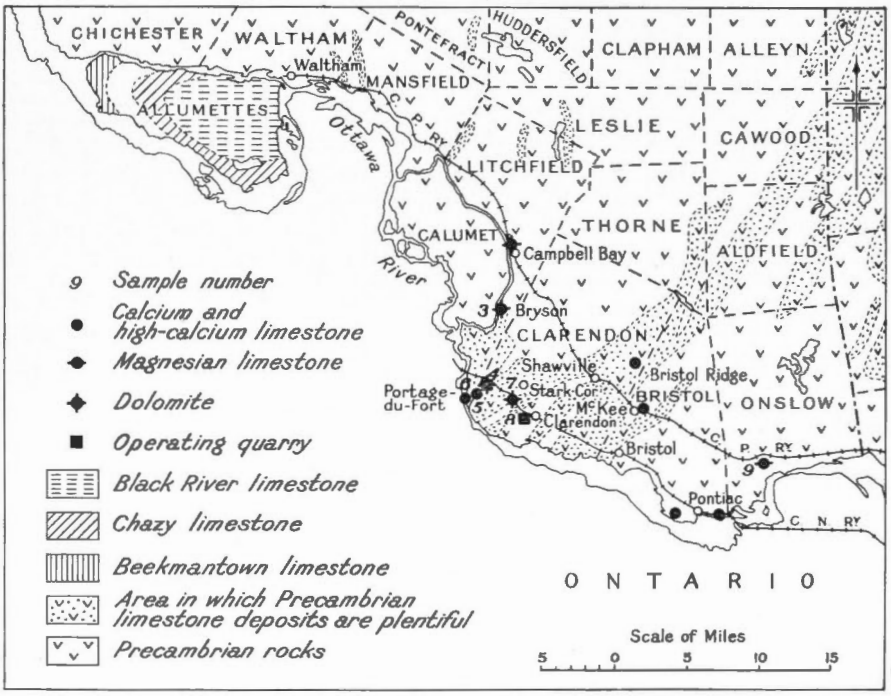


Figure 10. Map showing location of limestone deposits sampled in Pontiac county.

Bryson

Quarry of Robt. Carswell, Bryson. On the property of Robert Carswell, on the east side of a hill, in Bryson village, a large deposit of very coarse-grained Grenville limestone is exposed that consists in part of magnesian limestone, and in part of dolomite. The two types are entirely separate and a quarry has been opened in each. The strike of the limestone beds is somewhat variable, but the average is slightly east of north and the dip is at an angle of 45 degrees to the east. The magnesian limestone is next to the road and has been quarried into for 75 feet along the strike across a width of 40 feet. On the east side of the quarry the limestone is white, in the middle it is striped with light blue, and on the west side it all has a bluish tint. It is all heavily bedded and contains few visible impurities aside from a few flakes of graphite, an occasional crystal of some silicate mineral and some small masses of pale yellow, soft, slightly soluble mineral not as yet identified. Sample 3 was taken across the face of this quarry and is representative of 18 feet of beds.

The small quarry in the dolomite is 35 feet northeast from the one just described. The stone here is in beds up to 3 feet thick, is coarse-grained and white, but it contains many small, shapeless masses of fine-grained, faintly yellowish mineral, which on exposure dissolves very slowly leaving tiny pits in the stone. The analysis of this stone is as follows:

	Per cent
Silica	2·09
Ferric oxide	0·21
Alumina	0·36
Phosphorus pentoxide	0·01
Calcium oxide	34·65
Magnesium oxide	21·93
Water	8·23
Carbon dioxide	31·70
Sulphur	Nil
	99·18

The stone from the first-mentioned quarry was, until recent years, used for making lime, and the dolomite was used for building purposes, but there has been no production for either purpose of late years.

Portage du Fort

Very large deposits of pure Grenville dolomite and smaller deposits of pure calcium limestone of the same age are found in this vicinity. The dolomite is very coarse-grained and much of it is snowy white in colour. The calcium limestone is also coarse-grained, but most of it has a bluish tint or is white with faint bands of blue, though some is pure white and scarcely distinguishable in appearance from the dolomite with which it is associated. As a rule, however, the calcium limestone is characterized by the presence of tiny flakes of graphite and of small scales of light brown mica. Grains of silicate minerals, other than mica, occur in places in both types of limestone, but the dolomite, generally speaking, has less impurities than the calcium limestone. A quarry is being worked in the dolomite for the production of terrazzo, stucco dash, poultry grit, and other products. It was formerly quarried for marble and building stone.[1] There is no production at present from the calcium limestone but it has been quarried in small quantity for building purposes.

White Grit Company, Address, Hurdman Road, Ottawa. This company is quarrying and crushing white dolomite 1 mile north of Portage du Fort on the east side of the road to Bryson. The quarry, which is of the pit type, is 200 feet long, 80 feet wide, and has been worked to a depth of 55 feet. The dolomite is in thick but irregular beds that strike N. 10° E. and dip to the west at angles ranging from 15 to 30 degrees. (*See* Plate XXA, page 136). With the exception of the top few feet, which is in places stained to a light yellow colour, the rock is snowy white, but along the bedding planes, and filling what are apparently old fractures, are veins of pinkish brown, fine-grained dolomite from ⅛ inch to 2 inches in thickness. The yellow stone and stone containing the brown veins are cobbed out during the quarry operations and are discarded. Sample 4 is representative of the white dolomite quarried, exclusive of the brownish vein material. Sample 4A is of the brownish vein material.

The quarry is worked in 10-foot benches with jackhammers. Broken stone is loaded by hand into skips, hoisted out of the pit by means of a

[1] Mines Branch, Dept. of Mines, Canada, Rept. No. 279, p. 195 (1914).

A. Precambrian dolomite in quarry of White Grit Company, Portage du Fort, Pontiac county.

B. Outcrop of heavily bedded Beekmantown dolomite at Quyon, Pontiac county.

guy derrick, and deposited on a stock-pile adjacent to the crushing plant. The crushing plant, which is operated by steam, and which has a capacity of 40 tons per day, is equipped with a jaw crusher, two sets of rolls, and a number of screens with openings from 18 mesh to ¼ inch. Five sizes of stone are marketed ranging from sand, all of which passes an 18-mesh screen, to ¼-inch material. The principal uses are for surfacing driveways, for stucco dash, terrazzo, poultry grit, for making artificial stone, and for a filler in asphalt and magnesite floors. Shipments are made in bulk and in 100-pound burlap bags from Portage du Fort station on the Canadian National railway, ½ mile distant.

Immediately south of the deep quarry and also on the company's property is a quarry not now worked, 200 feet long, 50 feet wide and 10 feet deep, in a similar coarse-grained dolomite but much of which is of a pale yellow colour. Most of this discoloration is due to the action of surface waters and probably white stone would be found at a greater depth.

A peculiar feature of this white dolomite is that when it is struck with a hammer it gives off a very noticeable odour of hydrogen sulphide, yet on analysis no sulphur whatever was found. When burned in a kiln this stone tends to crumble. This explains in part why, in view of its purity, it has not been used for making lime.

Outcrops of the white dolomite are plentiful to the eastward and to the south, but a short distance to the north the dolomite is cut off by igneous rock. The dolomite is also seen in a small cutting on the railway several hundred yards east of Portage du Fort station.

Bluish calcium limestone, not so coarse-grained as the dolomite, is seen in many outcrops within the village of Portage du Fort. In places it contains tiny grains of angular quartz, which are responsible for the high silica content shown in the analysis of Sample 5, which was taken from outcrops in the village.

On the island in the Ottawa river opposite the village, and over which the highway to Renfrew passes, both calcium limestone and dolomite are exposed in association with igneous rock, and in places the two types of limestone are interbanded. Several small quarries were at one time opened here. Some of the calcium limestone is white and scarcely distinguishable from the dolomite in appearance, but most of it is either pale blue or else faintly striped with blue, and in places it contains many scales of brown mica. Sample 6 was taken from a deposit of white, high-calcium limestone in a small quarry on the east side of the island. In a cutting along the road farther toward the west, a deposit of interbanded white dolomite and bluish white calcium limestone is exposed.

One mile east of Portage du Fort is a small outlier of very impure magnesian limestone of the Beekmantown formation. Pebbles of quartz, quartzite, jasper, and other rocks are plentifully distributed throughout the beds, some of which are over 2 feet thick. On the north side of the highway a small quarry was at one time worked in this deposit, the product being rough building stone.

Stark Corners

Coarse-grained, white dolomite in contact with gneiss is exposed on the highway just south of the Canadian National railway and the exposures continue at intervals along the highway for more than 1 mile toward Portage du Fort, after which, with the exception of a small band of striped blue-and-white calcium limestone near the western edge of the limestone area, only granitic rocks were seen. Sample 7 was taken from the outcrops over a large area near the railway.

Clarendon

East of Clarendon station, very large outcrops of pure, coarse-grained, grey calcium limestone are seen in level ground on lots 7 and 8, range I, Clarendon township, and also on lots 7, 9, 10, 11, 12, and 13, range II. In places there are small areas of fine-grained, light blue limestone and also small areas of dolomitic limestone, but the greater part is of the coarse-grained calcium variety. A few flakes of mica and graphite and an occasional siliceous nodule constitute the main impurities in these outcrops, aside from a few intrusions of dark igneous rock. On lot 8, range I, John Wickens burns lime occasionally in a small, steel draw-kiln, the stone being obtained from a pit near the kiln. Sample 8 is representative of the stone quarried. Sample 8A was taken from a large outcrop of similar limestone on lot 7, range II, Clarendon township. The Canadian National railway passes close to this area.

Bristol Ridge

Much coarse-grained, Grenville limestone of the calcium type is exposed to the west and south of the settlement. Siliceous impurities and flakes of mica and graphite are plentiful, but in places fairly pure limestone can be obtained. An analysis on record at the Mines Branch from a sample taken from an outcrop on lot 4, range VIII, Clarendon township, is as follows:—

	Per cent
Insoluble	1·43
Ferric oxide	0·22
Alumina	0·02
Graphite	0·57
Calcium carbonate	89·02
Magnesium carbonate	9·17
	100·43

McKee Station

In this locality in Bristol township there are large outcrops of grey, coarse-grained Grenville limestone some of which are close to the Canadian Pacific railway. Most of the limestone is interbedded with quartzite and is intruded by masses of basic, igneous rocks, but there are small areas of fairly pure calcium limestone available at a number of places in this district.

Bristol Station

Between Bristol Station on the Canadian Pacific railway, and Maryland post office, a type of Grenville limestone similar to that near Caldwell is frequently exposed.

Norway Bay

Southeast of Norway Bay, both Grenville limestone and Beekmantown limestone are exposed over large areas on and near the shore of Chats lake. In places in this district the Beekmantown limestone rests directly on the Grenville limestone. Both types of limestone are very impure, the Beekmantown dolomitic limestone containing much sand and also small pebbles of other rocks; the Grenville containing masses of schist and quartzite and intrusions of basic igneous rock as well as flakes of mica, graphite, and grains of various other minerals.

Still farther to the south and east along the shore of Chats lake in range A of Bristol township, large outcrops of medium-grained, grey, banded Grenville limestone are to be seen. Most of the impurities in this limestone are concentrated in thin zones, 1 to 3 inches apart. Detailed descriptions of this and other outcrops of limestone in this vicinity are given in a report on the rocks of the Quyon area by M. E. Wilson.[1]

Pontiac

East of Pontiac station, coarse-grained, bluish grey, banded Grenville limestone containing considerable graphite and other impurities is seen along the Canadian National railway. An analysis on record at the Mines Branch of a sample taken in a cutting on the railway, a short distance west of the bridge over the Ottawa river, is as follows:—

	Per cent
Insoluble	2·06
Ferric oxide	0·43
Alumina	0·13
Graphite	0·58
Calcium carbonate	89·28
Magnesium carbonate	6·75
	99·23

Quyon

Impure, fine-grained, magnesian limestone of Beekmantown age is exposed in a small quarry on the east bank of the Quyon river a short distance above the village, and again on the highway just east of the village. In both places it is in rough, uneven beds some of which are over 2 feet thick. (Plate XXB, page 136). Sample 9 was taken from 15 feet of this limestone exposed in a small quarry on the river bank above the village.

[1] Wilson, M. E.: Geol. Surv., Canada, Mem. 145 (1925).

Analyses of Pontiac County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
3.....	1·94	0·25	0·55	0·02	82·60	16·45	101·81	0·03	46·26	7·83	5·9 : 1
4.....	0·35	0·12	0·12	0·02	55·88	43·92	100·38	Nil	31·30	21·00	1·49 : 1
4A.....	0·50	0·94	0·14	0·09	55·29	43·71	100·67	0·02	31·01	20·90	1·48 : 1
5.....	14·76	0·20	0·20	0·04	80·41	5·17	100·78	0·02	45·05	2·46	18 : 1
6.....	2·38	0·20	0·20	0·04	94·87	2·21	99·90	Nil	53·15	1·05	51 : 1
7.....	0·72	0·18	0·16	Tr.	55·70	44·23	100·99	Tr.	31·19	21·15	1·47 : 1
8.....	1·70	0·21	0·37	0·04	90·29	7·43	100·04	Nil	50·58	3·54	14 : 1
8A.....	2·30	0·21	0·19	0·04	90·21	7·31	100·26	Nil	50·54	3·48	15 : 1
9.....	8·68	1·69	1·29	0·09	60·66	26·71	99·12	Tr.	34·02	12·77	2·66 : 1

3.	Bryson.	Magnesian limestone on property of Robt. Carswell.
4.	Portage du Fort.	White dolomite in quarry of White Grit Co.
4A.	"	Brownish veins in the dolomite in the same quarry.
5.	"	Limestone in the village.
6.	"	White limestone on east side of the island in Ottawa river opposite the village.
7.	Stark Corners.	White dolomite south of railway track.
8.	Clarendon.	Stone quarried on property of John Wickens, lot 8, range I, Clarendon township.
8A.	"	Outcrops on lot 7, range II, Clarendon township.
9.	Quyon.	Beekmantown limestone in quarry on bank of Quyon river above the village.

Portneuf County

In this county Trenton limestone is being extensively quarried for the production of dimension building stone, lime, crushed stone, stone for chemical use, for asphalt filler, and for agricultural purposes. St. Marc des Carrières is one of the important centres of building stone production in the province, and limestone for the other above-mentioned uses is also quarried there. The limestone, which comprises part of the limestone belt extending from Montreal to below Quebec city, occurs in the St. Lawrence lowland in the southern part of the county (*See* Map No. 757), between the Champlain county boundary and the village of Neuville. From Neuville to the eastern boundary of the county the limestone is overlain by Utica shale. At Grondines and again at Neuville the limestone is exposed on the bank of the St. Lawrence river, but elsewhere it is available only at a distance of 1 to 8 miles from the river, the surface rocks in the intervening area being shales of the Utica and Lorraine formations which overlie the limestone. Pure, medium- to coarse-grained, heavily bedded, high-calcium limestone having a very low content of magnesium carbonate is available at St. Marc des Carrières, Pont Rouge, and Neuville, but elsewhere the limestone is mostly thinly bedded and has a considerable content of siliceous and argillaceous material, but this impure stone also is characterized by a low content of magnesium carbonate. From the map it may be seen that at the three places just mentioned, promontories of Precambrian rock extend southerly into the limestone area. Thick beds of pure limestone are found a short distance to the southwest of each of these promontories, and it is possible that these promontories by deflecting currents in the Trenton sea gave rise to areas of relatively quiet water where calcareous organisms flourished

and where for a time conditions were favourable to the accumulation of the thick beds of pure limestone found in these localities but not elsewhere.

The only Precambrian limestone in this county, known to the writer, is at Notre-Dame-des-Anges, though it is probable that other deposits occur in the northern part.

Grondines

For more than 2 miles eastward from the village of Grondines, thinly bedded, fine-grained, impure Trenton limestone forms a cliff over 100 feet high along St. Lawrence river. About ¾ mile east of the village a quarry was formerly worked in this cliff for the production of crushed stone, which was shipped from a wharf adjacent to the quarry. At this place the limestone is in beds 1 to 8 inches thick, with shale partings. In parts of the face, particularly near the bottom, the shale forms about 25 per cent of the whole. Some of the stone is hard and some is relatively soft with shaly seams all through it. Overburden varies from nil to 3 feet. The beds dip to the southwest at an angle of 2 degrees. Sample 96 taken here consists of pieces taken at intervals of 2 feet up the entire cliff face.

On the south side of the Canadian Pacific railway and 1½ miles east of Grondines station, flat-lying Trenton limestone is exposed over a large, flat area rising from 15 to 25 feet above the level of the track. The limestone is hard, fine-grained, and is dark brownish blue in colour. Irregular films of shale are present in many of the beds. Near the railway the beds are thin, but 300 yards south they are comparatively thick. All the stone smells strongly of petroleum when struck with a hammer. Sample 97 was taken from 12 feet of strata exposed near the track.

Ste. Anne River

From the Champlain county boundary to ½ mile above St. Alban, Trenton limestone dipping southwesterly at low angles is exposed at frequent intervals along the banks of Ste. Anne river. Away from the river valley it is deeply covered by soil. Along the lower part of the river the limestone is thinly bedded, fine-grained, and impure. At St. Alban the river has cut a narrow gorge 50 feet deep in the limestone, but the overburden of sand here is as much as 50 feet thick. Although this limestone is in places heavily bedded the beds are of irregular thickness, and consist of fine-grained, dark blue-grey stone through which are many seams of brown-weathering shale. (Plate IIIB, page 20). A few beds, 6 to 8 inches thick, are composed of medium- to coarse-grained, light grey limestone. Sample 98 was taken from the gorge below the bridge on the road to St. Marc des Carrières.

St. Marc des Carrières

St. Marc des Carrières, 47 miles west of Quebec city, and 5 miles north of St. Lawrence river, has long been an important quarry centre. Records at the village indicate that building stone was quarried there more than 100 years ago and was hauled by wagon to its principal market in Quebec city. Since shipment by rail became possible, the limestone has been widely used in building construction throughout the province of Quebec and to a lesser extent in eastern Ontario and the Maritime Provinces.

PLATE XXI

A. Quarry of Gingras Frères, St. Marc des Carrières, Portneuf county.

B. Quarry of Standard Lime Company, St. Marc des Carrières. Portneuf county.

At the present time the group of quarries at St. Marc ranks third in Canada in production of limestone for building purposes. The village is also an important lime-producing centre, three companies being engaged in the production of lime.

The following companies are operating in this area—

Martineau Fils, Ltée (Morrison Quarry Co.), 517 Marie Anne St. East, Montreal.
Olivier Gauthier, St. Marc des Carrières.
Gingras Frères, Ltée, St. Marc des Carrières.
Deschambault Quarry Corp., 52 St. Paul St., Quebec.
Standard Lime Co., Ltd., Joliette.
Canada Lime & Stone, Ltd., St. Marc des Carrières.
National Stone & Lime Co., 386 Lemoyne St., Montreal.

The quarries are all west and south of the village and close to the line of the Canadian National railway (from which spur tracks are laid to each property) and are opened in a line along the strike of the strata. They are all of the pit type and require pumps to keep them free from water. The prevailing dip of the beds is to the southwest at an angle of 3 degrees, though due to slight undulations and doming of the strata there are local variations in strike and dip. The land surface in this vicinity is almost perfectly flat and 1 to 6 feet of soil lies on top of the limestone now being quarried. Building stone is obtained from a series of thick beds of medium-grained, light brownish grey, pure, high-calcium limestone aggregating 9 to 12 feet in thickness, which is overlain and underlain by fine-grained, harder, and darker coloured limestone in thinner beds that is not suitable for the production of cut stone. The overlying stone is, however, together with waste from the building stone beds, utilized for lime burning, for shipment to pulp mills, and for making crushed stone, asphalt filler, and agricultural limestone.

The area known to be underlain by heavy beds of pure, medium-grained limestone that can be economically quarried, extends 1½ miles in a northwest-southeast direction and is more than ¼ mile wide. To the north and east the heavy beds of pure stone have been removed by glaciation. To the southwest they are covered to an increasing depth by inferior stone. How far they extend to the northwest has not been determined but southeasterly no heavily bedded stone suitable for building purposes has been found beyond the quarry owned by Canada Lime and Stone, Ltd., as only relatively thinly and unevenly bedded stone was encountered in the test pit recently sunk by Deschambault Quarry Corporation, 500 yards to the southeast of the first-mentioned quarry. The stone in this test pit is, however, comparatively pure. As shown in the generalized sections of the strata in the northwest and in the southeast parts of the quarry area, given below, the building stone beds in the northwestern quarries are thicker and more sharply defined from the overlying and underlying stone than in the southeastern quarries. Though the total thickness of medium-grained stone is greater in the southeastern part of the area than in the northwestern part, the individual beds are thinner and the stone contains slightly more impurities.

A generalized section of the strata in the northwestern part of the area as exposed in the Martineau, Gauthier, and Gingras quarries is as follows:—

1 to 6 feet—Soil.
0 to 10 feet—Thinly and unevenly bedded, mostly fine-grained, dark brownish limestone, in some beds of which are numerous small cavities filled with black petroleum.
2 to 8 inches—Seam of sandy, calcareous, blue clay.
9 to 12 feet—Medium-grained light brownish grey limestone in beds from 13 to 46 inches thick and occasionally more. These beds are quarried for building stone.
2 to 8 inches—Seam of sandy, calcareous, blue clay.
8 feet 6 inches—Hard, fine-grained, dark brownish grey limestone in beds 4 to 17 inches thick with numerous thin seams of black, bituminous shale, and containing small cavities filled with black petroleum. (Not at present quarried.)

Sample 99 represents the top 10 feet of strata in the Martineau quarry; Sample 99A represents the building stone beds in the Martineau and Gauthier quarries; and Sample 99B the bottom 8½ feet of hard, fine-grained limestone as exposed in the Gauthier quarry.

The succession of strata in the southeastern part of the St. Marc quarry area is somewhat different from that in the northwestern part as is shown by the following section of the face in the quarry of the Standard Lime Company:—

2 to 4 feet—Soil.
2 to 7 feet—Fine-grained, dark brown limestone in beds of variable thickness, between many of which are sandy seams.
14 feet 6 inches—Medium-grained to rather fine-grained, brownish grey limestone in beds 3 inches to 28 inches in thickness, with one bed at the top 40 inches thick but containing many seams of black bituminous shale.
2 inches—Seam of clay.
5 feet 6 inches—Beds 2 to 12 inches thick, some of which are medium-grained and light brownish grey in colour, others of which are fine-grained, dark, and contain shaly seams.
8 feet—Mostly thin beds of fine-grained, dark brown limestone some of which is fairly siliceous. This stone is not used for making lime.

Sample 100 represents the top 7 feet of strata; Sample 100A, the next 14½ feet of strata; Sample 100B, the 5½-foot section next to the bottom; and Sample 100C, the lowest 8 feet of strata exposed, but which is not used for making lime.

The active quarries in the St. Marc area are briefly described in the following paragraphs. More detail on the operations of the building stone quarries is given in a previously issued report, "Canadian Limestones for Building Purposes."[1] The quarries are described in order of geographical location, beginning with the most westerly quarry.

Martineau Fils, Ltée (Morrison Quarry Company), 517 Marie Anne St. E., Montreal. This company quarries building stone on the southwesterly part of lot 12, St. Alban parish. A spur track from the Canadian National railway runs through the centre of the property, and quarrying is carried on in what are in effect two separate quarries, one on either side of the track. On the northwest side of the track an opening 300 feet long by 180 feet wide has been made and is being advanced up the dip to the northeast. On the opposite side of the track the stone has been

[1] Mines Branch, Dept. of Mines, Canada, Rept. No. 733, pp. 38-54 (1933).

quarried over an area of 650 feet long by 130 feet wide and the working-face is being advanced down the dip to the southwest. At the northeast end of this quarry there is no fine-grained, dark-coloured stone on top of the building stone beds, but at the opposite end there is a thickness of 10 feet of this type of stone. This top stone, together with waste from the building stone beds, is marketed for use in sulphite-pulp mills. Dimension stone is shipped by rail to the company's cut-stone plant in Montreal.

Olivier Gauthier, St. Marc des Carrières. The property of O. Gauthier immediately adjoins that of Martineau Fils. The quarry is 300 feet wide and 800 feet long and is being advanced southwesterly, or down the dip. A siding from the Canadian National railway, 500 feet distant, runs along the eastern edge of the excavation. Twelve feet of heavily bedded building stone is quarried here. The building stone beds are overlain at the working-face by 4 feet of thinly bedded, dark, fine-grained limestone and a pit has been sunk to a depth of 8½ feet in the thinly bedded, fine-grained, dark limestone beneath, but this lower face is not now worked. The building stone is cut before being shipped, the cutting being done mostly by hand. Waste from the quarry and from stone-cutting operations, together with the top stone, is shipped for use in sulphite-pulp mills.

Gingras Frères, Ltée, St. Marc des Carrières. This quarry adjoins that of Olivier Gauthier and is being worked up the dip, or to the northeast, across a width of 175 feet. Twelve feet of heavily bedded stone overlain by 9 feet of thinly bedded stone and by 2 to 3 feet of soil is exposed in the quarry (Plate XXIA, page 142). A spur track is laid along the northwest side of the quarry. Building stone is the main product, but a large quantity of the waste stone is sold for use in sulphite-pulp mills. Building stone is cut on the property and shipped in the finished state.

Deschambault Quarry Corporation, 52 St. Paul St., Quebec. This company produces building stone, crushed stone, asphalt filler, and agricultural limestone. The plant is situated just south of St. Marc station and until 1931 a shallow quarry was also worked near the plant, but owing to the increasing depth of soil (over 12 feet) encountered in the quarry, and to the fact that the desirable stone had been removed by glaciation over much of the property, the quarry was abandoned and blocks of dimension stone are now obtained from the quarry of the Canada Lime & Stone, Ltd., about 300 yards to the southeast. The Deschambault Quarry Corporation sank a test pit in an outcrop of medium-grained, light-brownish grey limestone east of the highway and ¾ mile southeast of the former quarry, but the stone at that locality proved to be thinly and unevenly bedded and to consist in part of dark-coloured, fine-grained limestone, and not suitable for building purposes. The company has a stone-dressing plant and also a crushing and pulverizing plant for the making of road metal, asphalt filler, and agricultural limestone. Stone is also marketed for use in sulphite-pulp mills.

Standard Lime Co., Ltd., Joliette. The St. Marc plant and quarry of this company are 300 yards southeast of St. Marc station on the Canadian National railway and the property adjoins that of the Deschambault Quarry Corporation. The quarry (Plate XXIB, page 142) is fan-shaped and has been extended for 600 feet southerly from the foot of the incline

leading to the kilns, and the curved working-face is about 600 feet in length. A section of the 33 feet of strata exposed in the quarry is given on page 144. Jackhammers are used for drilling and the quarry is worked in benches. The blasted stone is loaded by hand into side-dump steel cars, running on narrow gauge tracks that radiate from the foot of the incline to various parts of the quarry face. The cars are pulled to the incline by horses. An electric hoist pulls them up the incline to the top of the kilns.

At present the quarry is not being worked and is full of water, the stone for making lime being purchased from neighbouring building stone quarry companies or from farmers who have high-grade limestone available on their farms.

The lime plant consists of 8 vertical, externally fired, continuous, steel kilns having a combined capacity of 90 tons of quicklime per 24 hours. Coal is used for fuel. The lime, which is of a brownish grey colour, is all sold in lump form either in bulk or packaged in barrels. A small crushing plant is also erected near the lime plant but has not been in operation for a number of years.

Canada Lime & Stone, Ltd., St. Marc des Carrières. This company operates a lime plant 100 yards northwest of St. Marc station and owns two quarry properties—one at the site of the lime plant, the other immediately southeast of the property of the Standard Lime Company. At the present time, however, the company is purchasing stone for the making of lime from farmers who have pure limestone available on their farms.

In the small quarry adjacent to the kilns, on lot 5, parish of St. Alban, 4 feet of medium-grained, light brownish grey limestone is exposed beneath 6 feet of soil. Sample 101 represents the 4 feet of stone. This quarry has not been worked for a number of years.

The lime plant, situated close to this quarry, consists of two vertical, externally fired, continuous, steel kilns having a combined capacity of 16 tons of quicklime per 24 hours. Coal is used for fuel. The lime is marketed as quicklime in lump form.

In the quarry owned by the Canada Lime & Stone, Ltd., adjoining that of the Standard Lime Co., the strata vary somewhat in thickness throughout the length of the 500 feet of working-face that has been developed here, but an average section of the face is as follows:—

3 to 5 feet—Soil.
6 to 9 feet—Thin beds of limestone of variable texture and colour, interbedded with seams of sand.
8 feet 6 inches—Beds of medium-grained, light brownish grey stone up to 30 inches in thickness, though in places two beds may be joined together giving a greater thickness than 30 inches.
2 feet 6 inches—Bed containing many thin seams of black, bituminous material.

Waste stone from this quarry is converted into crushed stone and agricultural limestone in a small crushing and pulverizing plant erected on the property. A siding is laid from the Canadian National railway to the quarry, but the large blocks quarried for the Deschambault Quarry Corporation are transported to that company's mill on special horse-drawn wagons.

National Stone & Lime Co., 386 Lemoyne St., Montreal. This company's plant and property are 800 yards southeast of the railway station

at St. Marc and a short distance southwest of the highway. A siding serves the plant, which consists of one vertical, externally fired, continuous, steel kiln having a capacity of 9½ tons of lime per 24 hours. Coal is used for fuel. A small quarry, which was nearly full of water when the property was visited, is opened at the foot of the incline leading to the top of the kiln. About 4 feet of stone overlain by 4 feet of soil was visible in the quarry. The stone is in part fine-grained and in part coarse-grained and is in irregular beds 4 to 14 inches thick.

In addition to the quarries above mentioned there are many shallow, abandoned quarries in the neighbourhood of St. Marc, and also a number of small quarries on farms from which stone is taken to sell to the lime companies. These small quarries are all opened in the medium-grained, light brownish grey, pure limestone.

Outcrops of limestone are to be seen northeast of the village along the road between St. Marc and St. Casimir.

Between St. Marc and Deschambault Station there are many outcrops of limestone along the road known as the " Old Quarry Road " and several small quarries have been worked in that area.

Deschambault Station

Many outcrops of Trenton limestone are to be seen along the southern margin of the great tongue of Precambrian rock that extends southerly to within 1½ miles of St. Lawrence river at Deschambault. Where the limestone is in contact with the granitic rock it is sandy and contains many pebbles of the older rocks. The limestone beds lie almost horizontally. On the north face of the hill, 1 mile southwest of Deschambault Station on the Canadian Pacific railway, alternate beds of medium-grained and fine-grained limestone are exposed on the upper slopes, but beneath this the limestone is fine-grained, dark brownish grey and is in thinner beds with shale between. A thickness of 22 feet of the lower beds is exposed in a small quarry at the base of the hill near the Canadian Pacific railway, ½ mile west of Deschambault Station. Several horizontal seams of sand and clay are seen in the quarry face. Sample 102 was taken from the beds near the top of the hill, and Sample 102A from the 22-foot thickness of the beds exposed in the quarry face, exclusive of shale.

St. Basile

At the road bridge over Portneuf river north of St. Basile station on the Canadian National railway, a thickness of 3½ feet of thinly bedded, hard, dark brownish grey limestone streaked with shale and having thick shale partings between the beds, is exposed beneath a heavy overburden of sandy soil. The stone is impure as shown by the analysis of Sample 103 which was taken here.

Pont Rouge

To the south of Pont Rouge village, Trenton limestone is exposed in the valley of Jacques Cartier river where it has been quarried to a small extent for building stone and for making lime. North of Pont Rouge only Precambrian rocks are to be seen, the contact between the Trenton limestone and the Precambrian granitic rock being just above the Canadian Pacific railway bridge. At the village the limestone is thin-bedded, contains relatively thick interbeds of shale, and is impure, as is shown by

the analysis of Sample 104, which represents 18 feet of strata exposed in the river just below the railway bridge. Farther down stream, ¼ mile below the paper mill, the limestone is heavily bedded and comparatively pure. Beds up to 6 feet thick are to be seen but they are composed of alternate bands of medium-grained, grey limestone and fine-grained, dark brownish blue limestone, with an occasional band of shaly stone. All is very fossiliferous. Sample 105 represents the pure, medium-grained stone. Sample 105A is a channel sample of 13 feet of strata including the fine-grained stone and shaly bands as well as the medium-grained stone. On the east bank of the river below Pont Rouge, *Arthur Boivin* burns lime for local use in a small field kiln. A short distance from the channel of the river there is a heavy overburden of sandy soil, but in places there is a width of about 100 feet on either side of the channel where there is no overburden and where small-scale quarry operations could be carried on. The dip of the strata varies from place to place owing to gentle undulations in the strata, but the prevailing dip is to the southwest at a low angle.

Sample 106 was taken from 15 feet of heavily bedded limestone exposed in the banks of the river at the road bridge, 1 mile in a straight line south of Pont Rouge. The limestone is similar to that below the paper mill at Pont Rouge and the dip is to the southwest at a low angle.

Neuville

In the vicinity of the village of Neuville, Trenton limestone is exposed along the shore of St. Lawrence river and is traceable northerly along the west side of a spur of Precambrian rock for a distance of 6 miles. East of Neuville to beyond the eastern boundary of Portneuf county the Trenton is overlain by Utica and Lorraine shales. Preparations were at one time made to manufacture Portland cement from the limestone at this village but the plant was not completed. In recent years the limestone was quarried for road metal on the north side of the highway at the eastern end of the village, and many years ago a small quarry was worked on the property of Wilfred Gauvin on top of the ridge ½ mile to the north.

On the road to the wharf, thinly bedded, fine-grained, dark brownish blue limestone in beds up to 5 inches thick, separated by thin beds of calcareous shale, is exposed in a cliff, and somewhat heavier beds are exposed on the beach at low tide. Sample 107 was taken from the cliff, the shale beds being excluded. The average dip of the strata is to the southwest at an angle of 3 or 4 degrees.

Along the beach east of Neuville, thinly bedded, fine- to medium-grained limestone, interbedded with black shale, is exposed in a cliff over 50 feet high. Near the contact with the shale a quarry was at one time opened in limestone. Sample 108 was taken in this quarry excluding the shale beds.

Quarry of Doré & Naud, Neuville. This quarry, which has not been worked for the past 2 years, is at the eastern end of the village on the north side of the highway to Quebec. It is of the side-hill type and has been worked back 200 feet into the hillside across a width of 125 feet. In all about 35 feet of strata are exposed. At the entrance to the quarry the beds dip toward the river at a low angle but in the quarry proper they dip in the opposite direction at an angle of 8 degrees. The top 20 feet of

stone is in uneven beds up to 5 inches thick with very thin shale partings; most of it is fine-grained and dark brownish blue but some beds are medium-grained and others are in part fine-grained and in part medium-grained. In the lower 15 feet, beds of medium-grained, brownish grey stone, in general thicker than the top beds, alternate with fine-grained beds. Sample 109 was taken from the top 20 feet, and Sample 109A from the bottom 15 feet. A small crushing plant is situated at the entrance to the quarry.

In the cutting on the Canadian National railway on the hillside 200 yards north of the quarry, rubbly, thin-bedded, fine- to medium-grained, rather shaly limestone is exposed beneath 1 foot of soil. On the south side of the cutting the beds dip southwesterly at an angle of 8 degrees but on the north side the dip is in the opposite direction. Sample 110 was taken from the 15 feet of strata exposed.

On top of the ridge 700 yards north of the railway a soft, coarse-grained, heavily bedded, dark grey, fossiliferous limestone containing much bituminous matter is exposed over a considerable area and has been quarried to a small extent. The beds here also have a slight anticlinal structure and dip gently in both directions from the crest of the ridge, which crest trends locally N.70°W. Sample 111 was taken from 8 feet of coarse-grained stone exposed in a small quarry. This coarse-grained limestone seems to be surrounded in all directions by finer grained stone. All over this ridge the overburden is very light and outcrops are numerous.

Notre-Dame-des-Anges

A peculiar variety of impure dolomite that glows when struck with a hammer, or other hard object, is found in the now idle Tétreault lead-zinc mine in Montauban township, 6 miles by road south of Notre-Dame-des-Anges on the Canadian National railway. This limestone, which is locally known as *fire stone,* is of a dirty white colour, fine- to medium-grained, and of a sugary texture. The analyses of two hand specimens are as follows:—

No. 1

	Per cent
Insoluble	17·50
Oxides of iron and alumina	1·00
Calcium carbonate	43·80
Magnesium carbonate	35·80
	98·10

No. 2

	Per cent
Silica	4·52
Ferric oxide	0·62
Alumina	1·40
Calcium oxide	40·51
Magnesium oxide	11·83
Carbon dioxide	39·62
Water	0·74
	99·24

In many places the limestone is much mashed, and the bright sheen of the flattened crystal faces gives it a sericitic appearance.

Analyses of Portneuf County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
96.....	10·82	0·43	1·57	0·17	84·96	1·76	99·71	0·08	47·58	0·84	57 : 1
97.....	4·88	0·51	0·76	0·15	91·36	1·74	99·40	0·03	51·24	0·83	62 : 1
98.....	2·60	0·39	0·41	0·39	96·14	0·53	100·46	0·03	54·05	0·25	218 : 1
99.....	1·01	0·45	0·43	0·68	95·07	0·74	98·38	0·12	53·61	0·35	153 : 1
99A.....	0·36	0·15	0·01	0·35	97·59	0·69	99·15	0·02	54·84	0·33	166 : 1
99B.....	1·20	0·22	0·41	0·24	96·53	0·59	99·19	0·06	54·19	0·28	193 : 1
100.....	1·46	0·19	0·17	0·22	95·91	0·69	98·64	0·04	53·83	0·33	163 : 1
100A.....	0·64	0·20	0·04	0·44	96·87	0·65	98·84	0·03	54·49	0·31	176 : 1
100B.....	1·52	0·27	0·16	0·20	96·14	0·99	99·28	0·08	53·95	0·47	115 : 1
100C.....	2·96	0·45	0·30	0·24	93·86	1·53	99·34	0·13	52·69	0·73	72 : 1
101.....	1·00	0·60	0·20	0·66	96·79	0·63	99·88	0·07	54·56	0·30	182 : 1
102.....	1·32	0·26	0·24	0·11	97·34	0·63	99·90	0·06	54·57	0·30	182 : 1
102A.....	6·18	0·46	0·98	0·24	90·25	1·81	99·92	0·12	50·67	0·86	59 : 1
103.....	7·46	0·64	2·10	0·22	86·64	1·11	98·17	0·17	48·64	0·53	92 : 1
104.....	6·86	1·61	1·45	0·17	88·79	0·88	99·76	0·26	49·81	0·42	119 : 1
105.....	0·56	0·27	0·29	0·13	97·38	1·20	99·83	0·03	54·60	0·57	96 : 1
105A.....	1·52	0·39	0·35	0·17	95·96	0·97	99·36	0·08	53·83	0·46	117 : 1
106.....	1·14	0·81	0·73	0·20	94·11	1·43	98·42	0·11	52·81	0·68	78 : 1
107.....	9·88	0·86	1·52	0·15	85·50	1·07	98·98	0·10	47·96	0·51	94 : 1
108.....	3·00	0·21	0·23	0·15	94·93	0·71	99·23	0·06	53·24	0·34	157 : 1
109.....	8·84	0·44	1·28	0·31	87·00	1·68	99·55	0·12	48·89	0·80	61 : 1
109A.....	4·58	0·40	0·41	0·37	93·61	0·86	100·23	0·08	52·62	0·41	128 : 1
110.....	6·02	0·44	1·18	0·24	90·55	1·05	99·48	0·16	50·84	0·50	102 : 1
111.....	0·60	0·47	0·03	0·13	98·23	0·38	99·84	0·06	55·08	0·18	306 : 1

96.	Grondines.	Cliff on St. Lawrence river east of the village.
97.	"	South side of C.P.R., 1½ miles east of the village.
98.	St. Alban.	Gorge of Ste. Anne river at St. Marc road.
99.	St. Marc des Carrières.	Top 10 feet of strata in quarry of Martineau & Fils, Ltée.
99A.	"	Average of building stone beds in the Martineau and Gauthier quarries.
99B.	"	Bottom 8½ feet of strata in the Gauthier quarry.
100.	"	Top 7 feet of strata in Standard Lime Co. quarry.
100A.	"	Next 14½ feet of strata in " " "
100B.	"	Next 5½ feet of strata in " " "
100C.	"	Bottom 8 feet of strata in " " "
101.	"	Four feet of stone in quarry of Canada Lime & Stone, Ltd., near station.
102.	Deschambault Station.	Upper strata on top of hill ½ mile west of the railway station.
102A.	"	Lower beds as exposed in quarry in same locality.
103.	St. Basile.	Bank of Portneuf river at road bridge.
104.	Pont Rouge.	Thinly bedded strata in bank of Jacques Cartier river just beneath the railway bridge.
105.	"	Medium-grained beds in small quarry on bank of Jacques Cartier river ¼ mile below the paper mill.
105A.	"	Channel sample at same locality including both medium-grained, pure stone and the less pure stone.
106.	"	Limestone in river bank at road bridge 1 mile south of the village.
107.	Neuville.	Cliff face on road to wharf.
108.	"	Quarry on beach east of the village.
109.	"	Top 20 feet of strata in Doré & Naud quarry.
109A.	"	Bottom 15 feet " "
110.	"	Cutting on C.N.R. at eastern end of the village.
111.	"	Coarse-grained stone in small quarry on top of ridge at eastern end of the village.

Quebec County

The available limestone resources of this county are found in an area of Trenton limestone between Loretteville and Montmorency river, just south of the Precambrian escarpment. The limestone apparently underlies an area 11 miles long and from 1 to 4 miles wide. From Loretteville to Bourg Royal, limestone exposures are found over a strip of country averaging 1¼ miles in width, but east of the latter place the limestone area widens and between Giffard and Montmorency river it extends southerly nearly to St. Lawrence river. To the north and east the limestone is seen to be in contact with Precambrian rocks, and to the south and west it is overlain by the shale. The lower beds as seen at Loretteville, Bourg Royal, and Montmorency river, are composed of fairly pure calcium limestone averaging between 3 and 4 per cent total impurities, but the upper beds near the contact with the shale consist of hard, fine-grained, and siliceous calcium limestone with an average of 12 per cent total impurities exclusive of shale interbeds. In only two samples taken in this area does the content of magnesium carbonate exceed 2 per cent. Quarries are worked in the more impure types at Giffard and Charlesbourg West for the production of crushed stone, rubble and riprap, and agricultural limestone. Formerly it was also quarried for building stone—much rock-face ashlar and foundation stone in buildings in Quebec and in neighbouring towns having come from these quarries. Small quantities of lime for local use are made by the farmers at several places.

Loretteville

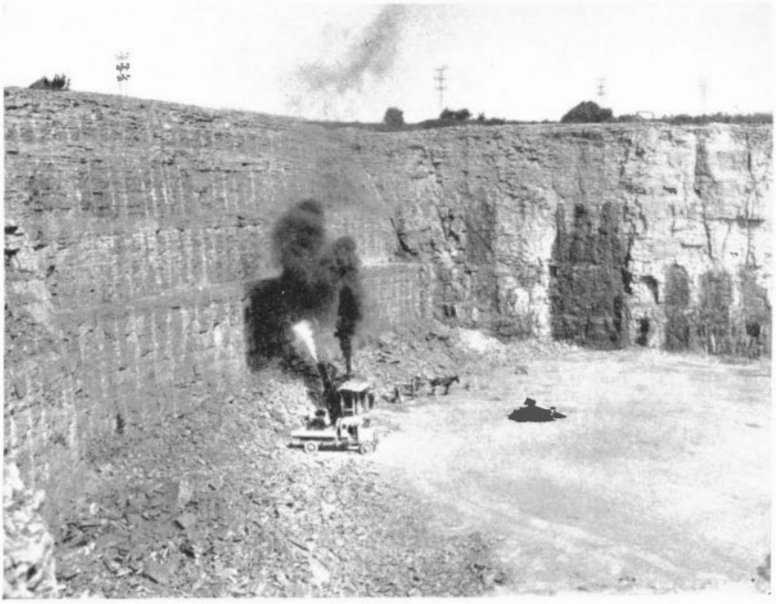
On the property of A. T. Dacre, at the southwest edge of the village the Trenton limestone is seen resting on Precambrian rock and it has been quarried here in small quantity for road metal. The limestone is fine-grained, brittle, dark brownish grey and occurs in rather heavy, uneven beds through which runs a network of shale seams. It is apparently sharply folded, for, on the east side where it is in contact with the Precambrian rock it strikes N. 30° E. and dips northwesterly at an angle of 30 degrees. Nearer the road it dips southerly at an angle of 44 degrees. Sample 112 is representative of the stone exposed.

In the gorge of St. Charles river south of Loretteville, fine- to medium-grained, dark brownish grey nodular limestone, much of which is similar to that on the Dacre property, is seen resting directly on the Precambrian rock and dipping southward at angles of from 10 to 30 degrees. The bottom beds are heavier, coarser grained and more fossiliferous than the upper beds. A network of shale is present in much of the stone giving it a nodular appearance on weathered surfaces. Shale also occurs between the beds, particularly in the upper part. Sample 113 was taken from over 100 feet of the strata nearest the bridge. There is an apparent thickness of at least 400 feet of limestone strata here, though it is possible that there is some repetition due to faulting.

Charlesbourg West

Quarry of Joseph Pagé, Charlesbourg West. The quarry (Plate XXII A, page 152) operated by Mr. Pagé for the production of crushed stone and rubble, is ½ mile east of the village on the northeast side of the road to

A. Trenton limestone in Joseph Pagé quarry, Charlesbourg West, Quebec county. This quarry is worked for crushed stone and rubble.



B. Thinly and evenly bedded Trenton limestone in quarry of Elzéar Verreault, Ltée, Giffard, Quebec county.

Charlesbourg. The quarry is 400 feet long by 250 feet wide and in it a maximum thickness of 36 feet of nearly flat-lying, fine-grained, dark brownish blue, siliceous calcium limestone in beds 2 to 8 inches thick with partings of hard, black shale, is exposed beneath about 2 feet of soil. Along the south edge of the quarry the Utica shale is seen in sharp faulted contact with the limestone, the fault plane trending N. 70° E. and dipping at an angle of 60 degrees to the southeast. In some of the limestone beds a variation in grain size is observable and some have thin, shaly seams parallel to the bedding. Sample 114 is representative of the stone in the quarry face.

Jackhammers are used for drilling the stone and the quarry face is worked in 6-foot benches. Broken stone is loaded by hand to horse-drawn carts for conveying to the crusher. Squared rubble for building purposes is cut in the quarry and shipped by motor truck. Two small crushing plants with a combined capacity of 35 tons an hour are in use, one being in the quarry and the other just at the entrance. Fine screenings from the crushers are sold for agricultural use. Motor trucks are used for shipping the crushed stone. A branch of the Canadian National railway passes just south of the quarry.

On the hillside ⅓ mile northwest of the Pagé quarry a small pit was at one time opened in thinly bedded, fine-grained limestone having relatively thick shale seams between the beds.

Where the road to Loretteville crosses rivière du Berger, 1½ miles west of the Pagé quarry, thinly bedded, fine-grained, dark brownish blue limestone is seen in the river bed. At the road bridge it lies nearly flat but a short distance downstream the dip suddenly increases to 30 degrees in a southerly direction. Sample 115 was taken here from 10 feet of strata excluding the interbedded shale. These beds are somewhat lower in the series than those at the Pagé quarry and, as shown by the analysis, are somewhat purer.

Charlesbourg

One-half mile north of the village on the east side of the road to Rivière Jaune is a small abandoned quarry once worked for road metal and for stone for lime burning. In it 8 feet of medium- to fine-grained, dark brown limestone in uneven beds 2 to 12 inches thick is visible above the water. On top of this is 2 feet of fine-grained, hard, blue limestone in beds 2 to 5 inches thick. The brown limestone is quite pure as shown by the analysis of Sample 116 but the blue stone is more siliceous. Calcite crystals are numerous in vugs and joint planes in the brown limestone which on being pounded gives off a decidedly oily odour. Depth of soil in the vicinity varies from 2 to 5 feet. Several other small openings have been made in the past in this brown limestone to obtain stone for making lime, and it is stated that the lime was light-coloured and of good quality.

Bourg Royal

Three-quarters of a mile southeast of the crossroads at the village along the road to Giffard, 10 feet of hard, tough, fine-grained, dark brownish blue limestone in beds 2 to 9 inches thick, with very little shale between, is exposed in a small quarry. The dip is southerly at about 5 degrees. Sample 117 was taken from the 10 feet of stone exposed.

Quebec City

The city of Quebec is largely underlain by a series of rocks, known as the Quebec group (Ordovician) consisting of limestone, limestone conglomerate, and shale. The limestone is siliceous, fine-grained, and dark grey in colour. Some is magnesian but the major part is of the calcium type.

Giffard

Nearly flat-lying, fine-grained, dark brownish blue, impure calcium limestone in thin beds with hard, black, bituminous shale between, is exposed in an escarpment along the west bank of Beauport river, just north of the village of Giffard, and is being quarried for crushed stone, rubble, and riprap in two large quarries.

Quarry of Elzéar Verreault, Ltée, 194 Bridge Street, Quebec. In this quarry, which extends 300 feet northerly into the cliff and 500 feet along the side of it, 90 feet of impure, hard, fine-grained, dark brownish blue limestone is exposed (Plate XXII B, page 152). The beds vary from 1 to 7 inches in thickness but those of 2 and 3 inches predominate. Between each is a layer of hard, black shale, and a thin seam of shale occurs in the centres of most of the beds. The stone in the lower 50 feet of the face is somewhat harder than that in the upper part. Back of the quarry the land rises in a series of benches and the soil cover is very thin. In the eastern part of the excavation the strata dip easterly at an angle of 5 degrees, but in the western half the strata are level. Sample 118 is representative of the stone in the entire face.

The quarry is worked by jackhammers in a series of 20-foot benches and at present is being extended westerly. Stone for crushing is loaded by a steam shovel, with a $\frac{7}{8}$-yard dipper, into 4-ton, self-dumping, steel-body trucks, of which the company owns five, and taken to the crushed stone plant, which is situated at the entrance to the quarry and which has a capacity of 80 tons per hour. Screenings are pulverized for agricultural use in a small grinding plant operated in connection with the main plant. The products of the quarry—crushed stone, rubble, riprap, and agricultural limestone—are shipped by motor truck.

Carrière Giffard, Ltée, 71 St. Peter Street, Quebec. The quarry operated by this company for the production of crushed stone and rubble is a short distance northeast of the Verreault quarry and is opened in lower beds than the latter, the floor of the Verreault quarry being at about the same elevation as the top of the face in the Giffard quarry. The quarry has been worked into the hill for about 400 feet and is about the same in width. A face of 55 to 60 feet of thinly bedded limestone is exposed, of which the top 45 to 50 feet is similar to that in the Verreault quarry, but the bottom 10 feet is very thinly bedded and very shaly. Sample 119 is from the top 45 feet of strata and Sample 119A from the bottom 10 feet. The strata strike N.30°E. and dip westerly at an angle of 4 degrees.

Jackhammers are used for drilling the stone for blasting, 20-foot benches being worked. Stone is loaded by hand to trucks for conveyance to the crushing plant which is located at the entrance to the quarry. This

plant has a capacity of 50 tons of crushed stone an hour. A siding from the electric line of the Quebec Railway, Light, and Power Company serves the plant, but practically all the quarry production is now shipped by motor truck.

Beauport

North and northeast of Beauport are many outcrops of thinly bedded limestone similar to that quarried at Giffard and many small quarries for the production of rubble and of stone for lime burning have been opened, but there is no steady production.

Montmorency

Along the west side of Montmorency river fine-grained, dark blue, thin-bedded limestone interbedded with a coarse-grained, dark brownish variety, is exposed at the falls, and similar stone probably underlies a considerable area in the vicinity. Sample 120 represents the stone in the river bank at the falls.

Analyses of Quebec County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
112.....	2·52	0·74	1·22	0·24	93·09	1·28	99·09	0·16	52·26	0·61	86 : 1
113.....	2·40	0·37	0·89	0·20	94·02	1·41	99·29	0·28	52·76	0·67	79 : 1
114.....	10·76	0·78	1·58	0·17	84·20	1·43	98·92	0·15	47·24	0·68	69 : 1
115.....	7·26	0·43	1·35	0·15	88·52	1·03	98·74	0·14	49·65	0·49	101 : 1
116.....	1·24	0·23	0·63	0·26	95·39	1·76	99·51	0·05	53·56	0·84	64 : 1
117.....	3·99	0·42	0·40	0·20	92·59	1·62	99·22	0·05	51·96	0·77	67 : 1
118.....	10·48	0·77	1·71	0·20	82·75	2·42	98·33	0·15	46·45	1·16	40 : 1
119.....	9·78	1·02	1·74	0·20	84·16	1·83	98·73	0·18	47·24	0·87	54 : 1
119A.....	17·88	1·13	4·07	0·22	72·18	2·42	97·90	0·28	40·54	1·15	35 : 1
120.....	3·82	0·39	0·77	0·20	92·39	1·43	99·00	0·05	51·85	0·68	76 : 1

112.	Loretteville.	Property of A.T. Dacre.
113.	"	Gorge of St. Charles river below bridge.
114.	Charlesbourg West.	Quarry of Jos. Pagé.
115.	"	Bank of Berger river below bridge.
116.	Charlesbourg.	Abandoned quarry ½ mile north of the village.
117.	Bourg Royal.	Quarry on road to Giffard ¾ mile south of Bourg Royal.
118.	Giffard.	Ninety feet of strata in quarry of Elzéar Verreault, Ltée.
119.	"	Top 45 feet of strata in Giffard quarry.
119A.	"	Bottom 10 feet " "
120.	Montmorency.	West side of Montmorency river.

St. Maurice County

No readily accessible limestone of good quality is known in this county. The limestones of the Beekmantown, Chazy, and Trenton formations that cross the county in a belt 2 to 4 miles wide just southeast of the Precambrian, or Archaean escarpment, are visible only in the beds of the rivers that have cut steep-sided valleys through the heavy covering of soil. Pure Trenton limestone is seen in the valley of Yamachiche river northeast of St. Barnabé, and impure magnesian limestone of Beek-

mantown age is visible in the west bank of the St. Maurice river a short distance south of the Canadian Pacific railway bridge. In the Precambrian area to the north, a few bands of highly metamorphosed limestone of the Grenville series are reported, but the only deposits near transportation—those near St. Boniface station on the Canadian National railway—are very siliceous, graphitic, and contain many inclusions of other rock. White, micaceous Grenville limestone is reported[1] to occur on Mattawin river in the far northern part of the county.

St. Barnabé

Where the road crosses Yamachiche river 2 miles northeast of the village, pure, medium-grained, fossiliferous, brownish grey, high-calcium limestone is exposed in the river bed to a depth of 6 feet. Sample 92 was taken there. The river banks of soil rise steeply to a height of over 50 feet above the limestone, and stone can be quarried from the bed of the river only when the water is low. The beds range from 4 to 16 inches in thickness and dip to the southwest at an angle of 2 degrees.

Shawinigan Falls

At Shawinigan Falls the largest lime plant in Quebec is operated by Shawinigan Chemicals, Ltd., in connection with the plant for making calcium carbide. The limestone used is brought by rail from the company's quarry near Bedford, Missisquoi county (see page 219). The lime plant consists of 3 rotary kilns having a combined capacity of 300 tons of lime per day. Each kiln is equipped with a waste-heat boiler. Screened limestone ranging in size from 2 inches to 9 mesh is fed to the kilns by automatic feeders. Powdered coal, pulverized in ball mills so that 90 per cent will pass a 200-mesh screen, is used for fuel. The burnt lime from each kiln passes to a cooler sprayed with water, from which it is discharged to a conveyer and taken to a storage bin from which it is withdrawn for use in the carbide plant. By the process now used by Shawinigan Chemicals, Ltd., in generating acetylene gas, a dry hydrated lime is obtained as a by-product, and part of this hydrate is sold for commercial use.

Analysis of St. Maurice County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
92.....	0·77	0·33	0·41	0·37	96·96	0·57	99·41	0·03	54·50	0·27	202 : 1

92. St. Barnabé. Limestone in bed of Yamachiche river 2 miles northeast of village.

Soulanges County

The major part of Soulanges county is underlain by sandy Beekmantown dolomite as shown on Map No. 757 in the pocket of this report.

[1] Geol. Surv., Canada, Rept. Prog. 1888-89, p. 35A.
Geol. Surv., Canada, Rept. Prog. 1895, p. 43A.

In the extreme western corner of the county there is a small area underlain by the Black River and Chazy limestones, but overburden of clay soil is heavy and no outcrops were seen. The Beekmantown dolomite too is rarely exposed, but along the upper part of the Soulanges canal is a rather extensive area where it is only lightly covered with soil, and in this area it has been quarried for road metal at two places between Coteau Landing and Coteau du Lac, but no quarries are regularly operated.

Coteau Landing

About ¾ mile north of the Canadian National railway (Grand Trunk) at Soulanges Station, and ½ mile west of the highway paralleling the Soulanges canal, a quarry has been opened in the Beekmantown dolomite to obtain road metal. The stone is hard, brittle, very fine-grained, dark grey in colour and is in flat beds up to 2 feet 10 inches in thickness. Large crystals of opaque calcite and dolomite are present in some of the stone, and shale partings occur between the beds. Sample 31 was taken from 6 feet of strata exposed in the quarry.

Coteau du Lac

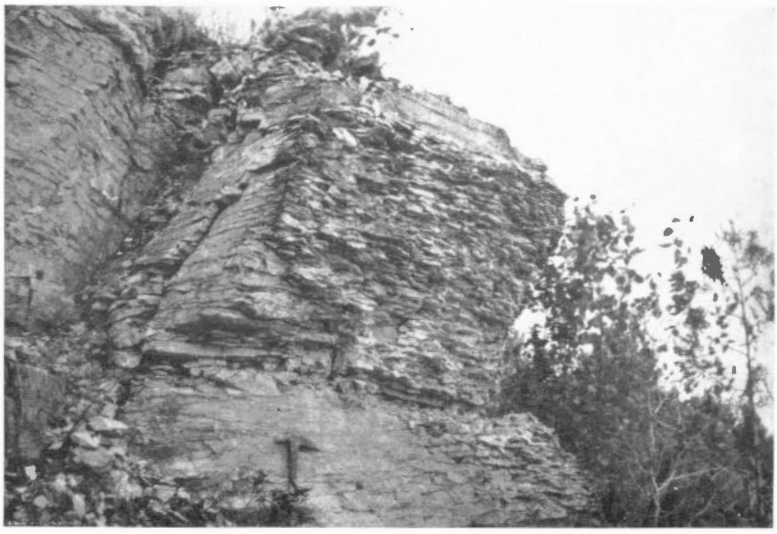
About ¼ mile west of where the Soulanges canal passes over Delisle river, an extensive quarry was formerly worked for road metal in the Beekmantown dolomite by Quinlan and Robertson, Ltd. of Montreal. The quarry is now flooded, but about 9 feet of flat-lying strata are visible above the water. The top 7 feet of stone in places is all in one bed but in other places it is split into two or three beds; it is fine-grained, dark grey with a brownish cast, and contains many geodes of calcite and dolomite. Beneath this is thinly bedded, very fine-grained dolomite of a darker colour than the top stone, and with thin partings of shale between the beds. All the stone is hard and tough and, though the top stone contains less impurities than the thinly bedded stone, even it is impure as is shown by the analysis of Sample 32 which represents the top 7 feet. Sample 32A represents the 2 feet of thinly bedded stone beneath the heavily bedded stone. Overburden in the vicinity of the quarry averages about 7 feet in thickness and the land is bush-covered.

Analyses of Soulanges County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
31.....	9·56	1·88	0·46	0·11	50·62	37·61	100·24	0·19	28·35	18·07	1·57 : 1
32.....	4·68	1·08	0·16	0·02	53·45	40·40	99·79	0·05	29·94	19·32	1·55 : 1
32A.....	10·10	1·51	2·39	0·07	47·13	36·70	97·90	0·45	26·43	17·55	1·51 : 1

31. Coteau Landing. Six-foot face in small quarry ¾ mile north of Soulanges station.
32. Coteau du Lac. Top 7 feet of heavily bedded stone in quarry ¼ mile west of Delisle river and north of the Soulanges canal.
32A. " Two feet of thinly bedded dolomite beneath the heavily bedded stone in the same quarry.

PLATE XXIII



A. Thinly bedded Silurian limestone, near top of cliff on east side of Burnt island in lake Timiskaming.

B. Silurian dolomite overlain by thinly bedded calcium limestone of the same age. east side of Burnt island in lake Timiskaming.

Témiscamingue County

The only known accessible limestone deposit of commercial size in this county is on Mann island, or Burnt island as it is sometimes called, on the Quebec side of lake Timiskaming opposite the town of Haileybury. This island, 3 miles long, 1 mile wide, thickly wooded and uninhabited, is composed of Silurian limestone of a type similar to that found in a large outlier of Palæozoic rocks on the Ontario side of the lake. This outlier has been described by G. S. Hume.[1]

No very pure limestone is available on the island. Much of it is magnesian in character, some being true dolomite. Exposures are seen at several places around the shore, but the principal exposures are on the east side where formerly the limestone was quarried in small quantity for making lime and for rough building stone. At the site of the old lime kilns the following succession of strata is visible:—

25 feet—Very thinly bedded, soft, fine-grained, buff, calcium limestone containing some silicified fossils and crystals of secondary calcite. Sample 1 represents this part of the section.

2 feet 6 inches—Yellowish brown, shaly stone.

7 feet—Impure, sandy, thinly bedded, buff limestone, similar in appearance to the top stone. Sample 1A was taken from this section.

3 feet 6 inches—Impure, argillaceous, thinly laminated, buff, dolomitic limestone from which Sample 1B was taken.

10 feet—Massively bedded, finely granular, soft, brown dolomite of a fair degree of purity as shown by the analysis of Sample 1C, which represents this section. The stone weathers deeply to a yellow-brown. Calcareous streaks occur in places especially near the base.

9 feet—Heavily bedded, bluish grey limestone that weathers deeply to a buff shade and in parts is fainty mottled. Sample 1D represents this section.

12 feet—Covered with debris to the water level. A short distance north, however, a light buff, earthy, fine-grained, magnesian limestone, overlain by thinly bedded limestone, is exposed at the water's edge; and from the 2 feet of the latter type exposed, Sample 1E was taken.

Southerly along the beach from the place above described, two small quarries were at one time worked for building stone in finely granular, soft, light brown dolomite occurring in regular beds 6 inches to 14 inches thick, but which are split by vertical fractures into a series of rectangular blocks. About 8 feet of this type of stone, which underlies the lowest stratum seen in the section farther north, is exposed and is represented by Sample 2. There is only a small area where this stone can be quarried, as a short distance inland it is overlain by limestone of the character of that in the section to the south.

On the west side of the island, near the north end, a small quarry, said to have been worked for building stone, has been opened along the beach. The strata here are very sandy.

All the strata exposed lie almost flat though there are slight local undulations.

[1] Hume, G. S.: Geol. Surv., Canada, Mem. 145 (1925).

Analyses of Témiscamingue County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
1.....	6·14	0·54	1·04	0·07	84·07	7·87	99·73	Tr.	47·12	3·76	13 : 1
1A.....	13·22	0·93	0·91	0·02	76·86	7·70	99·64	Tr.	43·05	3·68	12 : 1
1B.....	11·70	1·13	1·59	0·09	50·52	34·94	99·97	Tr.	28·34	16·71	1·69 : 1
1C.....	3·30	1·02	0·42	0·02	56·41	38·48	99·65	Tr.	31·60	18·40	1·71 : 1
1D.....	7·34	0·64	0·58	0·02	81·39	9·77	99·74	0·20	45·59	4·67	9·8 : 1
1E.....	7·00	0·86	0·82	0·02	67·46	23·02	99·18	0·03	37·79	11·01	3·4 : 1
2.....	2·38	1·10	0·48	0·28	54·10	41·98	100·32	Tr.	30·45	20·07	1·51 : 1

1. Mann island. Top 25 feet in cliff on east side of island.
1A. " Seven feet of limestone separated from the above by 2 feet 6 inches of very shaly stone.
1B. " Next 3 feet 6 inches.
1C. " Next 10 feet.
1D. " Next 9 feet.
1E. " Two feet of strata at water's edge.
2. " Eight feet of dolomite at lake level a short distance north of where the first series of samples was taken.

Terrebonne County

The hilly, wooded part of Terrebonne county, north of St. Jérôme and New Glasgow is underlain mostly by Precambrian rock in which are found occasional deposits of highly crystalline Grenville limestone, most of which are very impure. The southern portion of the county lies in the St. Lawrence plain and this part is entirely underlain by limestones of the Beekmantown, Chazy, and Trenton formations, which occur in flat-lying deposits. The distribution of these formations is shown on Map No. 757 in the pocket of this report. Owing to the thick blanket of sandy soil covering most of the area, however, exposures of limestone are relatively few. Quarries have been worked from time to time in the county to obtain stone for road metal, building purposes, and for making lime, but there is none in operation at present.

Ste. Thérèse de Blainville

One-quarter mile south of the village, midway between the branch line of the Canadian Pacific railway to St. Eustache and the road to Ste. Rose, 12 feet of flat-lying Beekmantown limestone is exposed in an old quarry formerly worked for road metal. The following section is visible:—

3 feet—Soil.
3 feet 6 inches—Massive, grey-blue, hard, fine-grained magnesian limestone, containing vugs filled with crystals of calcite and dolomite.
1 foot—Black, shaly magnesian limestone.
1 foot—Light blue-grey magnesian limestone.
7 feet—Black, fine-grained, hard magnesian limestone in beds up to 18 inches thick.

Sample 75 represents the top 3½ feet and Sample 75A the bottom 8 feet.

In the northwestern part of the village, on the south side of the road to St. Augustin, impure Beekmantown dolomite has been quarried for road metal. The quarry covers an area 200 by 120 feet and a maximum of 15 feet of stone is exposed beneath 3 feet of soil. The dolomite is hard, fine-grained, bluish grey and occurs in flat beds up to 1 foot thick, separated by thin beds of shale. Sample 76 was taken from the 15 feet of stone exposed.

Two miles north of Ste. Thérèse, high-calcium Chazy limestone, in a belt 1 mile wide, is exposed along the road to Ste. Anne des Plaines. On the east side of this road a small quarry has been opened to supply a small lime kiln, the owner of which is Barthélémy Juteau. The stone has also been used for local building purposes. About 5 feet of bluish grey, medium- to coarse-grained, soft limestone in fairly thick level beds is exposed in the quarry. Sample 77 represents this stone. Lime is made only occasionally to supply local demand.

One mile farther to the northeast, on the property of François Sarrazin, a large outcrop of very fine-grained, calcium limestone, containing an irregular network of shale films, occurs on the east side of a low ridge about ¼ mile east of the Canadian Pacific railway. The stone is in beds up to 15 inches thick, dipping to the east at an angle of 3 degrees, and is visible for 600 yards in a southeasterly direction. Sample 78 is from 4 feet of strata exposed.

St. Jérôme

Beginning about 3 miles east of St. Jérôme, thinly bedded, fine-grained, sandy, and otherwise impure Beekmantown dolomite is exposed at intervals for 3 miles along a low, broad ridge extending from Ste. Marguerite parish northeasterly along the road between the 1st and 2nd concessions of Paisley. Sample 79 was taken from this type of stone where exposed in a small quarry on the land of Zoël Drouin from which foundation stone has been obtained. On fresh fracture the dolomite is bluish grey, but it weathers rapidly and deeply to a drab-brown. Much of it is more impure than that sampled.

Ste. Sophie

Outcrops of impure Precambrian limestone, much intermixed with igneous rocks, occur in a narrow belt extending northerly from Ste. Sophie for several miles.

On cadastral lot 368 of the parish of Ste. Sophie, about 1½ miles northwest of the railway station, a vein of calcite enclosed in a gneissic rock is exposed. The vein is sharply defined from the gneiss and strikes east and west and dips vertically. It is exposed for 400 feet westerly from a small cave. On the surface the vein has a width of 1 to 2 feet, but at the cave it is seen to widen below the surface, and at a depth of 7 feet has a width of 6 feet. The calcite is coarsely crystalline and is white to pinkish white in colour. Sample 79A was taken across the width of 6 feet of calcite exposed in the cave. Mr. Joseph McKenna of Ste. Sophie de la Corne is owner of the mining rights on this deposit.

Piedmont

West of this village is a large area of Precambrian calcium limestone most of which is very impure. Two miles west of the village a small quantity has been quarried for making lime. The stone here, however, is very siliceous and also contains much graphite and iron oxide.

Shawbridge

Beginning 1 mile east of Shawbridge and extending for 2 miles easterly to Echo lake is an outlier of Beekmantown magnesian limestone and dolomite. The stone is apparently all impure; no samples were taken.

Analyses of Terrebonne County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
75	5·46	1·38	1·54	0·04	61·66	29·28	99·36	0·22	34·55	14·00	2·5 : 1
75A	4·90	1·43	1·33	0·04	60·70	31·77	100·17	0·29	34·01	15·19	2·2 : 1
76	13·10	1·82	1·78	0·09	48·88	33·40	99·07	0·24	27·42	15·97	1·72 : 1
77	1·28	0·55	0·67	0·17	95·02	1·89	99·58	0·03	53·30	0·90	59 : 1
78	2·24	0·45	0·51	0·02	94·09	1·93	99·24	0·02	52·70	0·92	57 : 1
79	8·46	1·84	4·36	0·04	47·41	36·20	98·31	0·38	26·57	17·31	1·53 : 1
79A	0·30	0·35	0·03	0·02	97·96	0·77	99·43	Nil	54·87	0·37	148 : 1

75.	Ste. Thérèse de Blainville.	Top 3½ feet of Beekmantown limestone in the quarry ¼ mile south of the village and midway between the Canadian Pacific railway and the road to Ste. Rose.
75A...	" "	Bottom 8 feet in the same quarry.
76	" "	Quarry in the northwestern part of the village.
77	" "	Quarry of Barthélémy Juteau 2 miles north of the village.
78.	" "	Ridge of limestone 3 miles north of the village on the road to Ste. Anne des Plaines.
79.	St. Jérôme.	Quarry on land of Zoël Drouin east of the village.
79A.	Ste. Sophie.	Calcite vein on cadastral lot 368, parish of Ste. Sophie.

Two Mountains County

The only limestone found in this county is the impure dolomitic variety belonging to the Beekmantown formation, which, in flat beds, underlies a large part of the county, as shown on Map No. 757. Outcrops are few owing to the heavy covering of sandy soil over most of the limestone areas. The impure stone has been quarried for road metal in a few places, and in the early days of the settlement of the country it was, for want of better material, utilized for making lime.

St. Augustin

One-third of a mile north of the village and 1 mile south of St. Augustin station on the North Shore branch of the Canadian Pacific railway, hard, fine-grained, dark grey magnesian limestone of the Beekmantown formation is exposed in a low ridge on the property of Joseph Leroux where it has been quarried for road metal. Overburden in the vicinity averages 4 feet in thickness. The limestone is in flat beds 2 to 8 inches thick, between which are thin shaly partings, and near the top of the quarry is a bed of shale 6 inches thick. In the uppermost bed are a number of vugs filled

with semi-translucent dolomite and calcite. Sample 33 was taken from the 11 feet of stone exposed, exclusive of the shale.

Ste. Monique

Similar limestone to that at St. Augustin is said to outcrop near Ste. Monique and to have been utilized for lime burning.

Fresnier

On the property of D. St-Pierre, slightly less than a mile north of Fresnier, on the north side of rivière du Chêne, Beekmantown dolomite has been quarried for road metal and used in the construction of the North Shore highway between Ottawa and Montreal. The stone is all hard, fine-grained, rather sandy, and varies in colour from dark brownish grey to a rather light grey. Shale partings are present between all the beds, but are most noticeable in the top 3 feet and these top beds are all weathered very deeply to a yellow-brown shade. The beds average about 1 foot in thickness and lie almost flat. Sample 33A was taken from the 8 feet of strata exposed.

St. Eustache

Beekmantown dolomite in beds up to 1 foot thick, with sandy shale partings, is exposed beneath 25 feet of soil in the bed of rivière du Chêne below the dam at St. Eustache.

Analyses of Two Mountains County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
33.....	12·40	1·84	3·08	0·07	53·38	28·48	99·25	0·38	29·93	13·62	2·2 : 1
33A.....	11·90	1·03	1·55	0·09	47·53	35·09	97·19	0·19	26·67	16·78	1·58 : 1

33. St. Augustin. Eleven feet of Beekmantown limestone in small quarry 1 mile south of St. Augustin station.

33A. Fresnier. Eight feet of Beekmantown limestone in small quarry on north side of rivière du Chêne, 1 mile north of Fresnier.

Vaudreuil County

Very little limestone is available in Vaudreuil county, but in the northern corner of the county, between Rigaud mountain and Ottawa river, is a small area underlain by flat beds of impure limestone of the Beekmantown formation. However, the soil is deep and outcrops are very frequent. One of the few places in this area where the limestone is visible is at Rigaud where the sandy dolomite and magnesian limestone beds of the lower part of the formation are to be seen in the bed of rivière à la Graisse. No sample was obtained in this area.

Calcium limestones of Chazy and Black River age, so prominently exposed in the adjoining county of Glengarry, Ontario, extend for some little distance eastward into Newton township in Vaudreuil county, and

presumably the impure dolomitic limestones of the Beekmantown formation are also present in the small area in the southwest part of the county as indicated on the map. The country in Newton township is very flat and the soil is deep, consequently there are very few exposures of rock. The only sample for analysis was obtained from the Black River limestone near Ste. Justine.

Ste. Justine de Newton

In the southern part of lot 2, range IV, Newton township, a short distance north of the Canadian National railway, fine-grained, brownish blue, high-calcium limestone of the Black River group is exposed in a pit. The depth of soil in the vicinity averages about 6 feet. The pit was partly filled with water when seen by the writer and Sample 30 taken at this place is from the top 1½ feet of stone only, and cannot be considered as being representative of a quarriable thickness. Examination of the more extensive exposures of the Black River limestone in Glengarry county shows that siliceous and shaly strata alternate with the purer grade of stone, and such is probably the case here.

Numerous boulders of limestone occur in low ridges in this vicinity and are being utilized by Albert Danis of Ste. Justine Station, for making lime in a small field kiln.

Analysis of Vaudreuil County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
30.....	1·28	0·23	0·45	0·02	96·71	1·43	100·12	Tr.	54·17	0·68	80 : 1

30. Ste. Justine de Newton. Top 1½ feet of limestone in pit ½ mile west of railway station.

LAKE ST. JOHN—SAGUENAY RIVER REGION

In this region both Precambrian and Trenton limestones are found, and both are quarried on a small scale. (*See* Figure 11.) Grenville limestone of Precambrian age is quarried near Dolbeau and near St. Jérôme for use in sulphite-pulp mills, and the Trenton limestone is quarried at a number of places for road metal, lime manufacture, for agricultural purposes, and for rough building stone.

Precambrian limestone is not common and no deposits other than those now quarried have been reported.

Trenton limestone occurs in three main areas: 1. Along the south and west shores of lake St. John. 2. Over a large area north of Saguenay river opposite Chicoutimi. 3. South of Saguenay river in the vicinity of Bagotville. In each of these three areas the limestone is essentially of the same character, being fine- to medium-grained, brownish and bluish grey in colour, rather thinly bedded, and only moderately pure. A uniformly low content of magnesium carbonate is everywhere characteristic of the limestone, the analyses of 23 samples taken at various places over the three areas showing from 0·29 to 1·53 per cent of this constituent. Owing to the content of impurities, particularly alumina, iron compounds and organic matter, the Trenton limestone of the region has not proven

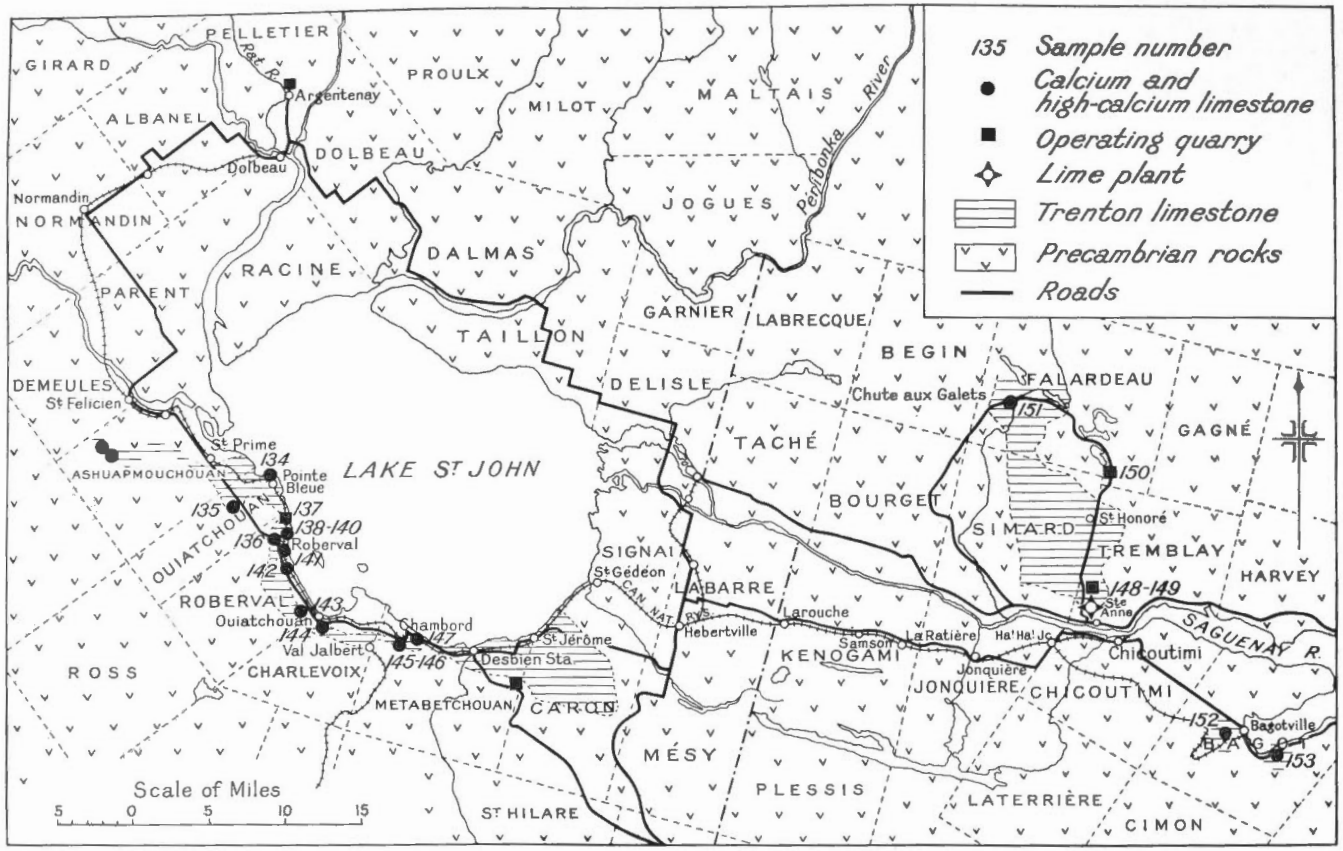


Figure 11. Map showing location of limestone deposits sampled in Lake St. John—Saguenay River region.

suitable for use in the sulphite-pulp mills, and prior to the opening of the quarries in the Grenville limestone, all limestone for this purpose was being brought in by rail from the quarries at St. Marc des Carrières in Portneuf county.

The Trenton limestone rests on the Precambrian rocks and in places is overlain by Utica shale. Sir William Logan[1] estimated the thickness of the Trenton limestone in the Lake St. John area at 100 feet, and detailed work by Dr. J. A. Dresser[2] confirmed this estimate. In the area north of Saguenay river, opposite Chicoutimi, B. T. Denis[3] measured 90 feet of Trenton limestone between the Precambrian rock and the overlying Utica shale.

Chicoutimi County

As shown on a geological map accompanying a report by B. T. Denis on The Simard Map Area, Chicoutimi County,[4] outcrops of Trenton limestone are found within a relatively flat area 2 to 6 miles in width extending 13 miles northerly, from 2 miles north of the Saguenay river opposite Chicoutimi, to beyond Chute aux Galets on the Shipshaw river. As stated by Mr. Denis[5] it is impossible, owing to the heavy mantle of drift over the area in question, to determine whether the limestone continuously underlies the whole of the area.

The limestone is similar to that bordering the south and west shores of lake St. John and in all outcrops seen it is lying nearly horizontally. North of Ste. Anne it is being quarried for the manufacture of lime, and north of St. Honoré a small quarry is reported to be in operation producing agricultural limestone. Stone for foundations and rock-face construction, and also road metal have been produced at various times from the limestone in this area. The area is not served by a railway but it is crossed by numerous roads.

In the vicinity of Bagotville, south of the Saguenay, two outcrops of Trenton limestone similar in general character to those north of the river and near lake St. John were seen. Whether they are small isolated outliers or parts of another large outlier was not determined. One of these deposits was at one time quarried for use in making sulphite pulp.

Ste. Anne de Chicoutimi

Beginning 3 miles by road northwest of Ste. Anne, or 2 miles directly north of the Saguenay, Trenton limestone is exposed in undulating beds for more than 1 mile on a low, bush-covered ridge over which the road to St. Honoré passes. Along the southern edge of the area are outcrops of Precambrian granitic rocks. To the north of it a thick layer of soil hides all the rock. The lowest beds seen vary from very fine-grained to dense in texture and from brown to bluish grey in colour. They are from 4 to 8 inches in thickness, with thin partings of fossiliferous shale, and in places hold nodules of black chert. All the stone is hard and rather brittle. Farther north, where higher beds are exposed, the stone is nearly all medium-grained, grey in colour, and chert nodules were not observed.

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[1] Logan, Sir Wm.: Geology of Canada (1863), p. 165.

[2] Dresser, J. A.: "Part of the District of Lake St. John, Quebec," Geol. Surv., Canada, Mem. 92, p. 30 (1916).

[3] Denis, B. T.: "The Simard Map Area, Chicoutimi County," Quebec Bur. Mines, Ann. Rept. 1933, Pt. D., p. 66 (1934).

[4] Quebec Bur. Mines Ann. Rept. 1933, Part D.

[5] Op. cit., p. 64.

On the east side of the road, about 3½ miles northwest of Ste. Anne, stone for making lime is quarried by *Praxède Bouchard*. Both very fine-grained, brown, brittle limestone and the medium-grained, grey limestone are seen in the 12-foot quarry face beneath 1 foot of soil. Sample 148 is representative of the stone quarried. The lime plant consists of two batch kilns, each 6 feet in inside diameter and 10 feet in height. Wood is used for fuel, and about 9½ tons of lime is obtained per kiln at each burning. The lime is sold in 200-pound steel drums and in bulk.

A little over ½ mile north of the Bouchard quarry a small amount of building stone for local use has been obtained from a shallow quarry near the road. About 4 feet of irregularly bedded, fine-grained, bluish grey limestone with shaly partings between the beds is here exposed. Sample 149 was taken in this quarry.

St. Honoré

Three and one-half miles north of St. Honoré is an outcrop of dense-textured, brittle, brown limestone containing in places a few nodules of black chert. Sample 150 was taken from 5 feet of beds at the northern edge of this exposure, and Sample 150A from 4 feet of beds near the southern end, about 150 yards distant from the first sample. Thin partings of shale occur between the beds. It is reported that this deposit is being quarried on a small scale for the production of agricultural limestone.

Chute aux Galets

Below the power house on Shipshaw river at Chute aux Galets, the river has cut a gorge 50 to 80 feet deep in beds of nearly flat-lying, bluish grey, medium- to fine-grained Trenton limestone. The top 30 feet of the limestone is in beds a few inches to 2 feet in thickness separated by thin seams of shale. Shaly streaks also occur in the beds themselves. Below this the limestone is in thinner beds and the proportion of shale increases, some of the shale interbeds in the lower part of the gorge being several inches thick. Sample 151 was taken on the east side of the river and represents the top 30 feet of strata, exclusive of shale partings. About 6 feet of sand overlies the limestone along the top of the gorge and the depth of sand increases away from the river.

Bagotville

A short distance west of Bagotville, on the north side of the branch line of the Canadian National railway between Bagotville and Ha Ha Bay Junction, is a small limestone quarry, now nearly filled with water, that was formerly worked by the Port Alfred Pulp & Paper Company for stone for use in its sulphite-pulp mill. The 2 feet of stone visible is brownish in colour, very fine-grained, hard and brittle, and is in thick beds. Sample 152 was taken here. On analysis this sample proved to be the purest of any taken from the Trenton limestone in the region and is apparently suitable for use in making sulphite pulp, but it is representative of only 2 feet of stone, and as the quarry was abandoned it is probable that the beds beneath contain a greater percentage of impurities. Four feet of soil lies on top of the limestone, and the surrounding country is flat and bush-covered.

Five miles east of Bagotville, on the road to Saguenayville, an impure, argillaceous limestone is exposed on the land of Ernest Simard. Sample 153 is representative of the outcrop.

Analyses of Chicoutimi County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
148.....	2·86	0·67	0·59	0·04	94·18	1·18	99·52	0·13	52·77	0·56	94 : 1
149.....	3·06	0·52	0·96	0·09	92·98	0·65	98·26	0·13	52·12	0·31	168 : 1
150.....	4·40	0·51	1·59	0·11	90·33	1·37	98·31	0·10	51·07	0·65	79 : 1
150A.....	2·24	0·66	1·62	0·09	93·88	0·76	99·25	0·20	52·62	0·36	146 : 1
151.....	5·04	0·76	1·75	0·15	90·41	1·37	99·48	0·38	50·71	0·65	78 : 1
152.....	2·23	0·60	0·82	0·02	94·18	1·09	98·94	0·12	52·75	0·52	101 : 1
153.....	6·14	1·28	4·60	0·04	85·39	1·07	98·52	0·22	47·84	0·51	94 : 1

148.	Ste. Anne.	Stone quarried by Praxède Bouchard 3½ miles north of Ste. Anne on the road to St. Honoré and used for making lime.
149.	"	Shallow quarry ½ mile north of Bouchard quarry on the road to St. Honoré.
150.	St. Honoré.	North end of outcrop of limestone 3½ miles north of St. Honoré.
150A.	"	South end of same outcrop.
151.	Chute aux Galets.	Top 30 feet of strata on east bank of Shipshaw river below the power house.
152.	Bagotville	Top 2 feet of stone in water-filled quarry formerly worked by Port Alfred Pulp & Paper Co.
153.	"	Limestone on property of Ernest Simard 5 miles east of Bagotville.

Lake St. John County

The two deposits of Grenville limestone previously mentioned as being quarried for use in the making of sulphite pulp are both in this county—the deposit near Dolbeau being 15 miles north of lake St. John between the two main branches of Mistassini river, and the deposit near St. Jérôme being 3 miles south of the lake.

Trenton limestone is found in the narrow lowland bordering the west and south shores of the lake. (*See* Figure 11, page 165.) Outcrops are numerous between Pointe Bleue and Desbien Station and though the limestone probably underlies part of the lowland areas northwest of Pointe Bleue and east of Desbien Station, these areas are deeply covered by soil and only one or two outcrops are to be seen. In the area between Pointe Bleue and Desbien Station the limestone has a prevailing dip toward the lake at angles varying from 3 to 30 degrees and in one or two places the dip is even steeper. Between Roberval and Chambord, as shown on Dresser's map, the overlying Utica shale occupies the lake front, the limestone being found only in a relatively narrow belt between the Precambrian escarpment and the shale.

The Trenton limestone has been quarried in many places near the lake, the products being road metal, stone for lime burning, stone for pulp mills, agricultural limestone, and rough building stone, but, in 1934, only one quarry—that operated by Messrs. Leclerc & Robitaille at Roberval—is reported as working in Trenton limestone. The products of this quarry are road metal and screenings suitable for agricultural purposes. The Trenton

PLATE XXIV

A. Nodular Trenton limestone on shore of lake St. John, at Pointe Bleue.

B. Heavily bedded Trenton limestone in bed of brook just west of Ouiatchouan river at Val Jalbert, Lake St. John county.

limestone is more suitable for road metal and crushed stone than the Grenville limestone in this area, the latter being too soft and friable. Most of the limestone in this area is close to the Canadian National railway and to good highways.

Dolbeau

On lots 43 and 44, range IV, Pelletier township, a deposit of white, coarsely crystalline Grenville (Precambrian) limestone is quarried for use in sulphite-pulp mills in the Lake St. John district. The quarry, which is on the east side of the Rat river, 5½ miles by road north of Dolbeau on the Canadian National railway, is owned by the Mistassini Trappist Fathers but is operated by Mr. J. O. Beaulac. Trucks are used to transport the limestone to Dolbeau. Samples of the stone sent to the Mines Branch were of two types: 1. Coarse-grained, white calcite in which the only visible impurities were a few crystals of white silicate minerals, an occasional flake of graphite and a little pyrite. 2. Medium-grained, bluish white calcite showing some golden mica in addition to the above-mentioned impurities. Analysis 133 in the table of analyses on page 174 was made from a sample consisting of 8 fragments of the limestone sent to the Mines Branch from various sources. The 3 per cent of insoluble material was made up of the following constituents:—

	Per cent
Silica	1·16
Ferric oxide and alumina	0·56
Calcium oxide	0·46
Magnesium oxide	0·82
	3·00

The following series of analyses of the Grenville limestone quarried near Dolbeau was kindly supplied by Price Brothers & Co., Limited and is representative of seven carloads of the limestone shipped to the Riverbend mill.

	Per cent				
Silica and insoluble matter	1·03	2·29	3·24	1·59	1·94
Iron and aluminium oxides	0·06	0·13	0·40	0·15	0·38
Calcium carbonate	97·93	96·93	95·50	97·20	95·12
Magnesium carbonate	1·08	0·83	1·00	1·14	2·68
	100·10	100·18	100·14	100·08	100·12

Through the courtesy of the Quebec Bureau of Mines the following reference to the limestone in this area, made by Mr. Bertrand T. Denis in his report "The Northwest Portion of the Lake St. John District" to be published in the Annual Report of the Quebec Bureau of Mines for the Calendar Year 1933, Part D, was furnished the present writer in advance of publication.

The coarse grain of the crystalline limestone together with its general impurity do not permit its utilization for building or ornamental purposes. It is, however, quarried on lot 43, range IV, Pelletier township to furnish limestone to the Lake St. John Pulp and Paper Company at Dolbeau; the distance of the quarry from Dolbeau is about six miles and the quarry product is transported by truck. The limestone at this point is reported to be very pure, and free from the graphite flakes which would constitute a very deleterious impurity. In the quarry the limestone is cut by pegmatite dykes in which sphene or titanite is a common accessory mineral. The pegmatite is easily sorted out by hand. In 1933 the production was 4,000 tons.

On lot 36, range IV, Pelletier township, the limestone in the vicinity of a narrow seam or crack is abundantly stained with malachite but there is no evidence of the existence of a larger body of copper ore.

Roberval

Between Pointe Bleue and Roberval the Trenton limestone is well exposed along the shore of lake St. John and for some little distance inland. At various times a number of small quarries have been opened to obtain stone for road making, for lime, and for building purposes. Transportation is provided by the Canadian National railway and by the highway, both of which run close to the lake in this locality. At present, Messrs. Leclerc & Robitaille operate a quarry for the production of crushed stone on lot 3, range A, Roberval township, and in 1932 Mr. Armand Levesque operated a quarry for the same purpose a short distance to the south.

At Pointe Bleue, 15 feet of fine- to medium-grained, bluish grey and brownish grey, blue-weathering, heavily bedded limestone is exposed on the shore of the lake (Plate XXIV A, page 169). Numerous irregular seams of shale are present in all the beds and render the stone nodular when exposed to the weather. Sample 134 was taken from the cliff at the point. One mile to the west, black Utica shale is seen overlying the limestone and dipping at an angle of 30 degrees to the northwest.

On lot 9, range II, Ouiatchouan township, a small quarry for road metal and stone for making lime has been worked in an outcrop of fine-grained, bluish grey and brownish grey limestone. The stone is fairly heavily bedded but contains seams of shale. Sample 135 was taken from the 4 feet of strata exposed. The dip here is to the northwest at an angle of 10 degrees and granite is exposed immediately to the eastward of the quarry.

In the valley of Ouiatchouaniche river, 2½ miles northwest of Roberval, a hard, very fine-grained, brown limestone is exposed just southwest of the river. It is practically free from shale. Sample 136 was taken from a number of outcrops. There are outcrops of granite nearby but drilling is said to have shown a depth of at least 15 feet of limestone. The beds have a slight dip to the east.

Along the shore of lake St. John, north of Roberval, the Trenton limestone forms a fairly high ridge or plateau on which the soil is very thin and where there are good opportunities for quarrying. It is in this ridge that the Levesque and the Leclerc & Robitaille quarries are opened. Sample 137 was taken from 13 feet of brownish grey, fine-grained limestone exposed in a small quarry 200 feet west of the lakeshore road, at a point about 1½ miles north of Roberval. The strata dip at an angle of 5 degrees to the east, they are heavily bedded where unweathered but, owing to the presence of numerous shale seams, they split into thin beds on weathering.

One mile north of the town, stone for making lime was at one time quarried near the shore of the lake. Twenty-five feet of limestone dipping at an angle of 10 degrees to the southeast is exposed here. All the stone is fine-grained, brownish grey, and rather nodular and shaly, particularly the lower beds which have thick shale partings between them. Fossils are abundant and there are many small vugs in the limestone lined with calcite crystals and containing black petroleum. This stone is impure as shown by the analysis of Sample 138, which was taken from the 25 feet of strata exposed, exclusive of the shale.

In a railway cutting 200 yards to the west of the quarry, soft, nodular, greyish blue, medium-grained limestone in beds up to 6 inches thick with very little shale, is exposed. Sample 139 represents the 10 feet of strata in the cutting.

One mile north of Roberval, 7 feet of flat-lying, brownish grey, fossiliferous, fine-grained, nodular limestone with shale seams between the beds, is exposed in a small quarry on the land of Elie Girard where it was formerly quarried for making lime. Sample 140 was taken at this place.

In the northern part of Roberval town, massively bedded, medium-grained, brownish grey limestone dipping at 5 degrees to the northeast is exposed beneath 1 to 3 feet of soil in an abandoned quarry on the land of Mme Eul. Ménard. Very thin irregular seams of shale are present in much of the stone causing it to split when exposed to the weather. The quarry extends for 300 feet parallel to the Canadian National railway and is 200 feet wide. Sample 141 represents the stone exposed in the face.

One and one-half miles south of Roberval, a quarry for road metal was opened on the property of Louis Boily. The quarry was nearly full of water when visited and only 4 feet of fine- to medium-grained, bluish grey limestone in flat beds was visible. Sample 142 was taken from these beds. Soil covers the limestone to a depth of 3 feet.

Val Jalbert

In this locality, about midway between Roberval and Chambord, limestone is exposed only in the valleys of the Ouaniche and Ouiatchouan rivers at a distance of ½ mile from the lake. The limestone rests on granitic rocks and, toward the lake, is overlain by black Utica shale.

In the valley of Ouaniche river, about ¼ mile west of the highway and the railway, a small quarry for road metal was at one time worked in a deposit of soft, medium-grained, brownish grey Trenton limestone in which are many tiny vugs containing petroleum. About ¾ mile farther up the river black shale is seen overlying the limestone. At the quarry the strata dip at an angle of 11 degrees to the southeast. Sample 143 was taken from the 8 feet of limestone exposed.

The Ouiatchouan river, just below the falls, runs between walls of Trenton limestone 25 to 30 feet high for nearly 1 mile. Near the falls the limestone may be seen resting directly on the granitic Precambrian rock. Below the highway bridge Utica shale overlies the limestone. Behind the church at Val Jalbert, and on the west side of the river, soft, medium-grained, bluish grey, argillaceous limestone containing streaks of shale is exposed to a depth of 12 feet in a quarry formerly worked by the Chicoutimi Pulp Company. Sample 144 was taken here. This stone was also used for constructing the abutments of the bridge on the branch line of railway serving the pulp mill at Val Jalbert, but it has weathered poorly, many cracks having appeared along the shaly seams.

Medium- to coarse-grained, brownish grey limestone interbedded with fine-grained, bluish, argillaceous limestone is exposed in the bed of the brook that joins Ouiatchouan river from the west about ¾ mile below the falls, (Plate XXIV B, page 169), and a considerable amount of quarrying has been done between the two streams about 150 yards above the junction. Sample 144A was taken from 7 feet of strata exposed in the quarry.

Chambord Junction

Four hundred yards east of the Canadian National railway station and opposite the locomotive coaling depot, a quarry was at one time operated in the hillside south of the track by Price Brothers & Co., Ltd. for stone for use in their pulp mills. Twelve feet of Trenton limestone dipping northerly at an angle of 6 degrees, or away from the face, is exposed. The top 4 feet is medium-grained, brownish blue limestone in which much pyrite is to be seen. The bottom 8 feet is hard, brittle, very fine-grained, brown limestone in beds up to 4 feet thick but which tend to split thinner. Sample 145 is from the top 4 feet, and Sample 145A from the bottom 8 feet. This quarry is opened near the southern limit of the limestone and a short distance to the south outcrops of granitic rock are to be seen. This would limit the distance to which the quarry could be extended into the hillside, but it could be extended along the hillside for a considerable distance in either direction.

One-quarter mile west of Chambord Junction, the railway passes through a cutting 25 feet deep in which thinly bedded, shaly, impure calcium limestone of Trenton age is exposed on the north side of the track.

Chambord

Between Chambord Junction and the town of Chambord, the Municipality of St. Louis de Chambord obtains road metal from a quarry near the top of a low hill. The stone is fine- to medium-grained and irregular seams of shale are present in most of the beds, but some beds are entirely free from shale. Sample 146 represents the stone exposed in the 8-foot face. Overburden averages 1 foot in thickness.

One and three-quarter miles east of Chambord, brownish grey, dense-textured and fine-grained limestone in beds up to 3 feet thick, dipping northerly at an angle of 6 degrees, is exposed in an abandoned quarry just south of the railway and the highway. Streaks of shale are present in some of the beds. Sample 147 was taken here. Several large buildings of corrugated iron were erected on this property a number of years ago for the purpose of making Portland cement but the project was not completed.

St. Jérôme

Coarsely crystalline, white Grenville limestone is being quarried by Emile Gagnon for use in pulp mills of the district from a deposit 3 miles south of St. Jérôme station on the Canadian National railway. Price Brothers & Co., Ltd. have kindly supplied the following analysis of the stone as shipped to their Riverbend mill.

	Per cent
Insoluble	1·77
Iron oxide and alumina	0·16
Calcium carbonate	98·17
Magnesium carbonate	Trace
	100·10

Dresser[1] describes the limestone in this locality as follows:—

The Grenville formation is represented by two small occurrences on lots 1 and 3, range I, of the township of Metabetchouan. Neither exceeds a few hundred square feet in area. The occurrence on lot 1 is on the wall of the fault scarp which bounds the lowland area about 400 feet above the level of Lake St. John, where it has been quarried for road metal. The exposure is from 4 to 15 feet wide and extends for 150 feet northwesterly. The other occurrence in lot 3, less than half a mile distant, is nearly 100 feet higher. It is exposed through the drift principally by a small solution cavern in the rock 6 or 7 feet in diameter.

The Grenville here found consists essentially of crystalline limestone or calcite, white in colour, and coarsely crystalline. In many places there are seams of cherty material running along the cleavage planes of the calcite. A small development of a micaceous schist, composed almost entirely of biotite, is probably an extreme phase of the alteration of the crystalline limestone.

Analyses of Lake St. John County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
133.....	*3·00	0·26	0·30	0·02	94·07	2·07	99·72	.....	52·69	0·99	53 : 1
134.....	3·44	0·86	1·42	0·09	92·98	1·24	100·03	0·21	52·12	0·59	88 : 1
135.....	4·90	0·82	1·06	0·42	90·93	1·53	99·66	0·14	51·15	0·73	70 : 1
136.....	2·48	0·37	0·57	0·04	95·80	0·65	99·91	0·12	53·67	0·31	173 : 1
137.....	4·02	0·62	1·48	0·28	92·41	0·67	99·48	.....	51·90	0·32	162 : 1
138.....	6·14	1·20	1·48	0·17	89·86	0·55	99·40	0·48	50·41	0·26	194 : 1
139.....	3·46	0·87	0·81	0·20	93·79	0·48	99·61	0·27	52·63	0·23	228 : 1
140.....	3·80	0·62	1·50	0·15	91·69	1·45	99·21	0·21	51·43	0·69	75 : 1
141.....	*5·27	1·11	1·36	0·22	91·59	1·18	100·73	0·39	51·30	0·56	92 : 1
142.....	4·74	1·06	1·44	0·15	91·29	1·30	99·98	0·30	51·20	0·62	83 : 1
143.....	5·24	1·31	1·69	0·31	90·57	0·50	99·62	0·50	50·89	0·24	212 : 1
144.....	6·10	0·90	1·98	0·22	88·05	0·86	98·11	0·44	49·43	0·41	121 : 1
144A.....	3·26	0·71	0·95	0·28	93·82	1·07	100·09	0·21	52·69	0·51	103 : 1
145.....	5·06	1·04	2·08	0·15	90·41	1·45	100·19	0·37	50·71	0·69	73 : 1
145A.....	3·86	0·51	1·07	0·15	92·69	0·29	98·57	0·18	51·98	0·14	371 : 1
146.....	5·71	0·68	1·92	0·20	89·06	1·25	98·82	0·20	50·01	0·60	83 : 1
147.....	3·82	0·56	1·74	0·17	92·63	1·18	100·10	0·14	51·96	0·56	93 : 1

*Insoluble.

133. Dolbeau. Precambrian limestone from quarry owned by Mistassini Trappist Fathers.
134. Roberval. Cliff of Trenton limestone at Pointe Bleue.
135. " Abandoned quarry on lot 9, range II, Ouiatchouan township.
136. " Outcrops in valley of Ouiatchouaniche river, 2½ miles northwest of Roberval.
137. " Quarry 200 feet west of lakeshore road, 1½ miles north of Roberval.
138. " Quarry on shore of lake St. John, 1 mile north of Roberval.
139. " Railway cutting 200 yards west of above quarry.
140. " Quarry on land of Elie Girard, 1 mile north of Roberval.
141. " Quarry on land of Mme Eul. Ménard, Roberval.
142. " Quarry on land of Louis Boily, 1½ miles south of Roberval.
143. Val Jalbert. Quarry in valley of Ouaniche river ¼ mile west of road between Roberval and Chambord.
144. " Quarry in valley of Ouiatchouan river.
144A. " Quarry between Ouiatchouan river and brook that joins it from the west.
145. Chambord Junction. Top 4 feet of limestone in quarry opposite the locomotive coaling depot at Chambord Junction.
145A. " Bottom 8 feet of stone in same quarry.
146. Chambord. Quarry operated by Municipality of St. Louis de Chambord.
147. " Quarry 1¾ miles east of Chambord on south side of the railway.

[1] Dresser, John A.: Mem. 92, Geol. Surv., Canada, pp. 22 and 23 (1916).

Saguenay County

The following reference is made regarding limestone in this county on page 804 of the Geology of Canada (1863).

> "About three miles below Tadoussac, on the St. Lawrence, and a little to the east of the mouth of the Rivière Baude, the Laurentian gneiss is cut by a perpendicular vein of calcspar, which runs northwestward, and has a breadth of twelve feet. This spar, which is coarsely crystalline, contains only scattered grains of copper pyrites; and if burned, would yield a good lime, which, in this locality, remote from any known deposit of limestone, is of some importance."

In the Annual Report of the Geological Survey, volume VIII, page 104A (1895), there is the following reference to limestone north of Mouchalagan lake, 200 miles north of the mouth of the Manicoagan river:—

> "About Mouchalagan lake, the garnetiferous gneisses (Laurentian age) predominate and appear to be associated with thin bands of crystalline limestone.
>
> "Above the lake, for some thirty miles, these crystalline limestones are developed in great thickness, and are associated with mica-schists, and garnetiferous gneiss. The limestone is often pure, and at times contains tremolite, or mica, of which no large crystals, however, were seen."

ANTICOSTI ISLAND

Anticosti island lies in the Gulf of St. Lawrence about 16 miles south of the Mingan islands and 360 miles below the city of Quebec. It is a large island, being 130 miles long and 35 miles across at the widest point. The population in 1931 was 454, most of whom live in two villages at the western end of the island. The island is owned by the Anticosti Corporation, which is a company controlled jointly by three paper companies—the Wayagamack Pulp and Paper Company, the St. Maurice Valley Corporation, and the Port Alfred Pulp and Paper Corporation.

As shown on geological maps, the various rock formations trend lengthwise of the island and dip southward at a very low angle. Those of the northern part of the island belong to the Ordovician system, and those of the southern part to the Silurian system. The following information on the limestones is compiled from Memoir 154, "Geology of Anticosti Island," by W. H. Twenhofel.

Table of Formations

Silurian	Niagaran	Chicotte	Limestone, 73 feet.
		Jupiter	Limestone and shale followed by limestone, 653 feet.
		Gun River	Alternating limestone and shale, 308 feet.
		Becscie	Limestone with shale partings, 199 feet.
Ordovician	Gamachian	Ellis Bay	On south shore, shale and limestone; on north shore, sandstone followed by limestone, 200 feet.
	Richmondian	Vaureal	Limestone and shale interbedded, 730 feet.
	Mohawkian	English Head	Limestone and shale, 228 feet.
		Macasty	Black shale.

"The rocks of Anticosti are more than one-half limestones which, for convenience, may be classified as argillaceous shell, coral-crinoid, compact and crystalline limestone."

"Argillaceous limestones are by far the most common, particularly in the lowest 1,000 feet of the sequence. The upper half of the Gun River formation also contains great thicknesses of this type. As a rule the colour is grey, and the thickness of an individual bed rarely exceeds 6 inches. In most cases the bedding planes are irregular."

"Shell limestones and shell breccia occur in limited quantities at many horizons, and nearly every bed of limestone is locally a mass of shells. Limestones of this type are particularly prominent in the upper half of the Becscie formation in which, on the south side of the island, there is a zone more than 50 feet thick locally almost wholly formed of the broken shells of the Brachiopod *Virgiana barrandei* and the bryozoan *Phaenopora surperba.*"

"Coral limestone occurs at many levels, formed of entire or comminuted corals, in some cases to the almost total exclusion of other organic remains. The English Head and Vaureal formations contain large masses of coral and coral heads. The Ellis Bay formation contains the lowest coral reef limestone. This has a thickness of about 5 feet and coral masses rise like ant-hills on the present wave-cut reef. Small reefs are in the Becscie, Gun River, and Jupiter formations, the total thickness of coral in the three formations probably exceeding 50 feet. It is in the Chicotte formation, however, that the corals make their greatest record, and here they occur in association with a great abundance of crinoid fragments."

"Compact limestone is well bedded, light coloured, very compact, extremely fine grained, turns yellowish white on exposure, and has a somewhat conchoidal fracture. This limestone appears to be that which Richardson described as bituminous. This rock contains few fossils, except on the surfaces of the beds, where in some cases they are thickly crowded, although mostly consisting of fragments. The larger part of

the lower half of the Becscie, the lower part of the Gun River, much of the upper part of the Jupiter, and considerable parts of the upper third of the Ellis Bay formations are composed of this class of rock, and small thicknesses exist in each of the other formations except the Macasty and Chicotte."

"Crystalline limestone is found in the Chicotte formation alone. Parts of this formation are "marble" with almost all fossils destroyed. The rock is compact, of fairly coarse texture, and has probably been diagenetically changed from the organic matter of which it was originally largely composed."

"Extensive studies of the Anticosti limestones were made for the writer by Mr. A. W. Weeks, and these have shown that each limestone bed studied has a remarkable degree of individuality in its texture and constituents; and so far as studied, no two beds have been found which are alike."

Aside from two analyses of shaly limestone from the Ellis Bay formation, little information is available as to the chemical characteristics of the Anticosti limestones, other than that they are mostly argillaceous. The Chicotte formation, consisting as it does largely of corals, is said to contain the purest limestone. Richardson[1] in referring to the economic importance of the limestones of Anticosti says: "In the immediate neighbourhood of Southwest point, coarse granular limestone for building purposes is displayed in abundance among the strata belonging to Division F (Chicotte formation). It occurs in beds from 6 to 18 inches in thickness, is easily dressed and yields good blocks of a yellowish white colour. The lighthouse at the point is built of it and so is that at Heath point."

Twenhofel[2] in referring to the geological resources of the island states: "Only limestone and sandstones are present; none of the varieties has any particular merit over other good average limestones or sandstones and not all of the limestones of the island are suitable for building purposes. The best stone of all is in the Chicotte formation in its exposures from Southwest point to rivière du Pavillon."

"Stone suitable for ornamental purposes occurs in the Chicotte formation. This is about 70 feet thick and is exposed for about 3 miles west of rivière du Pavillon to a little west of Southwest point and in large part is a dense, thick-bedded, crystalline limestone which, from a commercial point of view, is a marble. Blocks could be quarried up to about 3 feet in thickness and of almost any horizontal dimensions desired. At all localities the rock is filled with stems of fossil crinoids and heads of fossil corals which in most cases differ in colour from the enclosing materials, so that on polished surfaces the pink and white stems of the crinoids, and the honeycomb and chain arrangement of the corals give to the rock a unique beauty. The colours range from grey to flesh-red. This stone closely resembles the well-known Hoburgen marble of the island of Gotland, in the Baltic sea, which has been extensively quarried and used in Sweden and other adjacent countries. The two rocks are the same in origin and are not greatly different in characteristics."

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[1] Richardson, James: Geol. Surv., Canada, Report of Progress, 1853-1856, p. 235 (1857).
[2] Twenhofel, W. H.: Op. cit., p. 3.

"Some of the limestones of every Anticosti formation, the Chicotte excepted, may contain the proper percentages of impurities to produce natural cements. Limestone and shale suitable for the manufacture of Portland cement are present at a number of places."

The following analyses of Anticosti limestones are available:

	1. Per cent	2. Per cent
SiO_2	20·700	20·800
Al_2O_3	12·279	7·345
Fe_2O_3	2·771	2·355
CaO	33·200	34·600
MgO	Trace	Trace
Ignition loss	31·500	32·600
SO_3	0·800	1·300
	100·250	100·000

1. and 2. Made at the School of Mines of Paris from specimens taken from White Cliff, Ellis bay. These analyses are given on p. 24 of Memoir 154 of the Geological Survey of Canada.

The next three analyses were sent to Dr. A. W. G. Wilson, Mines Branch, by Mr. Horace Freeman of the Consolidated Paper Corporation, Ltd., Three Rivers, Que.

	3. Per cent	4. Per cent	5. Per cent
SiO_2	0·59	4·72	2·21
$Fe_2O_3 + Al_2O_3$	2·37	1·29	1·04
CaO	61·41	52·74	54·09
MgO	Trace	Trace	Trace
Moisture	8·51	0·10	0·13
Loss on ignition	28·67	41·53	42·45
	101·55	100·38	99·92

3. Sample of sand picked at random from points on the north side of the island.
4. Pieces of limestone from the south shore of the island.
5. Average of a composite sample of a large number of pieces taken from the cut banks of rivers at five different points on the island.

A significant feature of all the above analyses is the remarkably low content of magnesium carbonate found.

MINGAN ISLANDS

The Mingan islands are in the northern part of the Gulf of St. Lawrence close to the mainland and about 400 miles below the city of Quebec. They are uninhabited except for lighthouse keepers. The islands are composed largely of Ordovician limestone, the following information regarding which is taken from publications of the Geological Survey.

The lowest limestone formation is the Beekmantown and it is exposed on the islands and on the adjacent mainland " from Mingan River to Ste. Geneviève island, a distance of about forty-five miles. . . . It consists of brownish yellow and yellowish grey arenaceous magnesian limestone, holding many geodes and irregular masses of yellowish white calcspar, and many nodules and patches of yellowish white chert, which sometimes

replaces organic remains. . . . The strata are in general somewhat massive, and dip to the south at a small angle, probably not exceeding a hundred feet in a mile."[1] The thickness of the Beekmantown limestone is believed to be possibly as much as 250 feet.

Succeeding the Beekmantown formation are other limestones believed to be of Chazy and of Black River age. Detailed descriptions of outcrops of the Chazy limestone are given on page 134 of the Geology of Canada which show the limestone to be mostly impure, interbedded with shale, and in part magnesian. In one zone nodules of chert occur. The thickness of the Chazy limestone is estimated at not more than 300 feet and the formation is found on " all the islands outside of Harbor island, from the Perroquets to Clear Water point, and with this point the islands to the east of it as far as Wood island. From this range, however, is excepted the southern part of Large island, which appears to belong to the succeeding formation."[2]

" In the southern part of Large island of the Mingan group, the beds which have been given as belonging to the Chazy formation are followed by about thirty feet of yellowish-white pure limestone, some portions of which are filled with *Maclurea Logani*. The beds making up this mass are therefore supposed to belong to the Birdseye (Lowville) and Black River formation. Before however this is rendered certain, it would be necessary to obtain a larger number of characteristic fossils from the locality, which is the only one in which these strata have been obtained among the Mingan islands."[3]

NORTHERN QUEBEC

M. E. Wilson, in Memoir 39 of the Geological Survey (Kewagama Lake Map-Area, Quebec), pp. 63-70, describes a ferruginous, very siliceous dolomite that occurs in a few places southwest of Amos.

In the district formerly known as Ungava, limestone deposits are mentioned in reports of the Geological Survey, as occurring along the east coast of Hudson bay, and on the adjacent islands, between Portland promontory and cape Jones. It is stated that certain deposits are dolomitic and comparatively pure, but that the greater part of the limestone is siliceous and argillaceous. Deposits are also recorded on the shore of James bay in the vicinity of Eastmain river, and also in scattered localities within the vast hinterland.

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[1] Geol. Surv., Canada, "The Geology of Canada" (1863), pp. 119, 120.
[2] Op. cit., p. 135.
[3] Op. cit., p. 164.

CHAPTER V

LIMESTONES SOUTH OF THE ST. LAWRENCE RIVER

With the notable exception of deposits west of Richelieu river, which are almost unaltered and lie in nearly flat beds, the limestones found south of St. Lawrence river are for the most part metamorphosed, and occur in tilted and faulted beds. Many of the deposits are in the form of lenticular masses enclosed in rocks of another character. Limestones of Cambrian, Ordovician, Silurian, Devonian, and Carboniferous ages are available, but the principal quarrying activities are confined to the Ordovician and Devonian deposits from which some very pure, high-calcium limestone is obtained. The resources of the area are described by counties, the counties being arranged in alphabetical order in two groups as follows:

Southern Quebec

Arthabaska
Bagot
Beauce
Beauharnois
Bellechasse
Brome
Châteauguay
Compton
Dorchester
Drummond
Frontenac
Huntingdon
Laprairie
Levis
Lotbinière
Megantic
Missisquoi
Napierville
Richmond
Rouville
St. Johns
Shefford
Sherbrooke
Stanstead
Wolfe

Lower St. Lawrence River and Gaspe Peninsula

Bonaventure
Gaspe
L'Islet
Matane
Matapedia
Montmagny
Rimouski
Temiscouata

SOUTHERN QUEBEC

Arthabaska County

Only very impure, dark-coloured Ordovician limestones associated with slate, and commonly of a slaty structure themselves, were observed in this county. The following analyses of samples taken by Howells Fréchette[1] from two deposits in this county indicate the character of these dark, fine-grained limestones.

	A Per cent	B Per cent
Insoluble	17·44	17·20
Ferric oxide	1·10	1·07
Alumina	0·44	0·08
Calcium carbonate	78·39	77·59
Magnesium carbonate	1·52	2·65
	98·89	98·59

[1] Fréchette, Howells: Mines Branch, Sum. Rept. 1915, p. 49.

Sample A was taken on lot 23, range I, Warwick township, 3½ miles southwest of Warwick village.

Sample B was taken on lot 17, range VII, Tingwick township, 2½ miles southeast of Tingwick village, where the limestone was formerly used for making lime.

Other deposits of similar limestone occur on the western edge of the village of Warwick, and again on the east side of the highway a short distance southwest of the village of Arthabaska.

Bagot County

Limestones occur in Bagot county in the vicinity of St. Dominique, as well as over a large area embracing Acton Vale, Upton, and St. Théodore. Small quarries are worked for stone for lime, flux, and crushed stone at St. Dominique, and one quarry producing crushed stone is in operation at Acton Vale.

The limestone at St. Dominique is exposed in the west face and on the summit of a ridge that extends northeasterly for 7 miles from near St. Pie. It is considered to be of Chazy age. Two types of stone are available, viz. high-calcium limestone, and impure calcium limestone containing streaks of siliceous magnesian material, the pure limestone being found in a band estimated to be 50 feet thick, with impure stone above and below. Another band of pure limestone much veined with calcite also occurs along the foot of the ridge for 3 miles and more northeast of St. Dominique. Owing to faulting and folding of the strata, the relationship of this latter band of limestone to the rest of the limestone of the district could not be definitely determined.

The limestone in the Upton-Acton Vale district is for the most part rather siliceous, though some relatively pure zones are present. It is believed to be of Upper Cambrian age and is available in quantity.

St. Dominique

Near St. Dominique, 5 miles southeast of St. Hyacinthe, several quarries have been worked in a gently sloping hillside that faces the flat country to the west. Most of the quarries are close to the highway between St. Dominique and St. Hyacinthe, and are west of the village in the locality known as La Carrière, but limestone is available along the side of the ridge for 3 miles both northeast and southwest of the highway. The products are crushed stone, flux, and stone for lime burning. Formerly large quantities of stone for engineering construction and for building purposes in St. Hyacinthe and the neighbouring villages were also procured here. At present the quarries are worked only on a very small scale. The nearest railway shipping point for the group of quarries at the village is St. Hyacinthe, 5 miles distant, where connections can be made with the Canadian National, Canadian Pacific, and the Quebec, Montreal and Southern railways. However, very little stone is now shipped by rail, most of the output being consumed locally.

The stone is all of the calcium and high-calcium types, but there is a considerable variation in appearance and in purity. That formerly quarried for building stone is very dark grey, fine-grained, very heavily bedded and is striped parallel to the bedding with wavy seams of siliceous, ferru-

PLATE XXV

A. Weathered face of impure limestone at St. Dominique, Bagot county, showing streaks of siliceous magnesian material standing out in relief.

B. Synclinal fold in impure limestone at St. Dominique, Bagot county, with calcite filling the fractures.

ginous, magnesian material that weathers to a light brown in contrast to the light grey colour that the remainder of the stone assumes on exposure. This siliceous material is more resistant than the rest of the stone and on weathered surfaces it stands out in relief. (Plate XXVA, page 182). Apparently overlying this type of stone is 50 feet of a very fine-grained to dense, brittle, dove-grey limestone which in some places is pure but in other places contains much sand. The pure stone of this type is quarried for lime burning. Pure limestone is also seen along the base of the ridge to the north of the main group of quarries and it has been quarried in that locality for flux. The Champlain and St. Lawrence fault passes along the foot of the ridge and the limestone strata near the fault are usually much contorted.

The most westerly of the quarries along the St. Hyacinthe road is at the foot of the ridge just northeast of the curve on the road and is known as the Grand Trunk quarry. It was formerly worked by the Grand Trunk Railway Company for dimension stone for bridge piers and abutments, but has been abandoned for many years. It is 500 feet long, has been worked 125 feet into the hillside, and exposes 25 feet of fine-grained, dark grey limestone streaked with ferruginous, siliceous material. Bedding is exceptionally heavy, one bed being 15 feet thick without a distinct parting plane. Short, thick veins of white calcite and crystals of pyrite are common. The dip of the strata varies considerably but on the average is to the southeast at angles ranging from 10 to 20 degrees. Sample 215 was taken from the 25 feet of strata exposed. The same kind of stone is seen on the hillside back of the quarry. Across the highway a smaller quarry has been worked in similar stone, but is now idle, though rough building stone was produced there until 1926.

On top of the hill to the east of the Grand Trunk quarry, a dark dove-grey, fine-grained, hard, brittle high-calcium limestone has been quarried in two long, narrow quarries extending 600 feet northeasterly from the highway. The quarries are opened end to end along the crest of a small anticline striking N.45°E. About 8 feet of good quality limestone in beds 6 inches to 2 feet in thickness is exposed in the faces beneath 8 to 10 feet of soil and broken stone of poor quality. Sample 216 is representative of the 8 feet exposed. The output of these quarries was used for lime and crushed stone, but they are not worked at present.

On the opposite side of the highway are four quarries, two of which are worked for crushed stone, and one for stone for the making of lime. The most westerly of these quarries, which is close to the road, is opened in the impure limestone similar to that in the Grand Trunk quarry. The strata here are folded into a syncline (Plate XXVB, page 182). All fractures in this stone have been filled with white calcite. Sample 217 was taken only from the resistant siliceous bands that project from the weathered surface of this stone, and does not represent the stone as a whole. In 1934 the quarry was being worked for crushed stone by *O. F. St-Onge*, the limestone being quarried by hand drills and crushed in a small Blake breaker having a capacity of 15 tons per day.

The adjoining quarry to the east is owned by *Emile Lapointe* and is opened in dense-textured, blue-grey limestone apparently overlying that in the quarry just described. Many veins of white calcite are present in all

the stone and there is much sand in the top beds. From 8 to 15 feet of strata are exposed in the face beneath 1 to 3 feet of soil. Sample 218 represents the top 10 feet of stone. The excavation extends 200 feet southwesterly along the strike of the strata (S.45°W.) and is about 75 feet wide. The output of the quarry is crushed in a plant having a capacity of 150 tons per 10-hour day.

Stone for making lime is obtained from a quarry owned by A. Baran, 150 yards southwest of the Lapointe quarry. In this quarry (Plate XXVIA, page 187) which is about 200 feet wide, 8 feet of very dark, blue-grey, dense, high-calcium limestone, veined with white calcite and in beds up to 3 feet thick, is exposed beneath 5 feet of coarser grained, grey limestone and 4 feet of soil. The grey limestone on top is used for agricultural limestone as it is claimed that it crumbles when put into the kiln. Sample 219 was taken from the 8 feet of stone used for lime. The strata in the quarry strike N. 40° E. and dip to the southeast at various angles up to 5 degrees.

Four hundred yards to the southwest of the Baran quarry, and on the line of strike of the strata, is a long narrow quarry about 12 feet deep that has been abandoned for many years. It was apparently opened along an outcrop of the pure, fine-grained limestone, though very little stone is now to be seen, owing to a covering of soil.

Lime is burned at St. Dominique by *Camille Mercure, Joseph Lalumière,* and *Magloire Leclerc.* The plant of Camille Mercure consists of a small, vertical, continuous, steel kiln; the other kilns are of the batch type and are built of stone. Wood is used for fuel. All stone used for making lime at the present time is purchased from the Baran quarry.

At the southern end of the limestone ridge, midway between St. Dominique and St. Pie, fine-grained, dark-coloured, hard, brittle limestone, in rather thin beds, is exposed for nearly ½ mile along the road crossing the ridge in a northwesterly direction. The stone is impure as shown by the analysis of Sample 214, which consisted of chips taken at intervals across the entire outcrop. Ledges of impure, dark-coloured limestone are also to be seen in the bed of the Yamaska river at St. Pie. South of St. Pie only occasional small exposures of very impure slaty limestone were seen.

Northerly from St. Dominique, high-calcium and calcium limestones are exposed along the foot of the westerly face of the ridge, and a number of small quarries have been opened to obtain stone for building purposes and for making lime.

On the property of A. Plante, ½ mile north of the Grand Trunk quarry previously described, a small quarry once worked in connection with a lime kiln was opened at the foot of the ridge along the axis of an anticlinal fold in a blue-grey, fine-grained limestone striking N. 45° E. The top beds in the 10-foot face are dark blue-grey, hard, fine-grained and have slaty bands parallel to the bedding. The lower beds are lighter in colour and contain very little slate. Many cross fractures in the beds are filled with white calcite. All beds are thick. Sample 220 was taken from the lower 6 feet of strata in the quarry.

On the property of Lévis Loiselle, ½ mile northwest of the Plante quarry and ½ mile northeast of the road to St. Hyacinthe, rubble and foundation stone have been obtained from very fine-grained, light blue-grey limestone much veined with white calcite. The beds are much shattered, and

slickensided surfaces are common in the 8-foot face of the quarry, which has been extended 250 feet along the face of the ridge. A bed 12 to 18 inches thick of fine-grained, rusty weathering limestone (probably magnesian in composition) is interbedded with the high-calcium limestone. Sample 221 is representative of the stone in the quarry exclusive of the rusty bed.

Half a mile north of where Sample 221 was taken, Henri Loiselle has opened a small quarry in a fine-grained, grey-blue, high-calcium limestone thickly veined with coarse white calcite. The stone here is of the nature of a limestone breccia and no definite bedding is discernible. Sample 222 represents the stone from this quarry, the output of which is sold for flux to foundries in Montreal. Farther north along the base of the ridge the limestone exposed contains less calcite than that in the Loiselle quarry. A light covering of soil supporting a dense growth of trees covers the rock on the upper slopes of the ridge and no outcrops were observed.

Ste. Rosalie

One and one-half miles farther north along the ridge from Henri Loiselle's quarry, and 2 miles southeast of Ste. Rosalie Junction on the Canadian National railway, light blue-grey and dark blue, high-calcium limestone is exposed on the property of Frank Ledoux, where it has been quarried to a small extent. The blue-grey limestone, much veined with white calcite, is seen at the base of the ridge, and the dark blue limestone is exposed slightly higher up on the west slope of the ridge along the road leading southeasterly from Ste. Rosalie. Sample 223 consisted mostly of the blue-grey stone. The beds at this place strike N.60°E. and dip to the southeast at an angle of 22 degrees.

Upton

Three miles northeast of Upton and west of St. Nazaire river a number of large outcrops of rather impure, hard, metamorphosed, varicoloured, fine-grained limestone are seen in the flat country along the road going north to Royville. The limestone is predominantly of a light blue colour, tinged with white, pink, and mauve. It would make a handsome marble if obtainable in large blocks, but all outcrops are badly fractured. The limestone in places contains copper sulphides, and prospect pits have been opened in several of the outcrops. Sample 224 was taken across a small ridge of this limestone on lot 50, range XXI of Upton township, where it outcrops along the road to St. Théodore at a point ¼ mile east of the road between Upton and Royville. This same ridge of limestone can be traced southwesterly for ½ mile to the creamery on the last-mentioned road, at which place the exposures have a width of 500 feet. The apparent strike of the limestone is N.85°E. and the dip is to the south at an angle of 20 degrees.

Similar limestone is again exposed on both sides of the Upton-Royville road ¾ mile north of the creamery on lot 49, range XX of Upton township. Sample 225 was taken over a ridge of blue limestone, 20 feet high, on the property of A. Fréchette, just west of the road. A prospect pit for copper was dug here in 1866. Sample 226 was taken from a large outcrop, 600 yards long, 250 feet wide and 40 feet high, on the property of Adélard Houle, on lot 49, range XXI, Upton township, ¼ mile east of the road and slightly north of the Fréchette property. The limestone has a brecciated

appearance in some places but in other places it has a schistose structure. Some few siliceous nodules are apparent on the weathered surface. The apparent strike is N.80°E. and the dip is to the south at an angle of 35 degrees.

St. Théodore

On lot 38, range VII, Acton township, on the hillside west of a small brook, ¾ mile northwest of the village, fine-grained, light bluish grey limestone, containing many veins of calcite, is extensively exposed. In places some few nodules of siliceous impurities and also grains of sand were observed, but on the whole the deposit is of a good grade of purity as shown by the analyses of Samples 227 and 227A which were taken across the exposure in two directions. Lime was formerly burned here in a small field kiln, now in ruins. This deposit is about 3 miles in a direct line from both the Canadian Pacific and Canadian National railways.

Two miles directly northeast of St. Théodore a more impure limestone of the same type is exposed over a large area immediately west of the Canadian Pacific railway. In some places the limestone is sandy and holds nodules of chert and streaks of slate but in other places it is relatively free from these impurities. Sample 228 was taken across an outcrop 250 feet wide on lot 31, range VIII, Acton township, 1¼ miles north of the road going east from St. Théodore. Extensive exposures of the same type of limestone also occur on lot 32, range VIII, and on lot 31, range VII, in which latter location it is close to the Canadian Pacific railway. The latter outcrops, however, seem somewhat more siliceous than do those to the north and west.

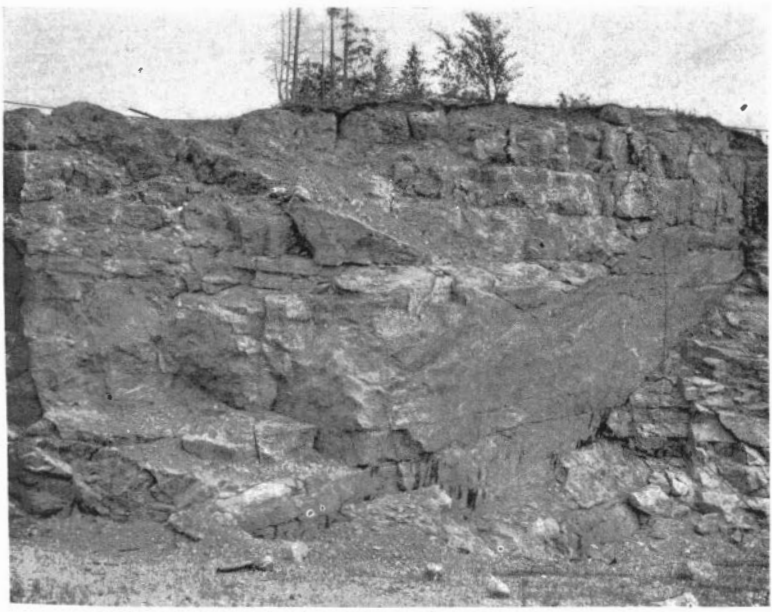
Acton Vale

In the vicinity of this village are several large outcrops of limestone not dissimilar in appearance to those near St. Théodore and Upton. Three-quarters of a mile southeast of Acton Vale a large quarry for the production of crushed stone is worked by the Kennedy Construction Company in a hill of limestone at the site of the former Acton Vale copper mine.

Quarry of Kennedy Construction Company, 407 McGill St., Montreal. This quarry, which is 300 feet long, 200 feet wide, and has a working-face 60 feet in maximum height, is opened in the western face of a hill composed of hard, blue-grey, very fine-grained, siliceous limestone containing masses of black chert, veins of white quartz and silicate minerals, as well as an occasional vein of calcite. The bedding is massive and irregular, as is shown in Plate XXVIB, page 187. Similar limestone is exposed on the hilltop to the east of the quarry, and the prevailing strike of the beds is N.50°E. and the dip 27 degrees to the northwest. At the west edge of the quarry, mashed slate is in faulted contact with the limestone. The limestone is more siliceous in some parts of the quarry than in others. Sample 230 was taken in the quarry excluding the most siliceous stone and Sample 230A was taken from a pile of screenings near the crushing plant.

The quarry face is worked in 16-foot benches, drilling being done with jackhammers. Blasted stone is loaded by hand to horse-drawn dump carts and conveyed to the crushing plant, which is situated 600 feet distant on a siding of the Canadian National railway, and which has a maximum

A. Quarry of A. Baran in Chazy limestone, St. Dominique, Bagot county.



B. Cambrian limestone in quarry of Kennedy Construction Company, Acton Vale, Bagot county.

output of 700 tons per 10-hour day. Motor trucks are used for transporting crushed stone to nearby localities.

A rather siliceous magnesian limestone is also extensively exposed on lot 34, range V, Acton township, 1 mile north of Acton Vale and ¼ mile west of the road to St. Théodore. It is similar in appearance to that in the Kennedy Construction Company's quarry and it also contains veins of quartz and nodules of chert. As shown by the analysis of Sample 229, it contains more magnesia than the other deposits in the county.

Analyses of Bagot County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
214.....	9·12	0·70	1·65	0·15	85·04	2·04	98·70	0·05	47·70	0·97	49 : 1
215.....	12·52	1·73	3·91	0·20	76·23	3·77	98·36	0·58	42·80	1·80	24 : 1
216.....	1·94	0·24	0·48	0·02	97·38	0·27	100·33	0·04	54·54	0·13	419 : 1
217.....	22·18	2·91	7·86	0·15	48·02	16·48	97·60	0·44	26·97	7·88	3 : 1
218.....	7·00	0·20	0·20	0·01	91·61	0·63	99·65	0·04	51·31	0·30	171 : 1
219.....	1·34	0·30	0·44	0·02	97·07	0·84	100·01	0·05	54·37	0·40	136 : 1
220.....	3·20	0·31	0·73	0·02	92·79	1·74	98·79	0·03	51·97	0·83	63 : 1
221.....	2·08	0·20	0·42	0·02	92·66	4·81	100·19	Tr.	51·90	2·30	23 : 1
222.....	0·54	0·21	0·55	Tr.	92·21	6·36	99·87	Nil	51·64	3·04	17 : 1
223.....	1·02	0·34	0·24	0·02	97·91	0·67	100·20	0·07	54·84	0·32	171 : 1
224.....	6·95	0·53	0·70	0·31	88·25	2·99	99·73	0·04	49·59	1·43	35 : 1
225.....	4·90	1·33	1·87	0·42	85·89	5·52	99·93	0·27	48·33	2·64	18 : 1
226.....	5·48	1·10	0·54	0·31	83·41	9·18	100·02	0·04	46·88	4·39	11 : 1
227.....	1·98	0·31	0·37	0·11	95·82	1·16	99·75	Tr.	53·72	0·55	98 : 1
227A.....	2·96	0·25	0·33	0·11	95·12	1·43	100·20	Tr.	53·32	0·68	78 : 1
228.....	4·74	0·70	1·28	0·31	90·23	2·68	99·94	0·05	50·61	1·28	40 : 1
229.....	6·06	0·91	0·33	0·26	79·39	12·82	99·77	0·07	44·60	6·13	7 : 1
230.....	3·66	0·72	1·08	0·26	87·52	6·98	100·22	Tr.	49·15	3·34	15 : 1
230A.....	6·92	0·72	1·48	0·22	84·64	6·23	100·21	0·16	47·52	2·98	16 : 1

214.	St. Dominique.	Outcrops of limestone at south end of ridge midway between St. Dominique and St. Pie.
215.	"	Grand Trunk quarry.
216.	"	Quarry on top of ridge immediately east of Grand Trunk quarry.
217.	"	Sample of rusty, siliceous material projecting in bands from weathered surface of the impure limestone of this district.
218.	"	Top 10 feet of strata in quarry owned by E. Lapointe.
219.	"	Quarry of A. Baran.
220.	"	Bottom 6 feet of strata in quarry of property of A. Plante.
221.	"	Quarry of Lévis Loiselle.
222.	"	Quarry of Henri Loiselle.
223.	Ste. Rosalie.	Outcrops on property of Frank Ledoux, 2 miles southeast of Ste. Rosalie Junction.
224.	Upton.	Outcrops of limestone on lot 50, range XXI, Upton township.
225.	"	Outcrops on property of A. Fréchette, 3 miles northeast of Upton village.
226.	"	Outcrops on property of A. Houle, ¼ mile to the northeast of where Sample 225 was taken.
227.	St. Théodore.	Outcrops ¾ mile northwest of the village.
227A.	"	Another sample from the same deposit.
228.	"	Outcrops on lot 31, range VIII, Acton township.
229.	Acton Vale	Outcrops 1 mile north of Acton Vale on lot 34, range V, Acton township.
230.	"	Quarry of Kennedy Construction Co., exclusive of siliceous bands.
230A.	"	Screenings from quarry of Kennedy Construction Company.

Beauce County

The northern and central parts of this county are largely underlain by slates and quartzites of Cambrian age (*see* Northeast sheet, Eastern Townships map issued by the Geological Survey), interbedded with which, in a number of localities, are relatively thin lenticular bodies of impure limestone. At St. Joseph de Beauce, near the junction of the Caldwell and Chaudière rivers, one of these limestone deposits, consisting of red magnesian limestone veined with white and pink calcite, has been quarried on a small scale for use as marble.

The southern part of the county is underlain by Ordovician slates and quartzites in which, according to Ells,[1] calcareous rocks are as a rule absent.

A narrow band of quartzites and slates, mapped as Precambrian by Ells, extends in a northeasterly direction across the centre of the county. Ells[2] states that within this belt limited outcrops of greyish, sub-crystalline limestones are found occasionally in the first and second concessions north of Beauce Junction, and also on the top of the hill ½ mile east of West Broughton church where they have been burned for lime.

St. Joseph de Beauce

Property of British Canadian Marble Co., Ltd., Address P.O. Box 456, Simcoe, Ontario. The quarry in the deposit of red magnesian limestone or marble on this property is on the hillside 1,000 feet east of the highway between St. Joseph and Beauceville, and a very short distance southeast of where Caldwell river empties into the Chaudière. The marble is fine-grained, hard, and of a pinkish red colour, veined and mottled with white and yellowish, coarse-grained calcite and also with an occasional stringer of white quartz. (Plate XXVIIA, page 190.) In places are inclusions of brick-red slaty stone. The deposit is from 10 to 20 feet in width at the place where it has been quarried. It strikes N.60°E., dips nearly vertically, and is enclosed in red and green slates having the same strike and dip. It is said to be traceable for ¼ mile or so along the strike in both directions from the quarry. As noted by Parks[3] the limestone appears to be in a series of elongated lenses rather than in a continuous band. Sample 252 was taken across a width of 12 feet of the stone exposed in the small quarry. A shaft was sunk to a depth of 160 feet in the red slate associated with the limestone to obtain slate for making roofing granules which were prepared in a mill on the property. Neither the marble nor the slate has been worked in recent years. The Quebec Central railway passes within 1,000 feet of the deposit.

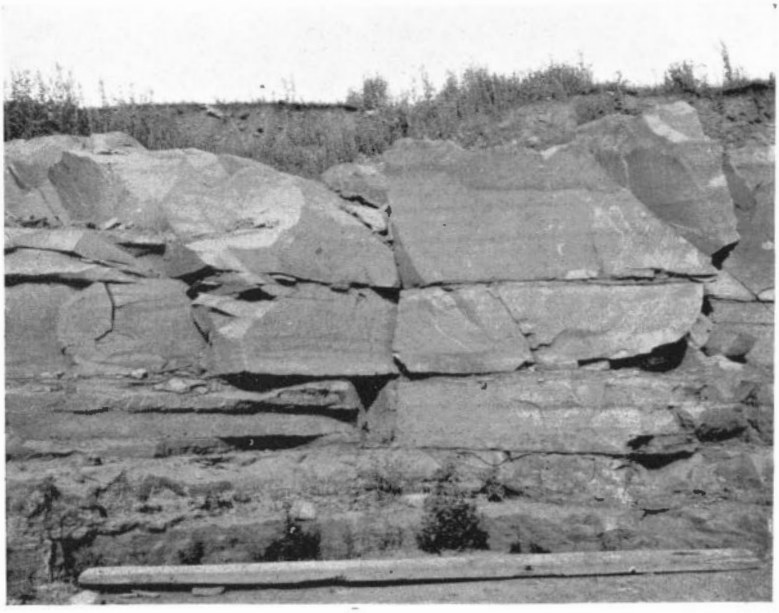
St. Georges

An outlier of dull-lustred, light blue, fine-grained, fossiliferous calcium limestone of Devonian age occurs on a hillside at St. Georges on the east side of Chaudière river and about ½ mile south of the mouth of Famine river. The limestone is veined with white calcite and is so much

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. III, pt. 2, p. 13K (1887-88).
[2] Ells, R. W.: Op. cit., p. 85K and p. 113K.
[3] Parks, W. A.: Mines Branch Rept. 279, p. 223 (1914).

PLATE XXVII

A. Red Cambrian limestone veined with white calcite. Property of British Canadian Marble Company, St. Joseph de Beauce, Beauce county.



B. Beekmantown limestone in quarry at Valleyfield. Beauharnois county.

weathered that the strike and dip could not be positively determined. Beneath the limestone is a slaty, metamorphosed conglomerate containing many pebbles of quartz, and a small patch of this conglomerate is also seen near the top of the outcrop facing Chaudière river. Beneath this conglomerate are steeply dipping slates. Sample 253 was taken from a 10-foot face of the limestone exposed in a small quarry from which stone for making lime was once obtained. As stated by Ells[1] the limestone deposit appears to extend for 20 chains along the face of the hill facing Chaudière river.

Analyses of Beauce County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
252.....	4·88	1·26	2·14	0·09	71·45	19·80	99·62	Tr.	40·06	9·47	4 : 1
253.....	5·32	1·30	0·58	0·07	91·77	1·11	100·15	0·11	51·43	0·53	97 : 1

252. St. Joseph. Quarry of British Canadian Marble Co., Ltd.
253. St. Georges. Abandoned quarry in outcrop of limestone on the hillside northeast of the junction of Famine and Chaudi're rivers.

Beauharnois County

Very hard, siliceous, dolomitic limestone of the Beekmantown formation underlies the western half of this county, and a small area of the same formation is also found in the northeast corner. Quarries for crushed stone are worked at Valleyfield and at St. Timothée. Formerly building stone and curbstone were produced from quarries at Valleyfield, but there has been no production within recent years. Quarries for road metal have also been worked near St. Louis de Gonzague, and outcrops are plentiful between that village and St. Stanislas.

Valleyfield

A number of quarries have been worked in the flat-lying, siliceous Beekmantown dolomite in the vicinity of Valleyfield, the products being rough building stone, curbstone, and crushed stone.

Quarry Operated by City of Valleyfield.

The city operates a quarry on De Salaberry island for the production of crushed stone. The excavation is 300 feet in diameter and exposes 18 feet of stone beneath 3 to 6 feet of soil. The top 10 to 11 feet, as shown in Plate XXVIIB, page 190, is heavily and evenly bedded. Beneath it is 7 feet of unevenly and thinly bedded stone. In places the top bed is 45 inches thick but is usually split into two beds; it and the bed beneath are fine-grained and light blue-grey in colour. The lower beds are darker in colour and contain many vugs partly filled with crystals of calcite and

[1] Ells, R. W.: Op. cit. p. 10K.

dolomite. Sample 160 represents the top 11 feet of strata, and, as the analysis shows, it is an extremely siliceous stone, much more so than the bottom 7 feet represented by Sample 160A.

A jackhammer is used in drilling the stone, which, after being blasted, is loaded by hand to horse-drawn carts and taken to the crusher on the quarry bank. The crushing plant has a capacity of 40 tons per hour.

Several small quarries for building stone and curbstone have been opened in the vicinity of the city quarry, but none has been operated within the past several years.

St. Timothée

At St. Timothée, siliceous Beekmantown dolomite is quarried for road metal by the Quebec Department of Highways. The stone is somewhat coarser in grain than that quarried north of Valleyfield but otherwise is similar.

Beauharnois

The village of Beauharnois is underlain by Potsdam sandstone, but a short distance to the east the Beekmantown formation overlies the sandstone.

Two miles east of the village, finely granular, brown, and also blue-grey, Beekmantown dolomite is exposed on the properties of François and Auguste Hébert at Hébert point, where the top beds have been quarried, chiefly for building stone. Beds up to 18 inches thick are available. The blue-grey stone contains much sand, but the brown stone is purer than is most of the Beekmantown limestone as is shown by the analysis of Sample 161, which was taken from the 3½ feet of brown stone exposed in a pit on the property of François Hébert. The brown stone, however, contains vugs filled with white calcite and also numerous grey fossils that spoil it for fine building stone.

St. Louis de Gonzague

Two miles southwest of here, on the south side of the road to St. Stanislas, very siliceous, hard, blue-grey dolomitic limestone of the Beekmantown formation has been quarried for road metal. Seven feet of finely granular stone in beds up to 18 inches thick is exposed beneath 6 inches to 2 feet of soil. As shown by the analysis of Sample 162, which was taken here, the stone is very siliceous.

Very similar limestone is also exposed 1¼ miles south of St. Louis where it has been quarried in small quantity, and exposures are also common west of the village, along St. Louis river.

Landreville

One mile southeast of Landreville and 600 yards northeast of the road to Ormstown, 2 feet of fine-grained, blue-grey, hard, sandy Beekmantown dolomite is exposed in a tiny quarry near the Châteauguay county boundary. Sample 163 was taken here.

Analyses of Beauharnois County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
160.....	42·78	1·65	2·47	0·20	30·71	21·42	99·23	0·25	17·31	10·25	1·69 : 1
160A.....	17·76	1·81	2·71	0·04	50·12	26·39	98·83	0·59	28·09	12·62	2·22 : 1
161.....	2·96	0·50	1·04	0·04	55·00	40·32	99·86	0·16	30·82	19·28	1·59 : 1
162.....	32·50	1·24	2·00	0·15	38·82	25·02	99·73	0·35	21·82	11·96	1·82 : 1
163.....	6·80	0·95	1·30	0·11	51·70	38·56	99·42	0·10	29·01	18·44	1·57 : 1

160.	Valleyfield.	Top 11 feet of strata in City quarry on De Salaberry island
160A.	"	Bottom 7 feet in the same quarry.
161.	Beauharnois.	Pit on property of François Hébert 2 miles east of the village.
162.	St. Louis de Gonzague.	Quarry 2 miles southwest of the village on the road to St. Stanislas.
163.	Landreville.	Quarry 1 mile southeast of the village.

Bellechasse County

Relatively small deposits of impure limestone and of limestone conglomerate, interbedded with shales, sandstones, and quartzites occur in the northwestern and central parts of this county. Those in the northwestern part are northwest of the Boyer river and those in the central part are mostly in the township of Mailloux. All seen were of small size, impure, and variable in composition. None has been worked in recent years. No samples were taken.

Regarding the deposits in Mailloux township Ells[1] states:—

"Limited amounts of greyish, sub-crystalline limestones (Cambrian) associated with black slates and quartzites are found in the township of Mailloux along the road leading northeast from the village of Buckland, where they have been burned for lime for local purposes."

Brome County

Lenses of metamorphosed limestone, 100 to 200 feet thick, enclosed in steeply dipping schistose rocks, occur at intervals northeasterly from south of Brome lake to the northern boundary of the county and thence into Shefford county through the village of South Stukely. These lenses may be part of the same band. On the older geological maps this limestone is shown as being of Precambrian age but, according to Clark[2], the limestone and its associated rocks in the southern part of Brome county are now believed to be of either Cambrian or Ordovician age. In the northern part of the county these lenses consist of calcium limestone and in part of dolomite, but in the southern part near Brome lake the limestone is apparently all dolomitic. In no place is the limestone of a high degree of purity; in the northern part it is veined with white quartz, and in the southern part it contains inclusions of schist as well. Formerly, near Knowlton, the limestone of this band was utilized for making lime.

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept. vol. III, pt. 2, p. 85K (1887-88).

[2] Clark, T. H.: "Structure and Stratigraphy of Southern Quebec," Bull. Geol. Soc. of America, vol. 45, pp. 1-20 (1934).

Another and much thinner band of very impure dolomite, practically a dolomitic sandstone, is exposed in the southwestern part of the county between West Sutton and Brome Centre. No samples were obtained from this band.

In the township of Farnham East, very impure Cambrian dolomite is exposed 1 mile east of the village of East Farnham. And in the same township impure, slaty calcium limestone is exposed at Farnham Centre, and along the south branch of the Yamaska river at Brigham village.

On the west side of lake Memphremagog, thinly bedded, impure, shaly calcium limestone of Silurian or Devonian age is exposed at a number of places. Fifty years or so ago small quantities of lime were made from limestone of this type at Knowlton Landing.

In the Geology of Canada (1863), on pages 457 and 458, references are made to deposits of magnesite on lots 17 and 24, range IX, Bolton township and on lot 12, range VII, Sutton township, but the deposits are not seemingly of economic value as they are extremely siliceous.

Farnham Centre

At Farnham Centre, on lot 26, range I, Farnham township, a small outcrop of impure, black, thin-bedded, slaty limestone of Ordovician age, was formerly quarried on a very small scale for the making of lime. It is probably similar in chemical composition to the limestones of similar appearance exposed to the north in Rouville county (*see* pages 227-228).

East Farnham

On lot 10, range II, township of Farnham East, 1 mile east of the village and on the north side of the road to Knowlton, is an outcrop of very siliceous, fine-grained, slaty, blue dolomite probably of Ordovician age. It is weathered deeply to an ochreous mass that is nearly black on the surface. The dolomite strikes N. 30° E. and dips at an angle of 45 degrees to the southeast. A width of 40 feet is exposed with slate on the west side. As shown by the analysis of Sample 200, which is representative of the dolomite, it is too impure to be classed as a limestone. A narrow band of similar stone is seen 2 miles to the east on the north side of the road.

Knowlton

On the property of J. C. Patterson, lot 9, range X, Brome township, 1¼ miles southeast of Knowlton, a band of light-coloured, fine-grained, metamorphosed dolomite, that in places is coloured green and purple, is exposed. The band is of variable width up to a maximum of 175 feet and contains masses of schist and veins of quartz. It has a prevailing strike N. 30° E. and apparently dips to the northwest at an angle of 60 degrees. Lime was burned here 40 years ago, and the stone is said to have made a dark, strong lime that would set under water. Sample 201 was taken across the band, excluding the large masses of schist.

One and a half miles north of Knowlton, on the east side of the road along the east side of Brome lake, on the estate of the late Senator Foster, an outcrop of similar blue dolomite veined with white calcite, and in places

tinted with mauve and green, is exposed in a knoll in a swampy valley. Sample 202 was taken across a width of 50 feet of the dolomite which apparently strikes N. 30° E. and dips northwesterly at an angle of 70 degrees. Near this outcrop are the ruins of two lime kilns indicating that the stone was at one time used for lime. The colouring of this dolomite is such that it would make a handsome marble but the quantity available is unknown. The Canadian Pacific railway passes 400 yards to the west of the outcrop.

Foster

Three and a half miles northeast of Foster, on the hillside directly east of the Canadian Pacific railway and within three hundred yards of the northern boundary of Brome county, blue and white, fine-grained calcium limestone veined with white quartz, is exposed on the property of R. A. Bourgoie. The limestone strikes northeasterly and the outcrop has a width of 100 feet. It is apparently a continuation of the limestone band exposed in several places at South Stukely, 1 mile to the northeast. Sample 203 represents the stone exposed on the Bourgoie property, exclusive of the quartz veins.

Knowlton Landing

On the hillside ¾ mile northwest of Knowlton Landing, thinly bedded, dark blue-grey, fine-grained, impure calcium limestone interbedded with slaty shale is exposed in a small quarry formerly worked to obtain stone for making lime. Sample 204 was taken from the limestone beds in this quarry but none of the shale was included. The strata strike N. 10° W. and dip easterly at a high angle. Similar limestone veined with calcite is exposed in the village itself and also to the north along the road to East Bolton, and also just west of East Bolton. The limestone is much weathered and appears to be in lenses enclosed in a slaty shale. Some of it is much more impure than that sampled, but all is of the calcium type. Other outcrops are reported to occur along the west shore of lake Memphremagog between Austin bay and Channel bay.

Analyses of Brome County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
200.....	52·00	4·20	7·76	0·42	18·91	18·57	101·86	Tr.	10·82	8·88	1·22 : 1
201.....	6·42	5·11	0·76	0·07	50·21	36·41	98·98	Tr.	28·16	17·41	1·62 : 1
202.....	5·78	2·95	0·81	0·07	52·10	38·58	100·29	Tr.	29·22	18·45	1·57 : 1
203.....	2·98	0·51	0·50	0·20	94·80	0·74	99·73	0·01	53·20	0·35	1·52 : 1
204.....	13·37	1·19	1·69	0·07	79·04	3·30	98·66	0·06	44·30	1·58	28 : 1

200. East Farnham.	Outcrops on lot 10, range II, township of Farnham East, east of the village.
201. Knowlton.	Outcrops on lot 9, range X, Brome township.
202. "	Outcrops on estate of the late Senator Foster, 1½ miles north of the village.
203. Foster.	Outcrops on property of R. A. Bourgoie, 3½ miles northeast of Foster.
204. Knowlton Landing.	Abandoned quarry ¾ mile northwest of the village.

Châteauguay County

Limestone available in this county is all of the siliceous, dolomitic variety belonging to the Beekmantown formation. It is found in the western part of the county north and west of Ormstown, and also underlying a strip of country 4 to 6 miles wide along the eastern boundary of the county. In this latter area it is quarried for building stone at Ville de Léry (Boisbriand), near Châteauguay village, and for crushed stone near Ste. Clothilde in the southeastern part of the county. No quarries are worked in the first-mentioned area.

Ormstown

North and west of Ormstown and Tatehurst several outcrops of flat-lying beds of siliceous Beekmantown dolomitic limestone were observed but no samples were taken as there was no face of stone exposed.

Ville de Léry (Boisbriand)

Quarry of Alphonse Faubert. Evenly bedded, fine-grained, hard, siliceous, steely blue, dolomitic Beekmantown limestone is quarried by Alphonse Faubert for building purposes near the top of the hillside facing lake St. Louis, a short distance east of Boisbriand station between Beauharnois and Châteauguay village. The quarry is about 250 yards southeast of the track of the St. Lawrence and Adirondack branch of the New York Central railway. Four feet of stone, in beds 14, 8, 16, and 12 inches thick, is worked. Beneath this, as seen in an opening in the quarry floor, the limestone is in thinner, irregular beds and is not suitable for building purposes. An area approximately 350 feet in diameter has been quarried over, and the quarry is being advanced to the southeast, in which direction the land rises slightly. One or two feet of soil covers the limestone. Sample 158 was taken from the 4 feet of stone quarried. Drilling is done by contract. The stone after being loosened by charges of black powder is broken by sledges into sizes suitable for laying in walls. Owing to its hardness it is not tooled in any way. Montreal is the principal market.

Preparations are being made by *Alfred Bissonette* of St. Laurent to quarry rubble on the property to the east of the Faubert quarry.

Châteauguay

Many outcrops of Beekmantown limestone are to be seen west of the village along the road to Woodlands, and several small quarries have been opened at various times to obtain stone for road metal. In the quarry on the north side of the road, 1 mile west of Châteauguay, 11 feet of hard, fine-grained, light blue, dolomitic limestone is exposed, beneath 1 to 2 feet of soil. The beds are from 4 to 16 inches in thickness, and are nearly horizontal. The stone is probably similar in composition to that at Ville de Léry. On the opposite side of the road two small quarries were at one time worked in the same type of stone, the one nearest the road being 15 feet deep.

Ste. Clothilde

Southwest of the village, along Norton creek, is an area but thinly covered with soil where outcrops of sandy, Beekmantown dolomite are plentiful. A small quarry producing crushed stone for road metal and concrete aggregate is in operation here. A short distance to the west the underlying Potsdam sandstone is exposed and thus the Beekmantown strata exposed in the vicinity are near the base of the formation. Many of the beds are very sandy.

La Carrière Marcil, Ltée. This quarry is opened on the south side of the Canadian National railway, 2 miles southwest of Ste. Clothilde, in siliceous, blue-grey, unevenly bedded dolomite that dips at an angle of 4 degrees to the northeast. The excavation is about 250 feet in diameter and the quarry face varies from 10 to 14 feet in height, depending on the topography. Sample 159 is representative of the stone quarried.

A jackhammer is used for drilling. The blasted stone is loaded by hand to motor trucks, which convey it to the crushing plant 200 yards distant on the north side of the railway. Shipments of crushed stone are all made by motor truck.

Near the crushing plant is an abandoned quarry 10 feet deep, in which the stone is heavier bedded than in the quarry now worked. Lime was formerly made here in small field kilns. Sample 159A was taken in this quarry.

Analyses of Châteauguay County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
158.....	40·40	2·16	2·90	0·13	30·00	23·09	98·68	0·40	16·87	11·04	1·53 : 1
159.....	26·74	1·78	2·62	0·17	43·77	24·74	99·82	0·48	24·60	11·83	2·08 : 1
159A.....	18·94	1·38	1·26	0·11	47·20	30·97	99·86	0·25	26·49	14·81	1·78 : 1

158. Ville de Léry (Boisbriand). Top 4 feet of stone in quarry of Alphonse Faubert.
159. Ste. Clothilde. Quarry operated by La Carrière Marcil, Ltée.
159A. " Abandoned quarry near the crushing plant of the above company.

Compton County

This county is almost entirely underlain by steeply dipping, slaty and sandy rocks of Ordovician age, which in the western part of the county, particularly in Compton, Eaton, and Westbury townships, are interstratified with wide bands of thinly bedded (2 to 6 inches), sandy, calcium limestone. This limestone in turn is interbedded with black, micaceous, shiny slate. All the limestone is very impure and most is dark grey-blue in colour, though some lenticular masses are light in colour and striped with dark blue. Cubes of pyrite are very common in most of the deposits. Limestone of this type is plentiful in the vicinities of East Angus, Cookshire, Eaton, Birchton, south of Bulwer, and south and west of Compton village. It has been used for flagging and for lime for local use at several of the above places, but there has been no production within recent years.

Cookshire

On the southern outskirts of Cookshire, very sandy, fine-grained, dark blue limestone of the above type is exposed on the road to Eaton. It strikes northeasterly and dips steeply to the south. Considerable quartzite is interbedded with the limestone. Sample 240 represents the limestone only.

Similar slaty arenaceous limestone in beds 2 to 5 inches thick is seen on the road between Cookshire and East Angus and also on the road between Cookshire and the village of Eaton.

Analysis of Compton County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
240.....	30·04	1·04	0·76	0·11	64·46	3·57	99·96	0·07	36·10	1·72	21 : 1

240. Cookshire. Outcrop at south end of the town on the road to Eaton.

Dorchester County

Ells[1] gives the following description of a small outcrop of limestone in the southern part of the county:—

"On the road leading to Ste. Justine, between the townships of Langevin and Ware, a very limited exposure of fossiliferous limestone (similar to that at St. Georges in Beauce county) rests on the black slates and hard grey sandstones. This is on lot 32, range IX, Langevin, at the summit of the ridge, midway between the crossing of the brook at the head of the Famine river and the corner of the road to Ste. Justine church. The breadth of this outcrop is not more than 12 to 16 feet, and it is about the same length."

Drummond County

A number of thin deposits of impure limestone are known to occur in the steeply dipping Ordovician rocks that underlie the greater part of this county, but no deposits of pure limestone are known. Also, in the vicinity of Wickham, deposits of rather siliceous limestone are found in an area of Cambrian rocks. This Cambrian limestone is much like that around Acton Vale and St. Théodore in the adjoining county of Bagot. Small quantities have been quarried in the past for making lime for local use and there is still an occasional small quantity of lime made near West Wickham, but this is the only use being made of the limestone in Drummond county at the present time.

West Wickham

Within the village itself and also 1 mile to the southeast along the road going in that direction, steeply dipping, sandy, impure limestone is

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. III, pt. 2, p. 10k (1887-88).

exposed. At the latter locality, on lot 14, range X, of Wickham township, a Mr. Derocher burns lime in a small field kiln from time to time as the demand for lime arises. The kiln has a capacity of only 3 tons of lime at each burning. The stone quarried is a hard, fine-grained, grey-blue, rather siliceous magnesian limestone veined with calcite, and containing many crystals of copper pyrites in some places, but none in others. Sample 231 is representative of the stone burned.

On lot 9, range X of the same township, a limestone of variable composition is to be seen, and just west of the village outcrops of siliceous, fine-grained, grey-blue limestone are visible near the ruins of a small lime kiln, in which the stone was formerly burned.

In the village itself a fine-grained, grey-blue limestone much veined with calcite, and dipping at a steep angle, is exposed along the side of the road for 100 feet or so. It is almost entirely free from magnesia as the analysis of Sample 232 shows. Though the stone could not be quarried at the outcrop it could probably be traced to a quarriable location if a demand for that type of stone should materialize.

Drummondville

Impure, slaty limestone is exposed along the St. Francis river above Drummondville. Some is apparently magnesian in composition and some contains only a small percentage of that constituent. Because of the variation in composition of the several beds visible no sample was taken.

St. Félix-de-Kingsey

On the property of Albert Lebel, ¼ mile southwest of the village, a fine-grained, black, impure limestone associated with black slate is exposed, and many years ago was quarried for burning in a nearby small kiln now in ruins. Sample 233 was taken from this outcrop. The beds strike N. 40° E. and dip to the southeast at an angle of 75 degrees.

Trenholm

Siliceous, red, fine-grained limestone veined with quartz and with white calcite is exposed in the vicinity of the old slate quarries on the east side of St. Francis river, 1½ miles north of Trenholm. The limestone in places is slaty but in others is massively bedded and appears to be in a thick band. Sample 234 was taken on the property of Henry Armstrong of Trenholm.

Analyses of Drummond County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
231.....	4·42	0·86	1·02	0·39	83·36	10·48	100·53	0·02	46·89	5·01	9 : 1
232.....	4·92	0·89	1·05	0·13	92·04	0·50	99·53	0·03	51·61	0·24	215 : 1
233.....	17·06	1·98	3·04	0·63	73·43	2·02	98·16	0·08	41·12	0·96	43 : 1
234.....	14·32	1·14	3·81	n.d.	70·89	8·21	98·37	0·09	39·72	3·93	10 : 1

231. West Wickham. Stone burned for lime, lot 14, range X, Wickham township.
232. " Outcrops along side of road in the village.
233. St. Félix-de-Kingsey. Outcrops on property of Albert Lebel.
234. Trenholm. Red limestone on property of Henry Armstrong.

Frontenac County

In the reports of the Geological Survey several references are made to limestone at the narrows on lake St. Francis about 4 miles from the head of the lake and on the east side. These limestones were first referred to in the report of the Geological Survey for 1849-50, p. 51, and later in the Geology of Canada (1863), page 429, and still later in the report of the Geological Survey for 1886, Part J, pages 9 and 10. The reports state that small deposits of brownish and greyish dolomitic slates and limestones outcrop on the east shore of the lake on lots 20-23, range III, Lambton township. They dip to the northeast at an angle of 25 degrees.

On the geological map accompanying Part I, Annual Report, 1886, limestone bands are shown in the Ordovician rocks at four places on the west shore of lake St. Francis within a distance of 4 miles from the head of the lake, and at one place on the opposite shore 3 miles from the head. A band of limestone is also shown 300 yards northeast of the cross-roads at Stornoway in Winslow township. None of these deposits were examined in connection with the present report.

Huntingdon County

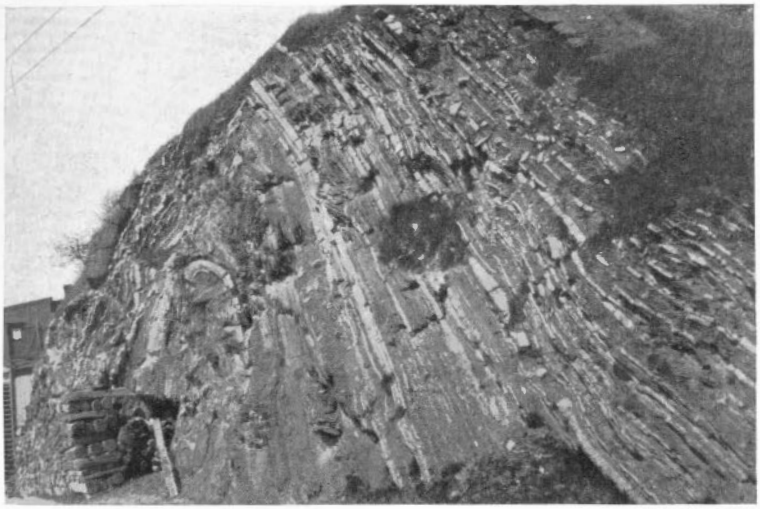
Flat-lying beds of siliceous, dolomitic Beekmantown limestone underlie a large area in the western part of the county between the valley of Châteauguay river and the St. Lawrence, and are also found in the extreme eastern part in the vicinities of Hemmingford and Barrington. Several quarries have been opened to obtain crushed stone for road metal and concrete aggregate, but no quarries are in continuous operation within this county at the present time. The limestone has also been utilized for foundations and rock-face wall construction and, despite its highly siliceous nature, has been used for making lime for local use. In the samples obtained for chemical analysis in this county the content of impurities ranged from 4·6 to over 17 per cent.

Huntingdon

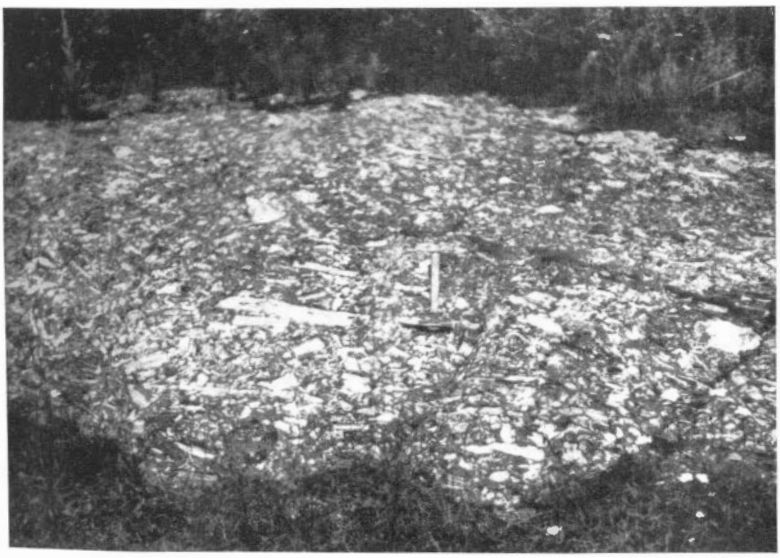
Many outcrops of siliceous magnesian limestone and dolomite are seen along the highway for 5 miles west of the town of Huntingdon. Two quarries were formerly worked in this locality for road metal. One of these quarries is on the property of Donald McNair and the other on the property of John Newman.

The quarry on the McNair property, which is close to the Canadian National railway, is ½ mile south of the highway and 3½ miles west of the town. About 10 feet of hard, tough, finely granular, bluish grey, sandy dolomite in beds up to 2 feet in thickness, separated by thin seams of shale, is exposed above the water that partly fills the excavation. The beds have a very slight dip to the south. The country in the vicinity is flat and soil is only a few inches deep in the vicinity of the quarry. As shown by the analysis of Sample 154, representative of the 10 feet of strata exposed, the stone is impure.

PLATE XXVIII



A. Thinly bedded limestone interbedded with shale, Levis.



B. Outcrop of Mystic conglomerate on lot 21, range VI, Stanbridge township, Missisquoi county.

The quarry on the Newman property, 1½ miles farther east is opened on the north side of a low hill near the summit and is dry. It is just a short distance south of the highway. Twelve feet of stone, in beds 1 to 2 feet in thickness, is exposed in the south face of the quarry and a further 6 feet of stone is seen on the hillside above. These strata are at a slightly higher horizon than those in the quarry on the McNair farm. The upper 11 feet of beds vary in colour from light brownish grey to dark brownish grey, are finely granular, and contain many crystals of white calcite. In the bottom 7 feet all the stone is dark grey, is somewhat coarser in grain than that above, and few crystals of calcite are to be seen. All the stone is hard and tough, and thin seams of shale are present between the beds. Sample 155 was taken from the top 11 feet and Sample 155A from the bottom 7 feet.

Five and a half miles northeast of Huntingdon a small quarry for road metal has been opened on the property of Robert Milne, on the south side of the highway. The country in the vicinity is flat. Four feet of finely granular, brownish grey, impure magnesian limestone in beds up to 28 inches thick, dipping at an angle of 3 degrees to the north, is exposed beneath 3 feet of soil. Crystals of pink and white calcite are present in the stone. Sample 156 was taken in this quarry.

Barrington

Finely granular, bluish grey, hard, Beekmantown dolomite, containing less impurities than that sampled elsewhere in Huntingdon county, is exposed on the property of Joseph Merlin, 1 mile south of Barrington in the extreme east end of the county. It was formerly quarried on a very small scale for making lime for local use. Sample 157 was taken from the 3 feet of heavily bedded stone visible in the small quarry. Soil is thin in this neighbourhood and outcrops of similar stone are to be seen to the northwest over a considerable area.

Analyses of Huntingdon County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
154.....	14·26	1·51	1·55	0·04	45·95	35·09	98·40	0·38	25·75	16·78	1·53 : 1
155.....	6·75	1·42	0·95	0·09	56·63	34·09	99·93	0·28	31·76	16·30	1·95 : 1
155A.....	6·76	1·33	0·93	0·15	52·07	37·47	98·71	0·39	29·24	17·92	1·63 : 1
156.....	6·46	0·95	1·21	0·07	52·89	37·17	98·75	0·15	29·66	17·77	1·67 : 1
157.....	3·32	0·66	0·60	0·02	53·11	42·21	99·92	0·06	29·75	20·18	1·47 : 1

154. Huntingdon. Quarry on land of Donald McNair, 3½ miles west of the town.
155. " Top 11 feet of strata at quarry on land of John Newman, 2 miles west of the town.
155A. " Bottom 7 feet of strata in same quarry.
156. " Quarry on land of Robt. Milne, 5½ miles northeast of the town.
157. Barrington. Outcrops on land of Jos. Merlin, 1 mile south of the village.

Laprairie County

Limestones of the Beekmantown, Chazy, and Trenton formations underlie the western and southern parts of this county. In the vicinity of Caughnawaga outcrops of limestone (Chazy) are plentiful, but elsewhere they are not, though doubtless there are a number of places where soil is sufficiently thin to make quarrying feasible. The territory included in this county, however, is very flat, and quarries opened in flat lowland areas generally require much pumping to keep them free from water. The approximate distribution of the various formations is shown on Map No. 757 accompanying this report.

Stone for building purposes, lime making, and for road metal has been obtained at several places. From Caughnawaga in particular, large blocks of stone for use in bridge piers were formerly obtained in quantity from the heavily bedded Chazy limestone, but no stone of this character has been quarried for a number of years. At present crushed stone is produced from one quarry near Caughnawaga.

Caughnawaga

Baillargeon and Faubert, 62 Union Blvd., St. Lambert. In 1934 this firm was producing road metal from the quarry owned by Chief Jocks of the Caughnawaga Indian Reservation. The quarry is on the east side of the highway, slightly more than 1 mile south of the ferry wharf at the village, and is 300 by 250 feet in area. Twelve feet of medium- to coarse-grained, grey limestone in flat beds up to 20 inches thick, between which there is no shale, is exposed. The limestone is cross-bedded and seamed with very thin streaks of black bituminous matter. Fragments of pink fossils and occasional patches and streaks of ferruginous, brown-weathering, magnesian material are visible in some of the beds, but the magnesian material is by no means common. Sample 164 was taken from the 12-foot face.

In working the quarry, drilling is done by jackhammers. After blasting, the stone is loaded by hand to horse-drawn dump carts and taken to the crushing plant, which is situated alongside the highway passing the quarry. The capacity of the plant is 300 tons per 10-hour day. The output is used for highway construction in the district and is carried by motor truck.

In the neighbourhood of Caughnawaga village, especially to the west, there are a great many outcrops of limestone all very similar to that in the quarry just described. At the southwestern edge of the village a quarry has been worked for some distance along the hillside on both sides of the highway. Sample 165 was taken from 10 feet of stone exposed here.

One mile south of the New York Central railway, which crosses the highway 2 miles south of Caughnawaga, is a quarry in which the same type of stone as seen near the village is exposed in a 5-foot face.

St. Isidore Junction

Two small, adjacent quarries, both now nearly full of water, were at one time worked on the properties of C. Marcil and A. Gibeault, ½ mile

southeast of the railway junction. It is stated that stone for the church of St. Constant was taken from the Marcil quarry. Only the top 2 feet of the limestone was visible above the water when the quarries were visited, and Sample 166 is representative of only that much of the quarry face. The stone is of Chazy age, is brownish grey in colour, medium-grained, and in general very similar in appearance to that at Caughnawaga, though, as shown by the analysis of the sample, it contains considerably less impurities.

St. Jacques le Mineur

The only sample obtained from the Trenton formation in Laprairie county was taken from 2 feet of stone visible above the water in a small quarry on the property of D. Deneault, 700 feet east of the St. Marc road, 2½ miles north of St. Jacques le Mineur. The stone was quarried for the construction of the church at St. Philippe de Laprairie. It is a medium-grained, brownish grey limestone apparently heavily bedded and not badly fractured. Sample 167 represents the 2 feet exposed. The country in the vicinity is very flat and the rock is covered with soil to a depth of 1 to 3 feet.

Analyses of Laprairie County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
164.....	2·98	0·91	1·17	0·39	92·45	1·45	99·35	0·10	51·98	0·69	75 : 1
165.....	3·56	0·78	1·32	0·22	91·95	1·34	99·17	0·08	51·61	0·64	81 : 1
166.....	1·20	0·69	0·75	0·09	96·77	0·38	99·88	0·11	54·24	0·18	301 : 1
167.....	1·38	0·64	0·74	0·09	90·02	6·25	99·12	0·14	50·46	2·99	17 : 1

164. Caughnawaga. Quarry owned by Chief Jocks.
165. " Quarry on southwestern outskirts of the village.
166. St. Isidore Junction. Top 2 feet of strata in quarry ½ mile southeast of the railway junction.
167. St. Jacques le Mineur. Top 2 feet of strata in quarry on property of D. Deneault, 2½ miles north of the village.

Levis County

Aside from some impure, thin-bedded, shaly limestone and bands of limestone conglomerate in the vicinity of the city of Levis, no limestone deposits of importance have been reported as occurring in this county.

Levis

Bands of thinly bedded, fine-grained limestone and limestone conglomerate are exposed in the shale cliffs facing the St. Lawrence river in the vicinity of Levis. The thinly bedded limestones with interbeds of shale (Plate XXVIIIA, page 201) are well exposed in the cliff face along Main Street and Davidson Street. The conglomerate is seen in the same localities and also north and west of Mount Marie cemetery on top of the cliff in the eastern outskirts of the city. Both types of limestones are impure, the thinly bedded stone being argillaceous and much interbedded with shale,

and the conglomerate containing occasional pebbles of igneous rock and quartzite as well as of siliceous dolomite, though it consists for the most part of fine-grained, grey calcium limestone. Both types have been quarried in small amount in the past for making lime for local use, and the conglomerate has also been quarried for crushed stone. Sample 254 was taken from a small quarry formerly worked for crushed stone by the Lévis Tramway Company in one of the conglomerate bands immediately north of Mount Marie cemetery. The distribution of the limestone in this vicinity is shown by Clark[1] in his paper on the Levis formation.

Analysis of Levis County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
254.....	3·48	1·01	0·50	0·02	83·50	11·27	99·78	Tr.	46·77	5·39	10 : 1

254. Levis. Limestone conglomerate north of Mount Marie cemetery.

Lotbinière County

All limestone known to occur in this county is of the impure, thin-bedded, shaly type.

" Near the extremity of Pointe au Platon are highly bituminous, brownish grey shales with bands of hard dolomitic limestone."[2]

Five and a half miles above St. Nicholas " a series of highly bituminous black and brown limestones and dark shales, with hard, blackish or greenish cherty beds, the dip of which is S. 15°-30° E. at angles of 55°-80°, is seen along the shore of the St. Lawrence."[3]

On the Northeast Sheet of the geological map of the Eastern Townships, limestone deposits are shown 2½ miles north of and again 1½ miles southeast of St. Apollinaire, and also north of St. Sylvestre, in the southeastern corner of the county.

[1] Clark, T. H.: Trans. Roy. Soc. Canada, 3rd Series, vol. XX, Sec. IV, pp. 169-180 (1926).
[2] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. III, pt. 2, p. 15K (1887-88).
[3] Op. cit., p. 16K.

Megantic County

Limestone available in this county is mostly impure and the greater part of it is far removed from railways. Concerning these limestones Ells[1] says—"In the vicinity of Somerset, and between that place and Ste. Sophie . . . . .beds of the graphitic limestone and black shales occur, similar to those described as occupying the basins of Arthabaska and Danville. These can be traced to the northeast in rear of Ste. Julie, but there they apparently terminate."

Thetford Mines

Very impure magnesite, or breunnerite, occurring in veins in serpentine is found in places in the asbestos quarries at Thetford Mines. The purest material so far obtained has the following analysis:—

	Per cent
Insoluble	34·02
Fe_2O_3	6·46
H_2O	0·23
CaO	0·82
MgO	26·58
CO_2 (calc.)	29·88
	97·99

Outcrops of impure slaty calcium limestone and limestone conglomerate are reported to be plentiful in Inverness township.

Cooke[2] gives the following description of a band of metamorphosed limestone that occurs in Leeds township:—

"Outcrops of crystalline limestone, all probably forming parts of a single band, were found in four places in Leeds township, near the north side of the map area. These places are: range V, lot 7b; range IV, lot 3b; range III, near boundary between lots 2 and 3, at northeast end of lots; and on range line II-III just at the boundary between Inverness and Leeds townships. In the most eastern outcrop the band is not more than 10 feet thick, and is a very pure calcium carbonate. On the west, however, it is more than 100 feet thick, and weathers to a deep brown colour characteristic of many magnesian limestones; and probably due to the presence of some iron carbonate."

Missisquoi County

Extensive deposits of pure, high-calcium limestone, much of which has been altered to a marble, occur in this county from the International Boundary immediately east of lake Champlain to near the village of Bedford—a distance of 8 miles (Figure 12, page 207). These pure high-calcium limestones, together with impure dolomites, calcium limestones of varying degrees of purity, and also slates, comprise part of a series of sedimentary rocks known as the Philipsburg series. According to Clark[3] the strata

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. III, pt. 2, pp. 63 and 113K (1887-1888).
[2] Cooke, H. C.: Geol. Surv., Canada Sum. Rept. 1931, pt. D p. 4. (1932).
[3] Clark, T. H.: Structure and Stratigraphy of Southern Quebec, Bull. Geol. Soc. Am., vol. 45, p. 6 (1934).

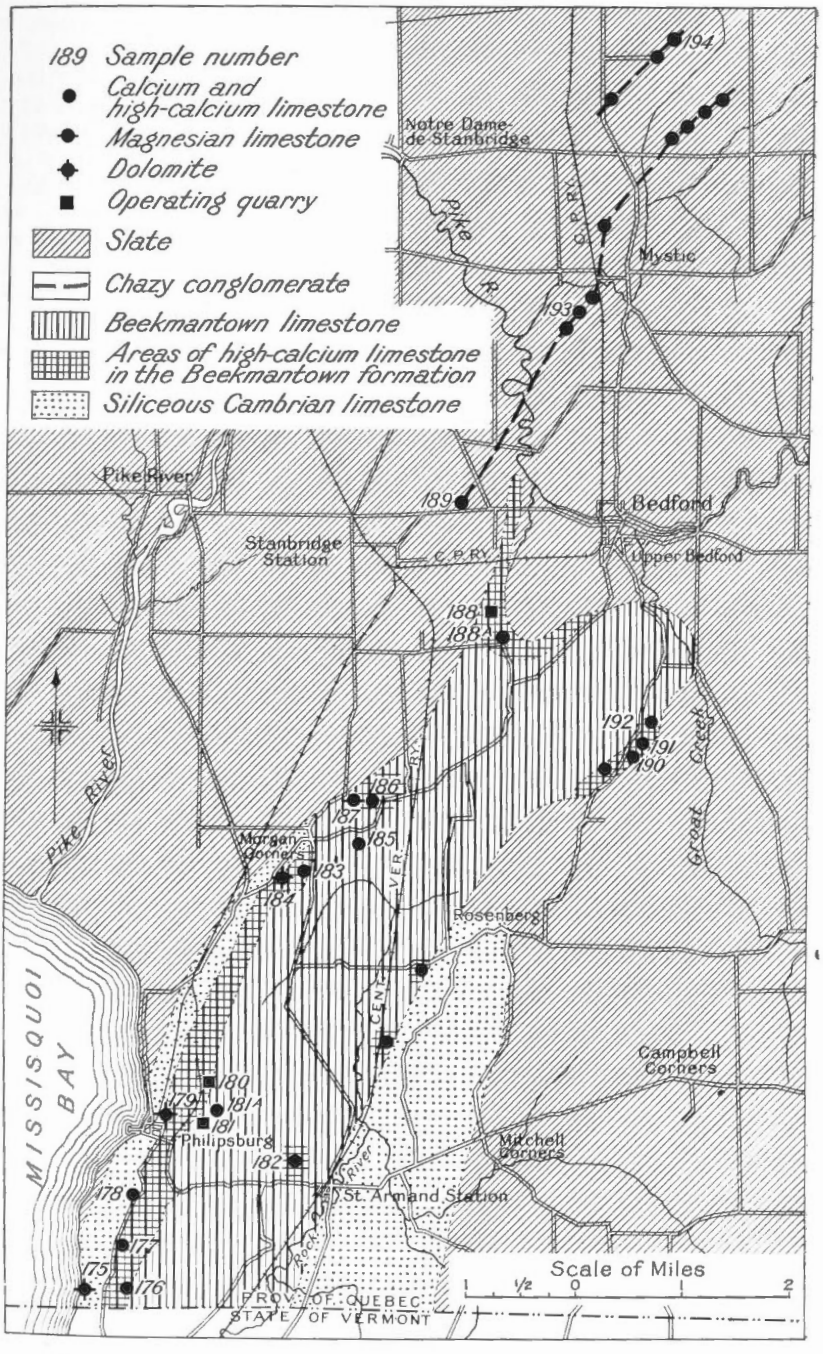


Figure 12. Map showing location of limestone deposits sampled in the Philipsburg district, Missisquoi county.

composing this series range from Upper Cambrian to Chazy in age, but most of the limestone is of Beekmantown age. Near Bedford, one of the high-calcium limestone formations of the series is being quarried by Shawinigan Chemicals, Ltd., and shipped to Shawinigan Falls, 180 miles to the north, for use in the manufacture of calcium carbide. At Philipsburg the largest marble quarry in Canada is worked in another formation of grey high-calcium stone, and a smaller quarry for black marble is worked in the impure dark limestone overlying the grey marble. Many years ago the impure dolomites and calcium limestones, as well as the pure stone, were quarried at a number of places for the making of lime in small field kilns, but at present with the exception of the black marble above mentioned, there is no production from the impure varieties of limestone.

Immediately east of the southern part of the area occupied by the limestones of the Philipsburg series, impure dolomite of Cambrian age underlies an area 1 mile wide and 4 miles long between the International Boundary and the village of Rosenberg. The dolomite is apparently interbedded with dolomitic quartzite, and in most of the outcrops masses of chert and quartz are very abundant. In general, this Cambrian dolomite because of its variable character appears to be of little economic value except for crushed stone. No samples for chemical analysis were obtained from it. This area of Cambrian strata is separated by a prominent fault from the limestones of the Philipsburg series to the west.

Six miles farther east, a steeply dipping band of impure dolomite, also of Cambrian age, extends northeasterly from the International Boundary, near St. Armand Centre, through Hunter Mills, Dunham, and Sweetsburg to Brome mountain. Descriptions of some of the more prominent outcrops of this dolomite band are given on pages 222 to 223.

PHILIPSBURG SERIES

The maximum thickness of the Philipsburg series as exposed in the Philipsburg-Mystic area is, according to Logan,[1] 4,860 feet, of which 2,260 feet are limestones. These limestones differ widely in purity, and range in type from high-calcium to dolomite. The prevailing strike of the strata in the southern part of the area is N. 20° E. and the average dip is to the southeast at an angle of 20 degrees. In the northeastern part of the area, there are wide local variations in both strike and dip, due to crumpling and faulting. Logan has divided the series into 13 formations, as shown below. The strata are tabulated in descending order and the descriptions as given by Logan are summarized in small type.

Division	Description	Thickness in feet
D3	Grey and black striped slates, in part calcareous and magnesian	1,500
D2	Black and greenish argillaceous slates terminated by a band of black limestone conglomerate	750-1,000

[1] Logan, Sir Wm.: Geology of Canada, 1863, pp. 844, 845.

Division	Description	Thickness in feet
D1	Black limestone conglomerates, composed chiefly of the ruins of Division C. The enclosed masses vary in size from pieces an inch in diameter, to blocks containing between 50 and 60 cubic feet, and are cemented by calcareo-magnesian paste, but owing to the close packing of the limestone fragments there is but little of the cementing paste. The limestones are generally close grained, and black or dark grey in colour, but there are mingled with them a few scattered blocks of lighter coloured, yellow-weathering dolomite (and also occasional blocks of sandstone and slate.) There appears to be at least two principal bands of this conglomerate, each varying in thickness from about 50 to 100 feet, with a band of slate 100 feet thick between. This slate in places holds rounded blocks of limestone.....	250-300

The conglomerate bands are well exposed in the neighbourhood of Mystic and between there and Bedford (Figure 12, page 207), but they were not observed south of Bedford. Samples 189, 193, and 194 were taken from these conglomerate bands.

C2	Black slates, or possibly thin-bedded black limestones. Very poorly exposed.....	170
C1	Black and dark grey, compact, pure limestones, weathering lead-grey, with a few bands of dove-grey. The beds are massive and very fossiliferous. Toward the top, one or two beds appear to be of a partially conglomerate character.....	150

Division C1 where exposed 2 miles southwest of Bedford contains a thick band of pure, high-calcium limestone that is extensively quarried by Shawinigan Chemicals, Ltd. for use in the company's carbide plant at Shawinigan Falls. Samples 188, 188A, and 188B were taken from this important limestone band which is not well exposed elsewhere. As noted on page 219 the apparent thickness of the division is considerably greater than that given by Logan.

B5	Black limestones, some of them massive, weathering bluish grey; interstratified toward the bottom with black and dark-grey, yellow-weathering magnesian beds	350

This division, containing at least one thick band of pure, high-calcium limestone and a number of thinner bands, is exposed on the hilltop northwest of St. Armand Station (Sample 182); north and northeast of Morgan Corners, where it was formerly quarried by Shawinigan Chemicals, Ltd. (Samples 186 and 186A); south of the present quarry of Shawinigan Chemicals, Ltd.; and in a ridge on lots 2, 3, and 4 of ranges VI and VII of Stanbridge township (2 miles south of Bedford) where Samples 190, 190A, 191, and 192 were taken. Bands of impure dolomite were observed near the top as well as near the base of this division; and there are also beds of banded limestone composed in part of shaly limestone and in part of pure limestone, as shown in Plate XXXA, page 217.

B4	Black, slaty, thin-bedded nodular limestones with two or three thick beds of purer limestone toward the base.....	300

Beds of dolomite and of sandy limestone occur near the top of this division, the strata of which are exposed in a narrow strip just west of Division B5 from the International Boundary nearly to Bedford.

B3 Dark bluish grey, thin-bedded, nodular limestones, with thin layers of bluish grey slate, probably magnesian. The surfaces of some of the beds weather to a red or yellow, ochreous, sandy earth 150

B2 Dark grey and black limestones, some of the beds being magnesian 120

One band of Division B2, about 50 feet thick, consists of fairly pure calcium limestone. The remainder consists of rather impure bands of calcium limestone interstratified with impure dolomitic bands.

B1 White and dove-grey, pure limestones with some yellow-weathering magnesian bands 120

Though there is some pure, high-calcium limestone in this division, the pure stone could be quarried only with difficulty as it is in relatively thin beds interstratified with shaly and impure dolomitic bands.

A3 Reddish grey, brown-weathering dolomites, and black dolomites with some thin-bedded, black limestones 200

All strata in this division contain a high percentage of impurities. The basal strata consist of very dark grey, impure, heavily bedded calcium limestone through which are a great many thin, black, shaly seams. These dark-coloured lower beds are being quarried for black marble by Wallace Sandstone Quarries, Ltd., at Philipsburg. Samples 181 and 181A were obtained from this division.

A2 White and dove-grey, pure, compact limestones 100

This division consists mostly of high-calcium limestone that has been metamorphosed to marble. In places some of the lower beds near the contact with the underlying Cambrian dolomite are themselves somewhat dolomitic. The chief impurities are sand grains, together with occasional nodules of chert and some pyrite. The marble band (*See* Figure 12, page 207) extends northeasterly for 5 miles from the International Boundary to Morgan Corners where it is apparently terminated by a fault. It underlies the eastern part of Philipsburg village and at this place is extensively quarried for marble by Wallace Sandstone Quarries, Ltd., of Montreal. Judging from outcrops the thickness of this band is, in places, at least 300 feet instead of the 100 feet as stated by Logan, and pure limestone could be quarried on a large scale at a number of places. Samples 176, 177, 178, 180, 180A, 180B, and 183 were taken from this division.

A1 Dark grey and yellowish white dolomites, weathering grey and yellowish brown 400

This division, which is considered to be of Cambrian age, forms the base of the Philipsburg series. It is exposed along the shore of Missisquoi bay of lake Champlain and immediately adjoins the western edge of the marble band (Division A2) from the International Boundary to near Morgan Corners. The dolomite is everywhere impure, containing sand, nodules of chert and veins of quartz. In places it is of the nature of a dolomitic sandstone. Samples 175, 175A, 179, 184, and 185 were taken from this dolomite. According to these analyses the purest of it contains over 4·5 per cent total impurities, and the impure stone may contain nearly 50 per cent of silica.

The important divisions of the Philipsburg series from the standpoint of providing large tonnages of limestone of uniformly high quality suited to chemical and metallurgical uses are Divisions C1, B5, and A2. Outcrops of these pure limestones were carefully examined and further details are given below in connection with the descriptions of the stone in the quarries and in the outcrops sampled.

In the area between the International Boundary and Morgan Corners the limestones of the Philipsburg series are folded into a syncline which is bounded on each side by prominent thrust faults. Owing to this faulting most of the strata composing the southeastern limb of the syncline have been removed or else are hidden by other rocks overthrust upon them. About 2 miles northeast of Morgan Corners is a prominent fault, trending southeasterly, and northeast of this the limestones have an anticlinal structure. North of Bedford the only limestones of the Philipsburg series exposed are the conglomerates of Division D (Chazy age).

Shipping facilities within this area are provided by the Canadian Pacific and Vermont Central railways and by highways. Some of the deposits of pure limestone are adjacent to the railways and none is more than 2 miles distant by road.

Philipsburg

Most of the lower divisions of the Philipsburg series are exposed in the neighbourhood of Philipsburg village, but all except the prominent band of marble (Division A2) contain too high a percentage of impurities to render them of value as a source of stone for chemical use or for lime manufacture. The marble band, however, is well exposed in this vicinity on both sides of a shallow valley, and is capable of yielding an enormous quantity of very pure high-calcium limestone. It is being extensively quarried at the present time for marble, and it is from these quarries that the well-known Missisquoi marbles are obtained. The first large-scale production of marble in the Philipsburg area was begun in 1905 by Missisquoi Marble Company. In 1912 this company amalgamated with the Lautz Marble Company of Buffalo, forming the Missisquoi Lautz Corporation, Ltd. This partnership was dissolved in 1916, and operations were carried on under the name of Missisquoi Marbles, Ltd. When this company went into liquidation in 1918 the entire property and assets were purchased by the present operator, the Wallace Sandstone Quarries, Ltd.

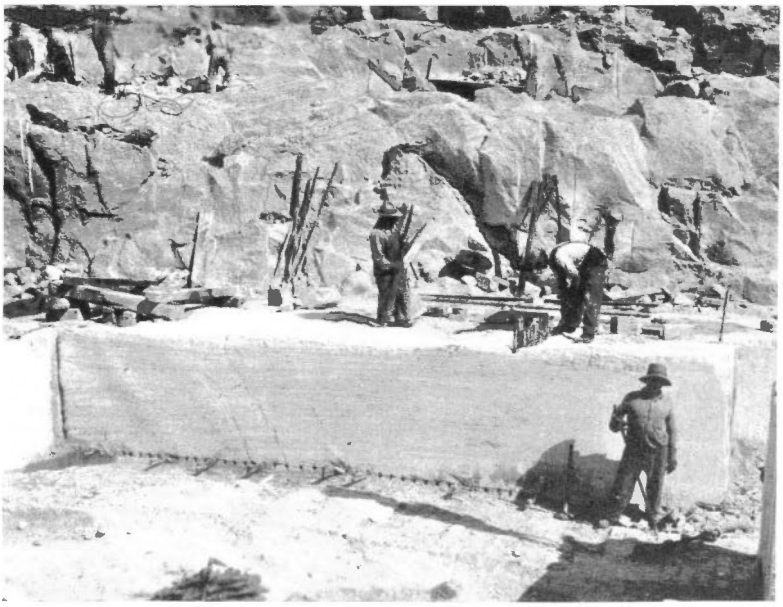
Wallace Sandstone Quarries, Ltd., 1135 Beaver Hall Hill, Montreal. This company operates two marble quarries ½ mile north of Philipsburg, from which the following 5 varieties of marble are obtained:—

1. Missisquoi Grey.—Dove-grey base with large cloudings of lighter grey and small mottlings of nearly white calcite. Very occasional tinges of yellowish green occur in this marble.

2. Missisquoi Vert Gris.—Clouded base of light and dark grey veined with a network of fine, light-green and to a lesser extent with fine, dark-green, irregular seams. Occasional small spots of dark grey translucent calcite ¼ inch in diameter are also visible.

3. Missisquoi Regina.—Nearly white base with faint cloudings of yellowish green with some small crystals of dark-coloured pyrites.

A. South end of marble quarry operated by Wallace Sandstone Quarries Ltd., in highly crystalline Beekmantown limestone at Philipsburg, Missisquoi county.



B. Cutting off a block of marble with wedges. Quarry of Wallace Sandstone Quarries, Ltd., Philipsburg, Missisquoi county.

4. Missisquoi Rex.—This variety is obtained from the same bed as is the "Regina," but is obtained by cutting the stone at right angles to the bedding, and shows irregular lines of light and dark green at intervals of $\frac{1}{4}$ inch to 2 inches, and occasionally more, on a nearly white base. The lines are not sharply defined but shade off gradually through very light tints into the very light grey of the base. Small crystals of pyrite occur along some of the darker lines. Some of the base is faintly mottled with crystals of semi-translucent calcite $\frac{1}{32}$ to $\frac{1}{8}$ inch in diameter.

5. Missisquoi Black.—This variety is cut at right angles to the bedding. The base is very dark grey, nearly black, with very numerous streaks of jet black, argillaceous material. The greyish black stone is faintly mottled with fossil fragments that are slightly lighter in colour than the remainder of the marble. Tiny crystals of pyrite are commonly associated with the jet black zones.

The four varieties of grey marble are obtained from the main quarry. The black variety is obtained from a small quarry about 150 yards southeast of the main quarry and in the ridge of the black limestone of Division A3 which overlies the band of grey marble.

The marbles are all very fine-grained and the four grey varieties take and retain a very high polish. The black variety, owing to its argillaceous nature, does not take so brilliant a polish as the others. The marble is shipped in the finished state, or in rough sawn slabs. Waste marble is sold for use in sulphite-pulp mills, for terrazzo, poultry grit, agricultural limestone, flux, and specially selected white marble waste is sold for the making of whiting substitute.

The main quarry (Plate XXIX A, page 212) is situated in the flat land at the western side of a high ridge composed of the impure, dark-coloured limestone of Division A3 which overlies the light-coloured marble. The quarry is 700 feet long (parallel to the strike), 100 feet wide and exposes 80 feet of marble in beds ranging from 2 feet 6 inches to over 5 feet in thickness and striking N. 30° E. and dipping to the southeast, or toward the ridge, at an angle of 17 degrees. The principal impurity consists of grains of colourless sand, which are particularly characteristic of certain zones. Nodules of chert and crystals of pyrite occur in some beds.

An average section of the quarry face is as follows:—

2 to 10 feet—Soil.

20 to 35 feet—Mottled grey marble consisting of a very fine-grained, grey stone thickly mottled with coarse-grained, white calcite. It is quarried for use in pulp mills and is rarely used for decorative purposes. Sample 180 represents the 35 feet of this stone exposed in the east wall at the northern end of the quarry excluding a sandy layer 8 inches thick that occurs about 17 feet from the surface. This type of stone is seen only on the eastern side of the quarry.

2½ to 3 feet—Grey marble finely veined with green and known as "Vert Gris."

5 feet—Of which the top 2 feet is light grey and the bottom 3 feet is light grey, faintly and sparingly veined with green. The bottom 3 feet when sawn parallel to the stratification is known as "Regina" marble and when sawn vertically as "Rex."

4¼ feet—Nearly white marble containing some sand grains. This stone is mostly sold for the manufacture of whiting substitute. Sample 180B was taken from this bed.

1 to 1½ feet—Greenish grey marble heavily veined with green, and in places clouded with pink. There is much sand in the top 2 inches of this bed. This marble

is not now marketed but was formerly known as "Sea Green" or "Vert Rose," the latter name being given to the stone in which the pink calcite was prominent.

5 feet—"Boulder grey" bed, which, with the exception of the bottom 6 inches, which is green, consists of grey marble. Nodules of chert, crystals of pyrite, and much sand are present in the top 2 feet of this bed rendering it very difficult to cut, and this part is not used. The bottom 3 feet is relatively free from these impurities.

5 feet—Light grey, clouded marble, known as "Silver Grey," containing some chert and crystals of pyrite. Two inches of green marble form the bottom of this bed.

3 feet 2 inches—Greenish grey marble heavily veined with green and sparingly clouded with pink. This marble was formerly known as "Regal" but is not now marketed.

3½ feet—Clouded grey marble, "A" bed.

5 feet—Dark clouded grey marble, "B" bed.

3½ feet—Clouded grey marble, "C" bed.

4 feet—Clouded grey marble, "D" bed.

Sample 180A represents 40 feet of marble below the top mottled beds.

As shown by core-drilling, grey marbles with minor quantities of greenish marbles are to be found to a depth of at least 60 feet beneath the present floor of the quarry. Cuttings from an artesian well drilled in the floor of the quarry to a depth of 620 feet were all of similar appearance according to the drill record, but it is probable that this well extends into the underlying formation of grey dolomite.

Outcrops of marble occur for 400 yards west of the quarry in a direction at right angles to the strike. Assuming that the dip of the strata averages not less than 15 degrees, the indicated thickness of the marble band (Division A2) at this place is thus in excess of 300 feet. The lower beds as here exposed appear to have been dolomitized to some extent, as on the weathered outcrops of these beds a network of dolomite crystals stands out in relief.

The quarry from which the black marble is obtained is of the side-hill type and is opened near the base of the band of massively bedded, impure limestone that forms a prominent ridge parallel to and immediately east of the band of grey marble. It has been worked for 80 feet easterly into the ridge and has a width of 60 feet. In all 35 feet of stone is exposed, from which Sample 181 was obtained. The strike and dip of the strata are the same as in the main quarry. The stone is very fine-grained and has a banded appearance due to streaks of black, argillaceous material which are particularly plentiful in certain zones parallel to the stratification. On weathering, the argillaceous material, due in part to the presence of pyrite, takes on a yellowish brown tint. The argillaceous material is also more resistant to weathering than the purer limestone and stands out in ridges on the outcrops. Higher up on the ridge the limestone is harder and more siliceous than that in the black marble quarry, as is shown by the analysis of Sample 181A taken on the side of the ridge a short distance north of the quarry.

The main quarry is worked the year round but the black marble quarry is worked only at intervals to maintain a stock on hand. In both quarries the marble is quarried with the aid of channelling machines and pneumatic drills. It is first cut into strips by the channelling machines. The strips are raised by means of long wedges and then divided into blocks which are

usually 7 feet 3 inches in length, 6 feet wide, and of the full thickness of the bed (Plate XXIX B, page 212), excepting the blocks of black marble which are usually cut to smaller dimensions. A 30-ton electric, overhead travelling crane, running on rails supported on steel columns on each side of the quarry, serves to hoist the blocks from a large part of the main quarry, but guy derricks are used for hoisting at the north end of the main quarry and also in the black marble quarry.

A large, electrically equipped marble mill is operated in conjunction with the quarry, and also a terrazzo plant. The equipment of the latter consists of a jaw crusher, a set of rolls and the necessary screens to produce 4 sizes of terrazzo, and also marble dust and agricultural limestone. Selected waste stone from the quarry operations is also sold for use in sulphite-pulp mills, for the manufacture of whiting substitute, and for a number of minor uses.

The company also owns a modern lime kiln with a capacity of 12 tons of lime per day, but it has not been operated for a number of years.

All products are shipped over 6½ miles of railway, owned by the company, to Stanbridge Station where connections are made with the Canadian Pacific, Central Vermont, and Canadian National railways.

South of Philipsburg

In this direction the band of pure marble extends to the International Boundary and is exposed over a strip of country about ¼ mile in width, the western edge of which closely follows the road to Highgate Springs, Vermont. Between the road and lake Champlain, the siliceous, dove-grey dolomite (Division A1), underlying the marble band, is well exposed.

The marble in this area is dense-textured and has more of a brownish tint than has that quarried at Philipsburg. The prevailing strike is N.35°E. and the dip is at 20 degrees to the southeast. Just north of the Boundary there are some sandy dolomitic areas in this band, and in general there is a slight but progressive increase in the content of magnesium carbonate as the marble band is followed south from Philipsburg. Three samples of the marble were obtained. Sample 178 is of creamy, brownish grey marble exposed ¾ mile south of the village, along the highway. Sample 177 represents a thickness of 30 feet of creamy, brown-grey, dense-textured marble exposed in a prominent ridge 1 mile south of Philipsburg, on the east side of the road to Highgate Springs. Sample 176 was taken from an exposure of dense-textured, creamy brown marble just north of the International Boundary and on the east side of a small brook. It represents the top beds of the marble band, which, at this place, has an exposed width of about 400 feet. To the east of this exposure a blue, sandy limestone outcrops on the side of a hill. A short distance to the north some patches of sandy dolomite were observed in the marble, there being apparently a gradual horizontal transition from one type of stone to the other.

The Cambrian dolomite exposed to the west of the marble in the area between the Highgate Springs road and lake Champlain is everywhere impure. Sand grains, stringers of quartz, and nodules of chert are plentiful, and, in places, there are interbeds of sandstone. The dolomite is of various shades of grey in colour and is medium- to fine-grained. Only

three samples were obtained for chemical analysis from the exposures between Philipsburg and the International Boundary and these represent the purer types of the dolomite. One of these (Sample 179) was from outcrops of bluish grey dolomite in the northeastern part of Philipsburg village, and the others (Samples 175 and 175A) were from the cliff of blue-grey dolomite on the shore of lake Champlain, a very short distance north of the Boundary. Sample 175 represents 20 feet of rather sandy strata at the top of the cliff and Sample 175A represents 15 feet of strata about half way down to the water. The strata here strike N.15°E. and the dip is southeasterly at angles of from 15 degrees to 22 degrees.

St. Armand Station

West of the village much limestone is exposed on both sides of the road to Philipsburg. Most of it is very shaly and impure, and some of the impure stone is dolomitic. But, in places, as on the hilltop ⅓ mile northwest of the village, are some exposures of blue-grey, high-calcium limestone, apparently belonging to Division B4, which, though overlain and underlain by impure stone, are sufficiently extensive to permit of them being quarried on a moderate scale. Sample 182 was taken on this hill from one of these bands of high-calcium limestone about 20 feet thick.

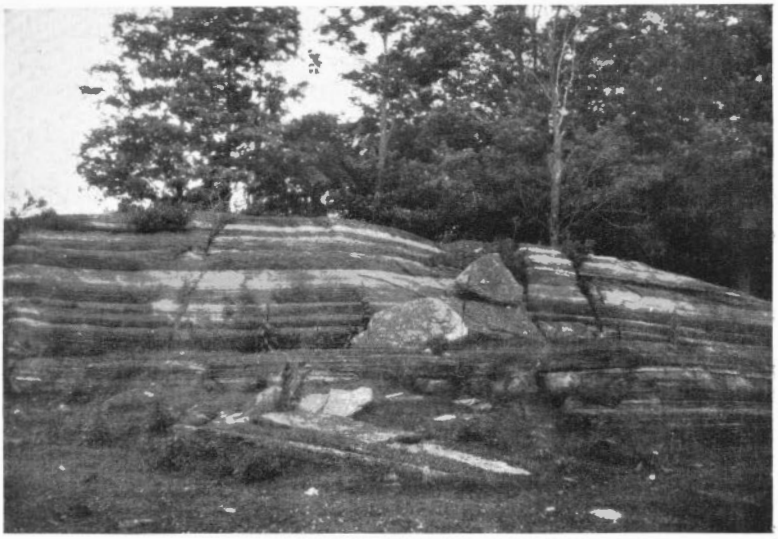
One mile west of St. Armand Station a rather sandy, blue calcium limestone interstratified with impure dolomitic limestone is exposed on the hillside north of the road to Philipsburg. There are also some relatively pure bands of calcium or of high-calcium limestone in this area, but no samples were taken.

North of St. Armand Station exposures of comparatively pure calcium limestone of Division B4 are to be seen between the Vermont Central railway and the road to Rosenberg. The most promising of these outcrops is just south of the road going westerly from Rosenberg to the St. Armand Station-Morgan Corners road, and about 450 yards east of the Vermont Central railway. The limestone is thinly bedded, dove-grey in colour, and contains a few thin, shaly beds. It is apparently lying nearly horizontally.

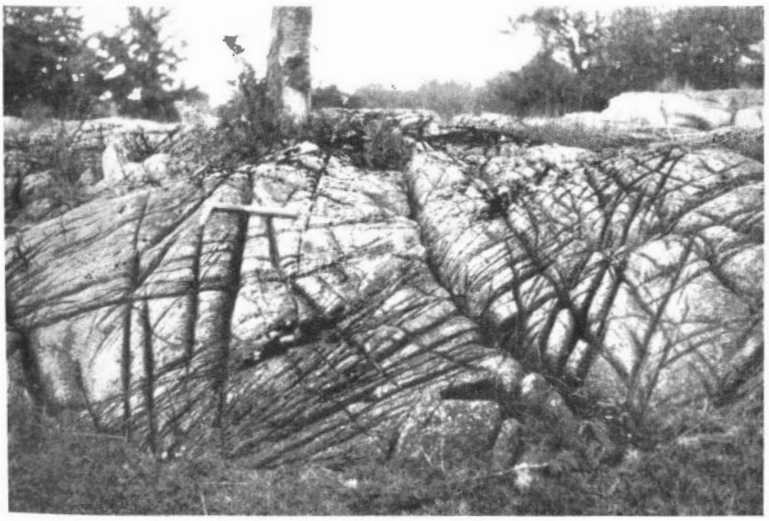
Morgan Corners

In this vicinity is a great deal of very pure, high-calcium limestone. Just south of the Corners are extensive exposures of the same band of fine-grained, grey marble (Division A3) which extents northeasterly from the International Boundary, and which is being quarried at Philipsburg. The band is terminated by a fault at Morgan Corners and is not positively identified to the north of this locality. Beginning a short distance south of the Morgan Corners schoolhouse the marble is exposed for over ¼ mile along the road going south, at which point it is terminated by a transverse fault but is again seen at some little distance to the southwest from where it is exposed almost continuously to the Boundary. The strike of the marble ranges from N. 10° E. to N. 30° E. and the dip is to the southeast at an angle of 25 degrees. The exposures extend across 1,000 feet of flat country. To the east the marble is overlain by impure, blue calcium limestone and to the west it is underlain by siliceous blue-grey dolomite of Division A1.

PLATE XXX



A. Outcrop of banded limestone on lot 3, range VIII, Stanbridge township, Missisquoi county. The dark bands are impure, shaly limestone; the light bands are pure limestone.



B. Weathered surface of Beekmantown dolomite at Morgan Corners, Missisquoi county.

Near the contact with the dolomite there are some very thin quartz veinlets in the marble. Most of the marble is very pure, though in places there are some interbedded thin, shaly and sandy strata. Sample 183 was taken across the whole width of the band excluding the few impure beds.

Sample 184 represents the blue-grey, medium-grained, siliceous dolomite (Division A1) underlying the marble band to the west.

Northwest of Morgan Corners, pure high-calcium limestone is exposed in a low ridge on lot 2, range IX, Stanbridge township. From 1915 to 1928 the Canada Carbide Company (Shawinigan Chemicals, Ltd.) quarried this limestone for use in the manufacture of calcium carbide, but in 1928 the company transferred its quarry operations to an equally pure deposit about 2 miles to the northeast. The stone is grey-blue, fine-grained, brittle, massively bedded and is veined and blotched with very coarse-grained, milky-white calcite. Faulting and folding are very pronounced in the locality and the relationship of this pure limestone to the marble belt exposed a short distance to the south is not known. The strike of the beds is N. 80° E. and the dip is to the south at an angle of 45 degrees. The quarry, which is now filled with water, is 1,200 feet long, 200 feet wide and has a depth in places of 60 feet. In all about 140 feet of strata were exposed in the excavation but there are indications that this thickness of pure limestone is due to repetition on account of a closed fold. Impure limestone overlies and underlies the high-grade stone, but along the strike of the beds, at a distance of 250 yards southwest of the quarry, are further outcrops of limestone similar in purity to that quarried. Sample 186 was taken from the top 75 feet of strata exposed in the quarry when it was in operation, and No. 186A from the bottom 75 feet. Sample 187 was taken 200 yards northwest of the quarry and represents about 60 feet of dark blue, sandy, brown-weathering calcium limestone interstratified with impure dolomite. These strata have the same strike and dip as the pure stone and apparently underlie it, though at a considerable depth.

Southeast of Morgan Corners is a series of low parallel ridges composed of limestone striking N. 80° E. and dipping to the south at angles varying from 25 to 35 degrees. Most of the ridges are composed of interbedded, impure calcium limestone and impure dolomite, all fine-grained. But the ridge 400 yards southeast of the cemetery at Morgan Corners is composed almost entirely of light blue calcium limestone containing veins of calcite and an occasional vein of quartz; the limestone varies somewhat in purity from place to place on the outcrop, which is 200 feet wide and elevated about 15 feet above the fields. Sample 185 was taken from the strata exposed. Impure, brown-weathering dolomite underlies the calcium limestone composing this ridge.

Bedford

Southwest of Bedford the limestones of the Philipsburg series occur locally as an anticlinal fold, and on the flanks of this anticline some pure high-calcium limestone of Divisions B5 and C1 is exposed.

Two miles southwest of Bedford, on the northwest flank of the anticline, extensive exposures of high-calcium limestone, belonging to Division C1 of the Philipsburg series, occur on a low, broad ridge on lots 6 and 7, range VIII, Stanbridge township. On lot 7 is the large quarry operated by

Shawinigan Chemicals, Ltd. The limestone is similar to that formerly quarried by Shawinigan Chemicals, Ltd. at Morgan Corners, being light blue in colour, very fine-grained, indistinctly bedded and brittle, but it is slightly darker in colour and contains a slightly higher percentage of silica due to the presence of sand grains. The sand, however, is mostly confined to several well-defined zones in the limestone and the main part of the limestone is nearly free from it. One of these zones, about 10 feet thick, occurs near the top of the exposed beds and another sandy zone is seen near the base of the section. The apparent thickness of this band of pure stone is about 250 feet. It is underlain by a formation of massively bedded limestone in which beds of comparatively pure stone alternate with beds of impure limestone containing a heavy network of slaty material, as illustrated in Plate XXXA, page 217. This latter type of limestone is exposed for more than a mile along the northwest side of the road from Morgan Corners to Bedford. Underlying this in turn, and exposed southeast of the same road, is a band of siliceous dolomite containing interbeds of quartzite.

Quarry of Shawinigan Chemicals, Ltd., Power Building, Montreal. The property of this company, 36 acres in extent, is on lots 7 and 8, range VIII, Stanbridge township, about 1 mile west of Bedford and ¼ mile south of the Canadian Pacific railway between Stanbridge and Bedford. A spur track from this line serves the quarry. The quarry which is about 450 feet in diameter and from 20 to 40 feet deep, is opened in a low ridge of pure high-calcium limestone striking N.10°E. and dipping easterly at an angle of 10 degrees. The limestone quarried is light blue-grey in colour, very fine-grained, brittle, and in places is oolitic. It is much veined and mottled with coarse-grained white calcite. It occurs in indistinct beds without shale partings. The only visible impurity consists of small grains of colourless quartz sand which is practically confined to two zones each about 10 feet thick. One of these sandy zones is to be seen at the extreme northwest edge (the entrance) of the quarry and the other is about 200 feet to the southeast, or near the centre of the quarry. The limestone in these sandy zones may, in places, contain as much as 3 per cent silica, but the remainder of the stone is extremely pure as shown by the analysis of Sample 188 which represents the stone being quarried. Sample 188A was taken from the sandy zone near the centre of the quarry. This stone, as the analysis shows, also contains more magnesia and iron than does the remainder.

The quarry is worked in 20-foot benches, drilling being done with drifter drills mounted on tripods. Horizontal "toe holes" are drilled at the base of the face to supplement the vertical holes. By this means good fragmentation of the rock is obtained and very little secondary blasting is necessary. Broken stone is loaded into a 7½-ton Mack truck by a 1½-yard, full-revolving electric shovel mounted on caterpillar treads, for transportation to the adjacent crushing plant. This plant has an output of 50 tons per hour of stone ranging from 2 inches to 9 mesh in diameter, which is the size range of the stone shipped to the carbide plant at Shawinigan Falls, 180 miles distant by rail. This plant is described on page 156.

A. Part of the quarry of Shawinigan Chemicals, Ltd., in Beekmantown high-calcium limestone near Bedford, Missisquoi county.

B. Weathered surface of pure Beekmantown limestone on the property of Shawinigan Chemicals, Ltd., near Bedford, Missisquoi county. Note the numerous veins of calcite in the stone.

Material under 9 mesh is sold for agricultural use. Broken stone is shipped for flux to foundries in Montreal, and the local demand for crushed stone is also supplied by the company.

Outcrops of pure limestone, similar to that in the quarry of Shawinigan Chemicals, Ltd., are seen to the north of the quarry for nearly 1 mile. To the west of the quarry the limestone is in faulted contact with slate, but to the south and east the pure limestone is extensively exposed in a low ridge for about ½ mile and then the line of outcrop swings to the east and finally to the northeast (Figure 12, page 207). Overburden is very thin over much of the ridge and the weathered surface of the limestone is gullied as shown in Plate XXXI B, page 220. Some distance south of the quarry the limestone contains occasional patches of fine-grained, argillaceous, rusty-weathering, magnesian material from which Sample 188C was taken. As shown in the analysis this material has a high content of calcium phosphate. The belt of pure limestone in which the quarry is located has a thickness of about 250 feet.

Two miles due south of Bedford, on the southeast flank of the anticline, high-calcium limestone of Division B5 is exposed in a ridge extending northeast-southwest for nearly a mile on lots 2, 3, and 4, ranges VI and VII, of Stanbridge township, along the road from Bedford to Rosenberg. The limestone is light blue in colour, very fine-grained, and occurs in heavy beds having indistinct lines of parting. A few veins of white calcite are present, and in places the stone has a brecciated character. In the brecciated parts are some few small fragments of brown-weathering dolomitic limestone.

On the property of D. J. Pells, at the south end of the ridge, the limestone is exposed across a width of 250 feet. The strike here is N.75°E. and the average dip is southeasterly at an angle of 60 degrees. The underlying rock is a calcareous slate and for some distance above the contact, irregular streaks of slate occur in the limestone. Samples 190 and 190A are channel samples taken 100 feet apart across the entire exposure of pure stone.

Midway along the ridge, on the property of P. A. Poissant, the limestone is of the same general character, but the strike here is N.55°E. and the dip southeasterly at an angle of 36 degrees. A thickness of 130 feet of strata is exposed and Sample 191 was taken here. On this property the continuity of the ridge is broken by a transverse fault having a throw of 250 feet. There is also a longitudinal gap of 250 feet between the two sections of the ridge.

Farther north the ridge becomes narrower and the last exposures of the limestone are seen on the farm of J. J. Creller where Sample 192 was taken.

The analyses of the above samples show the limestone to be of uniformly good quality, and good quarry sites are available in the low ridge, but the nearest railway, the Canadian Pacific, at Bedford, is 2 miles distant.

Mystic

Limestone conglomerates of Chazy age, that form part of Division D1 of the Philipsburg series, are exposed in the flat farming country in

the vicinity of the village of Mystic. The southernmost outcrops observed are south of the Bedford-St. Sébastien road at a point 1 mile west of Bedford. From there outcrops are to be seen at intervals in a northeasterly direction for 5 miles—the northernmost seen being 2½ miles northeast of Mystic. In all outcrops, the conglomerate band is dipping to the southeast at angles ranging from 45 to 80 degrees. The most extensive exposures occur just southwest of Mystic, and at this place the conglomeratic formation has a thickness of about 150 feet. It is underlain and overlain by slate. The conglomerate is massively bedded and is composed mostly of small, elongated, rectangular fragments of dark blue, very fine-grained calcium limestone embedded in a cement of similar character. (Plate XXVIII B, page 201). A few fragments of brown-weathering dolomite, and more rarely slate and sandstone, are also included. Veins of white calcite cut across both matrix and fragments. The limestone fragments, excepting those of dolomitic composition, weather nearly white, whereas the matrix weathers to a dark grey and thus the conglomerate character of the stone is very evident in the outcrop, but on fresh fracture, the fragments and matrix can scarcely be told apart. In some few localities the fragments are more rounded and of very large size—one boulder 11 feet long and 9 feet thick being observed. Though there are some rather shaly phases, on the whole, the conglomerate wherever exposed is remarkably uniform in composition for a rock of this character, as is shown by the analyses of Samples 189, 193, and 194 taken at the following localities (*See* Figure 12, page 207): Sample 189, 1½ miles west of Bedford on the south side of the road to St. Sébastien; Sample 193, general sample of large exposures southwest of Mystic on lots 13, 14, and 15, range VII of Stanbridge township; Sample 194, 2 miles north of Mystic on lot 21, range VI, of Stanbridge township. These analyses show, however, that the conglomerate is too impure for use by the modern lime industry or for most chemical and metallurgical purposes.

Three-quarters of a mile south of where Sample 194 was obtained, is an outcrop of similar conglomerate trending parallel to that in the outcrop where Sample 194 was taken. The dip in both cases is steep to the southeast. It is possible that the two exposures are of the same band, as overturned, closed folds are common in this area.

Cambrian Dolomite Band Between St. Armand Centre and Cowansville.

Between these places are many exposures of the band of impure Cambrian dolomite that strikes N.30°E. from the International Boundary to Brome mountain. The dolomite, however, is not continuous between these places, but rather is in a series of long lenses having a maximum thickness of about 70 feet, and the dip is usually at a steep angle to the southeast. The dolomite is hard, fine- to medium-grained and is generally massively bedded. On fresh fracture it is grey to light blue in colour but it weathers to a dark brown and, in places, to a nearly black, ochreous surface. Thin, wavy seams of shiny slate form a network through most of the beds and form a raised pattern on the weathered surface. The percentage of impurities ranges from 14·5 per cent in the few places where the dolomite is nearly free from quartz veins, to over 50 per cent where the quartz veins are particularly numerous. Owing to the erratic distribution of impurities

it would be almost impossible to quarry stone of uniform composition from this dolomite band. In a few localities, however, lime for use in local construction has been made from it. The following notes indicate the type of stone available at several places along the band.

St. Armand Centre

Dolomite containing many quartz veins is exposed on top of the hill ⅓ mile south of the village. At this place it is underlain by quartzite.

One mile southeast of the village an exposure of the same type of dolomite contains interbedded quartzite as well as veins of quartz.

Hunter Mills

Immediately west of the cemetery at Hunter Mills, the Cambrian dolomite is exposed in nearly level beds for 250 feet just north of the road and north of the Vermont Central railway. After a concealed interval of 375 feet the same dolomite is again exposed to the west in beds that dip at an angle of 45 degrees to the southeast and strike N. 40° E. Apparently the strata are folded here and this accounts for the two separate exposures. Where the dolomite is steeply inclined it contains a great many quartz veins but in the flat-lying part the quartz veins are relatively few. Sample 195 represents 20 feet of the flat-lying strata.

Meigs

One mile south of the cross-roads at Meigs, the Cambrian dolomite is exposed on the steep hillside on the east side of a small brook. Quartz veins are very abundant throughout most of this outcrop. Sample 196 was taken from the lowest beds exposed, in which the quartz is not so evident.

Dunham

The largest exposure of this band of impure Cambrian dolomite seen, is on the hillside between two small brooks on lot 8, range VIII, Dunham township, 2 miles southwest of Garrick Corners. The strata are seemingly pushed up into a dome and the rusty-weathering dolomite is exposed across a width of 400 feet. The stone is grey-blue and rather shaly, and quartz veins are prominent. Sample 197 was taken at this place from all strata exposed.

Similar dolomite to that described above is also exposed on lot 11, range VII, Dunham township, ½ mile west of Dunham on the road to Riceburg, and again 1 mile north of Dunham, a short distance east of the road to Cowansville, on lot 14, range VI, Dunham township.

Cowansville

On lot 23, range IV, Dunham township, ½ mile south of the Canadian Pacific railway station at Cowansville, a band of impure Ordovician limestone is exposed. It has a rather slaty appearance and is veined with quartz. The strike is N. 50° E. and the dip is to the southeast at

an angle of 80 degrees. Sample 198 represents the limestone exclusive of the quartz veins.

On lots 25 and 26, range VI, of Dunham township, 2 miles west of Cowansville, hard, brittle, fine-grained, blue, calcium limestone, veined with white calcite and seamed with slate, is exposed across a width of 90 feet along the road between Cowansville and Farnham Centre. The strike is N. 30° E. and the dip is to the southeast. Sample 199 was taken across the outcrop. Formerly this limestone was quarried on a small scale for making lime. This limestone is probably of Ordovician age.

Analyses of Missisquoi County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
175	6·82	0·97	1·05	0·17	52·98	37·85	99·84	0·05	29·76	18·10	1·64 : 1
175A	4·58	0·94	0·36	0·09	54·54	38·84	99·35	0·02	30·58	18·57	1·64 : 1
176	0·52	0·19	0·37	0·02	90·98	7·87	99·95	0·02	50·96	3·76	14 : 1
177	0·96	0·25	2·10	0·04	92·07	3·63	99·05	0·01	51·58	1·74	30 : 1
178	0·60	0·22	0·48	0·02	96·86	1·13	99·31	Tr.	54·25	0·54	101 : 1
179	7·12	0·85	0·61	0·04	56·13	35·11	99·86	Tr.	31·45	16·79	1·87 : 1
180	1·12	0·31	0·13	0·04	96·46	0·67	98·73	Tr.	54·04	0·80	68 : 1
180A	1·20	0·23	0·27	0·02	98·32	0·32	100·36	Tr.	55·07	0·15	367 : 1
180B	3·40	0·20	0·58	Tr.	95·11	0·96	100·25	Tr.	53·26	0·46	116 : 1
181	9·62	1·05	2·79	n.d.	84·06	1·40	98·92	0·07	47·09	0·67	70 : 1
181A	20·64	1·59	3·23	0·17	70·71	1·89	98·23	0·10	39·69	0·90	44 : 1
182	1·61	0·12	0·07	0·04	95·68	2·69	100·21	0·01	53·63	1·18	45 : 1
183	1·12	0·22	Tr.	0·02	97·62	1·30	100 28	Tr.	54·67	0·62	88 : 1
184	4·04	0·43	0·15	0·04	53·80	41·83	100·29	Tr.	30·15	20·00	1·51 : 1
185	6·28	0·38	0·50	0·02	89·95	2·12	99·25	Tr.	50·38	1·01	41 : 1
186	0·20	0·22	0·04	0·11	98·36	0·80	99·73	Tr.	55·14	0·38	145 : 1
186A	0·28	0·26	0·56	0·02	97·80	0·46	99·38	0·02	54·78	0·22	249 : 1
187	6·06	0·72	1·26	0·13	77·07	14·64	99·88	0·06	43·23	7·00	6 : 1
188	0·88	0·17	0·37	0·04	97·25	0·98	99·69	Tr.	54·48	0·47	116 : 1
188A	1·50	0·25	0·81	0·09	95·96	1·34	99·95	Tr.	53·79	0·64	84 : 1
188B	0·71	0·30	0·23	0·04	97·11	1·22	99·61	Tr.	54·42	0·58	94 : 1
188C	5·20	1·08	3·23	2·20	59·59	28·06	99·36	0·03	34·56	13·42	2·58 : 1
189	6·05	0·61	0·59	n.d.	90·53	1·81	99·59	0·04	50·70	0·87	58 : 1
190	1·14	0·24	0·34	0·04	98·18	0·29	100·23	Tr.	55·00	0·14	393 : 1
190A	0·66	0·43	0·11	0·02	98·23	0·97	100·42	0·03	55·02	0·46	119 : 1
191	2·10	0·27	0·41	0·04	96·52	0·48	99·82	0·02	54·07	0·23	235 : 1
192	1·86	0·24	0·20	0·02	97·02	0·36	99·70	0·02	54·34	0·17	320 : 1
193	5·22	0·74	0·41	0·52	90·75	1·91	99·55	0·05	51·10	0·91	56 : 1
194	5·17	0·49	0·51	n.d.	91·78	1·56	99·51	0·03	51·40	0·75	69 : 1
195	26·36	2·42	4·06	0·39	36·71	29·47	99·41	Tr.	20·77	14·09	1·42 : 1
196	30·44	2·22	0·98	0·46	38·50	26·69	99·29	Tr.	21·81	12·76	1·71 : 1
197	30·48	3·95	2·47	0·46	34·23	26·50	98·09	0·02	19·42	12·67	1·52 : 1
198	13·95	1·69	1·01	0·59	80·16	1·14	98·54	0·07	45·18	0·55	82 : 1
199	12·14	1·57	0·07	0·63	83·16	0·74	98·31	0·05	46·91	0·35	134 : 1

175. Philipsburg. Twenty feet of dolomite from upper part of cliff on east shore of Missisquoi bay a short distance north of the International Boundary.

175A. " Fifteen feet of dolomite from strata halfway down the face of the above-mentioned cliff.

176. " Outcrop just north of the International Boundary and east of the road between Philipsburg and Highgate Springs, Vt.

177. " Ridge of limestone 1 mile south of Philipsburg on the road to Highgate Springs, Vt.

178. " Outcrop ¾ mile south of the village along the road to Highgate Springs, Vt.

179.	Philipsburg	Bluish, impure Cambrian dolomite exposed in the northeastern part of the village.
180.	"	Marble quarry of Wallace Sandstone Quarries, Ltd., 35 feet of dark, mottled grey marble overlying the grey marble in the north end of the quarry.
180A.	"	Marble quarry of Wallace Sandstone Quarries, Ltd.; 40 feet of grey and greenish grey marble exposed in the west wall.
180B.	"	Marble quarry of Wallace Sandstone Quarries, Ltd.; white marble waste shipped for making whiting substitute.
181.	"	Black marble quarry of Wallace Sandstone Quarries, Ltd.
181A.	"	Dark limestone on top of the ridge on the east side of the quarries of Wallace Sandstone Quarries, Ltd.
182.	St. Armand Station.	Band of pure limestone interbedded with impure limestone on top of the hill just northwest of the village.
183.	Morgan Corners.	Northern end of the large marble belt where exposed just south of Morgan Corners.
184.	"	Impure dolomite underlying the marble band a short distance west of where Sample 183 was taken.
185.	"	Impure limestone 400 yards southeast of the cemetery.
186.	"	Top 75 feet of strata in quarry ½ mile northeast of Morgan Corners and formerly worked by Shawinigan Chemicals, Ltd., but now abandoned.
186A.	"	Bottom 75 feet of strata in the same quarry.
187.	"	Outcrop of impure magnesian limestone 200 yards northwest of the above quarry.
188.	Bedford.	Quarry of Shawinigan Chemicals, Ltd.
188A.	"	Sandy stratum in the quarry of Shawinigan Chemicals, Ltd.
188B.	"	Outcrops to the south of the above quarry.
188C.	"	Rusty-weathering patches seen in a few places in the limestone south of the quarry of Shawinigan Chemicals, Ltd.
189.	"	Outcrop on road to Pike river 1½ miles west of Bedford.
190.	"	Ridge on property of D. J. Pells, 2 miles south of Bedford.
190A.	"	Another sample across the ridge on the Pells' property taken 100 feet distant from Sample 190.
191.	"	Sample of the same limestone ridge where it crosses the property of P. A. Poissant.
192.	"	Sample across the north end of the same limestone ridge on the property of J. J. Creller.
193.	Mystic.	Limestone conglomerate on lots 13, 14, and 15, range VII, Stanbridge township.
194.	"	Limestone conglomerate on lot 21, range VI, Stanbridge township.
195.	Hunter Mills.	Cambrian dolomite exposed west of the cemetery.
196.	Meigs.	Cambrian dolomite 1 mile south of the village.
197.	Dunham.	Cambrian dolomite on the hillside 2 miles southwest of the village.
198.	Cowansville.	Ordovician limestone on lot 23, range IV, Dunham township.
199.	"	Ordovician limestone on lots 25 and 26, range VI, Dunham township.

Napierville County

Napierville county is shown on geological maps to be entirely underlain by limestone. Beekmantown limestone underlies a narrow strip along the western and southern sides, Chazy limestone underlies the main part of the county, and Trenton limestone is to be found in a small area in the northern part. The territory included within the county is, however, very flat, and outcrops of limestone are infrequent. The only samples obtained for analysis were from a small area west of Napierville town where the Chazy limestone is exposed in several places, and has been quarried on a small scale for making lime. The analyses of the two samples obtained show the limestone to be fairly pure calcium limestone containing from 6·7 to 9·4 per cent of magnesium carbonate. No quarries are being worked in this county at present.

Napierville

Between Napierville town and Douglasburg, Chazy limestone, dipping to the southeast and to the east at angles of 3 to 5 degrees, is exposed in a number of places both along the road and to the south of it, and has been quarried in the past on a very small scale for making lime.

Sample 168 was taken from 3 feet of heavily bedded, hard, fine-grained, dark brownish blue limestone seen in a pit on the land of Arthur Fortin, ¾ mile west of Napierville. The pit was dug in the east side of a low hill about ¾ mile south of the road to Douglasburg, and many outcrops of similar stone are to be seen on the hillside in a favourable position for quarrying. Fine-grained, brown-weathering magnesian material is plentiful in most of the beds. The strata dip to the east at an angle of 4 degrees.

One and one-quarter miles west is another small quarry on the land of Hormidas Béchard, where 3 feet 6 inches of heavily bedded, hard, fine-grained, dark blue Chazy limestone is also exposed. Magnesian material is also evident at this place, both in the stone seen in the tiny quarry and in neighbouring outcrops. The dip here is northward at an angle of 4 degrees. Sample 169 was taken from the stone in the quarry.

Analyses of Napierville County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
168.....	2·34	0·35	0·69	0·02	86·55	9·43	98·38	0·14	48·48	4·51	11 : 1
169.....	2·18	0·61	1·07	0·04	89·32	6·69	99·91	0·11	49·88	3·20	16 : 1

168. Napierville. Three feet of Chazy limestone on property of Arthur Fortin, ¾ mile west of the town.
169. " Three feet 6 inches of Chazy limestone on property of Hormidas Béchard, 2 miles west of the town.

Richmond County

Impure calcium limestone occurs in this county in the townships of Cleveland, Shipton, and Stoke. In the two former the limestone is found in a narrow belt of Ordovician rocks along the Canadian National railway from Richmond to beyond Danville, and in Stoke township the limestone is found in a narrow belt of Silurian or Devonian rocks extending northeasterly through Stoke Centre and North Stoke.

Danville

Dark blue, fine-grained, slaty calcium limestone, veined with quartz and calcite, is exposed in a number of places in this vicinity and has been used as a source of lime for local use. Limestone of this character is available on the property of Bert Onley at Castlebar, 2½ miles northeast of Danville, where a small quantity has been quarried and shipped to the plant of Canadian Johns-Manville Co., at Asbestos, for use in connection

with the making of rock wool. The company states that the following analysis is representative of this limestone:—

	Per cent
Silica	18·31
Ferric oxide	1·06
Alumina	3·14
Calcium oxide	41·78
Magnesium oxide	1·32
Loss on ignition	33·70
	99·31
Sulphur	0·11

A sample of slaty limestone taken by Howells Fréchette[1] from an outcrop on the same locality, viz. lot 18, range I, Shipton township, had the following analysis:—

	Per cent
Insoluble	9·58
Ferric oxide	0·85
Alumina	0·11
Calcium carbonate	87·14
Magnesium carbonate	1·90
	99·58

Southwest of Danville several outcrops of very impure slaty limestone were seen.

Stoke Township

A narrow belt of sandy slates, of Silurian or Devonian age, containing thin bands of siliceous calcium limestone extends northeasterly through the middle of Stoke township. All the limestone seen in this belt is very impure.

Rouville County

Only impure calcium limestone is known to occur in this county. The principal outcrops are found east of Yamaska river within a narrow strip of country extending from the west side of Yamaska mountain to south of Canrobert. The limestone is of Trenton age and apparently is in lenticular deposits enclosed in black calcareous slate. In most of the outcrops there is no sharp line of demarcation between the slate and the limestone, but rather a gradual transition from one type of rock to the other. Folding and faulting are very pronounced. Samples for analysis were obtained from only two outcrops where the limestone has been quarried, but exposures of slaty limestone are numerous in the area east of Yamaska river.

Canrobert

One and a half miles south of Canrobert station on the Canadian Pacific railway, two small quarries were at one time worked to obtain stone for lime burning on the farm now owned by Joseph Bienvenue. At this place the limestone is exposed in a ridge rising about 20 feet above the flat farming country and extending in a southwesterly direction for

[1] Fréchette, Howells: Mines Branch, Sum. Rept. 1915, p. 49.

300 yards from the Casimir road. The strike of the limestone strata is extremely variable but in general it is parallel to the trend of the ridge, or southwest-northeast. The dip is to the southeast at angles varying from 35 to 80 degrees. The stone is dark blue in colour, fine-grained, thin-bedded, rather soft and graphitic, and is much veined across the stratification with snow-white calcite. One of the quarries—merely a pit 7 feet deep—is close to the farm house; the other, 800 feet southwest of the road, is 100 feet long, 50 feet wide and was worked to a maximum depth of 15 feet. Sample 212 was taken from the strata exposed in the larger quarry. Sample 212A represents a width of 100 feet of the limestone exposed at the southwestern end of the ridge.

Abbotsford

Two miles south of Abbotsford, one-third mile west of the Canadian Pacific railway and 800 feet north of the Papineau road, soft, thin-bedded, dark blue, graphitic calcium limestone much veined with snow-white calcite is exposed in a ridge 700 feet long and 150 feet wide. The ridge at its highest point rises about 20 feet above the flat surrounding country. The strata strike N. 25° E. and dip to the west at angles varying from 65 to 80 degrees. A dyke of trap rock, 5 feet wide trends N. 60° W. across the ridge. In places the limestone is so much fractured that it has a brecciated appearance, the cementing material being white calcite. On both sides of the ridge contacts with the slate, in which the limestone is enclosed, are to be seen. Several small pits have been dug in places where the calcite veins are most numerous to obtain stone for lime burning in a nearby kiln, now in ruins. Sample 213 was taken across the entire width of the limestone outcrop.

Seven hundred feet southeast of this ridge is another smaller ridge of similar limestone on the property of Alfrais Blais. The strike of the limestone on the Blais property is N. 45° E. and the dip is to the southeast at an angle of 75 degrees.

North of Abbotsford and to the west of Yamaska mountain are a number of other outcrops of nearly black, impure calcium limestone.

Analyses of Rouville County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
212.....	13·80	0·32	0·72	0·24	81·50	3·05	99·63	0·04	45·69	1·46	31 : 1
212A.....	9·26	0·34	0·20	0·15	87·59	2·40	99·94	Tr.	49·13	1·15	43 : 1
213.....	12·28	0·35	0·53	0·11	84·68	2·02	99·97	0·12	47·48	0·96	49 : 1

212. Canrobert. Dark blue, thin-bedded limestone from an old quarry on property of Joseph Bienvenue, 1½ miles south of the village.

212A. " Similar limestone at southwestern end of the limestone ridge on the same property.

213. Abbotsford. Dark blue, thin-bedded limestone in ridge just north of the Papineau road and ½ mile west of the Canadian Pacific railway.

St. Johns County

Trenton, Chazy, and Beekmantown limestones are found within this county—the Trenton over an area 3 miles in width extending westerly from the city of St. Johns to the county boundary; and the Chazy limestone south of the Trenton along the western boundary of the county to Lacolle and thence in a narrow strip southerly to the International Boundary. The Beekmantown limestone occurs in the southwestern part of the county west of Lacolle. The Trenton and the Chazy formations are abruptly terminated to the east by a prominent fault that extends the length of the county at a distance of 1½ to 2½ miles west of and nearly parallel to Richelieu river. Very little of the Beekmantown formation is exposed in this county, but what little is seen consists of very siliceous magnesian limestone and it has not been quarried to any extent. Most of the Chazy limestone is relatively free from siliceous impurities, but much of it is mottled and streaked in an erratic fashion with ferruginous, yellow-weathering magnesian material, though some areas are practically free from this objectionable material. The Chazy has been quarried for building stone, crushed stone, and for making lime in several localities, particularly around Grande Ligne, but no quarries have been worked in this formation in St. Johns county for a number of years. The Trenton limestone exposed in this county is thinly bedded and impure. It has been used to a small extent for building purposes (mostly for foundations) and is at present being quarried for crushed stone near the city of St. Johns.

St. Johns

Two and a half to three miles west of the city of St. Johns, several quarries have been opened in thinly bedded Trenton limestone which here is available over a slightly elevated area covered by only a relatively thin blanket of soil. Only one of these quarries—that operated by Standard Clay Products—has been worked during the past few years.

Quarry of Standard Clay Products, Ltd., St. Johns. This quarry is 2½ miles west of St. Johns, and a short distance south of the Napier road. It is 400 by 300 feet in area and is worked to a depth of 20 feet. Overburden varies from 1 to 2 feet. The stone is fine- to medium-grained, dark grey in colour, very fossiliferous, and is in uneven beds 2 to 4 inches thick with seams of shale between. The dip is to the northeast at an angle of about 4 degrees. Sample 170 is representative of the limestone exclusive of the shale.

Jackhammers are used for drilling the stone. After blasting, the stone is loaded by hand into 1-ton, side-dump, steel cars that are hauled by cable up the incline to the crushing plant. Crushed stone and rubble are the products. The crushing plant has a capacity of 100 tons per 10-hour day.

Similar stone is seen in two other quarries in this neighbourhood. The nearest of these is on the east side of the road going south from Ménard Corner, ½ mile to the west and about ½ mile south of the Standard Clay Products quarry. The other is on the east side of the Napier road, ¼ mile south of where the road turns south to Napierville. Both of these quarries have been idle for some years and are nearly full of water.

Trenton limestone is also reported to outcrop in the vicinity of L'Acadie.

Grande Ligne

North and southwest of Grande Ligne, Chazy limestone is available beneath a thin covering of soil, and a number of quarries for building stone and one for crushed stone were formerly worked in this neighbourhood. The limestone is heavily bedded and much of it contains pink fossil fragments and also mottlings and streaks of the yellow-weathering, finely granular magnesian material that characterizes much of the Chazy limestone in Quebec, though in some few quarries the undesirable magnesian material is not at all prominent.

One mile north of the village, and about ¼ mile west of the road going northerly from the village of St. Johns, is a large quarry, known as the Otis quarry, that was formerly worked for crushed stone, but is now abandoned. When in operation it was connected with the Canadian National railway by a spur track. The quarry is now nearly full of water, and only 8 feet of flat-lying, oolitic limestone in thick but uneven beds is exposed. Streaks and patches of fine-grained, yellow-weathering magnesian material occur in most of the beds, which otherwise are of blue-grey calcium limestone varying from fine to medium in grain size. Some pink fossils are to be seen but they are not conspicuous. Sample 171 was taken from the 8 feet of strata above the water. The prevalence of magnesian material is shown by the high content of magnesium carbonate determined by analysis; the distribution of this material is very irregular, however.

On lot 14, in the parish of St. Blaise, near Grande Ligne, is a small, abandoned quarry 8 feet deep in which beds up to 20 inches thick are available. In places the top bed is thickly dotted with fragments of pink fossils. Some of the stone here carries a great deal of yellow-weathering magnesian material.

One mile northwest of the mission buildings at Grande Ligne, and ¾ mile southwest of the road, is a small quarry from which much of the stone in the mission buildings was obtained. Six feet of medium-grained, oolitic, blue-grey Chazy limestone, in rather uneven beds up to 30 inches thick, is here exposed. Pink fossil fragments are seen in some parts of the quarry but not in others. The magnesian material is not noticeable. Sample 172 was taken from the strata exposed.

Between this quarry and the highway is a large outcrop of similar limestone but containing many magnesian streaks.

Many other outcrops and small quarries are to be seen within a radius of 1 mile of Grande Ligne.

Girard

One and one-half miles southwest of Girard station on the Canadian National railway, grey, medium- to coarse-grained, pure Chazy limestone nearly free from undesirable magnesian streaks and mottlings is exposed in a low ridge trending north and south. In the south tip of this ridge, in which limestone is exposed for 1,100 feet across a width of 200 to 400 feet, a small quarry was at one time worked exposing 10 feet of fairly pure calcium limestone in beds up to 3 feet thick. A few pink fossil fragments were observed in some of the beds. Sample 173 was taken here. A great deal of limestone is available in this ridge in a good location for quarrying

but, owing to the irregular distribution of impurities in the Chazy limestone, it may not all prove as pure as that sampled. The distance by road to Girard station is slightly over 2 miles, but the railway is only 1¼ miles distant by road at a point 1 mile south of Girard.

Stottsville (St. Valentin)

On the property of Fred Rémillard, 2 miles northwest of Stottsville station on the Canadian National railway, a thickness of 10 feet of pure calcium limestone of Chazy age is exposed in several small quarries at one time worked for building stone and for stone for making lime. Beneath this is less pure limestone. The pure stone is medium to coarse in grain, dark grey in colour, very fossiliferous and is in flat-lying beds up to 20 inches in thickness. Pink fossil fragments are very plentiful in some beds. Sample 174 represents the coarser grained stone. Beneath this, as seen in some of the deeper pits, is a dense-textured, brownish grey limestone from which Sample 174A was obtained. The quarries are in a small woods and in very flat country. The depth of soil in the vicinity ranges from 1 to 2 feet.

Lacolle

South and west of Lacolle a number of outcrops of very siliceous magnesian limestone (probably the top beds of the Beekmantown formation) were observed. No samples were taken. Much of the area around the headwaters of the Lacolle river is swampy and no rock outcrops are known.

Analyses of St. Johns County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
170.....	7·17	0·78	0·60	0·11	88·55	1·68	98·89	0·10	49·59	0·80	62 : 1
171.....	1·86	0·87	0·45	0·04	79·42	16·98	99·62	0·10	44·50	8·12	5 : 1
172.....	0·90	0·18	0·35	0·02	97·39	1·13	99·97	0·07	54·55	0·54	101 : 1
173.....	1·76	0·70	0·50	0·17	95·09	1·60	99·82	0·06	53·34	0·76	70 : 1
174.....	0·96	0·79	0·36	0·11	94·14	3·78	100·14	0·06	52·78	1·81	29 : 1
174A.....	4·19	1·35	1·66	0·13	88·66	4·18	100·17	0·22	49·72	2·00	25 : 1

170.	St. Johns	Quarry of Standard Clay Products, Ltd.
171.	Grande Ligne.	Top 8 feet, Otis quarry.
172.	"	Small quarry 1 mile northwest of village and ¾ mile southwest of road.
173.	Girard.	Quarry 1½ miles southwest of the railway station.
174.	Stottsville.	Top coarse-grained stone in quarry on property of F. Rémillard, 2 miles northwest of the station.
174A.	"	Bottom dense-textured stone in same quarry.

Shefford County

A band of highly metamorphosed limestone, or marble, enclosed in schistose rocks extends into this county from Brome county, and is exposed at intervals from the county boundary southwest of South Stukely northeastward to the northern boundary near the village of Racine. This band

and its associated rocks are shown as being of Precambrian age on the geological map of the Eastern Townships[1] but, according to a personal communication from Dr. John Dresser, these rocks are now considered to be of either Cambrian or Ordovician age. The limestone appears to be not in a continuous band but rather in a series of elongated lenses some of which are over 200 feet in thickness. The dip is to the northwest at a high angle. In some localities the band consists of calcium limestone, in others it is largely dolomitic, and in still others it consists of interbanded calcium limestone and dolomite. Veins of milky quartz are common in some outcrops, and crystals of pyrite and of copper sulphides are generally noticeable, in fact in places, as at South Stukely, the limestone of this band contains deposits of copper ore of such size that they have been mined. The better grade of the limestone contains from 3 to 5 per cent total impurities. It is not being quarried for any chemical or metallurgical use but has been used for making lime and at present is quarried at South Stukely for road metal, and formerly was quarried there for marble.

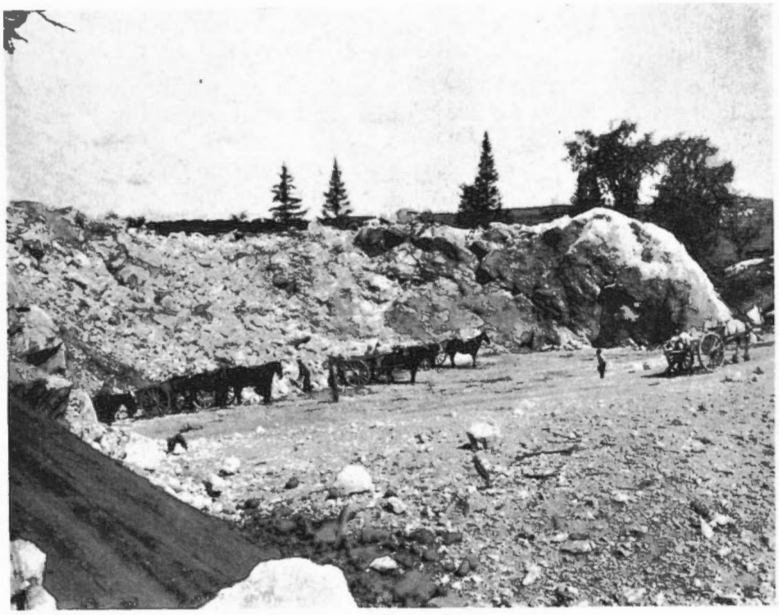
The western part of the county is underlain by shales, slates, and sandstones of Cambrian and Ordovician ages that in places contain thin, lenticular deposits of impure limestone, some of which are reported to be dolomitic. Most of these deposits are remote from transportation and, so far as known, none has been utilized for any purpose.

South Stukely

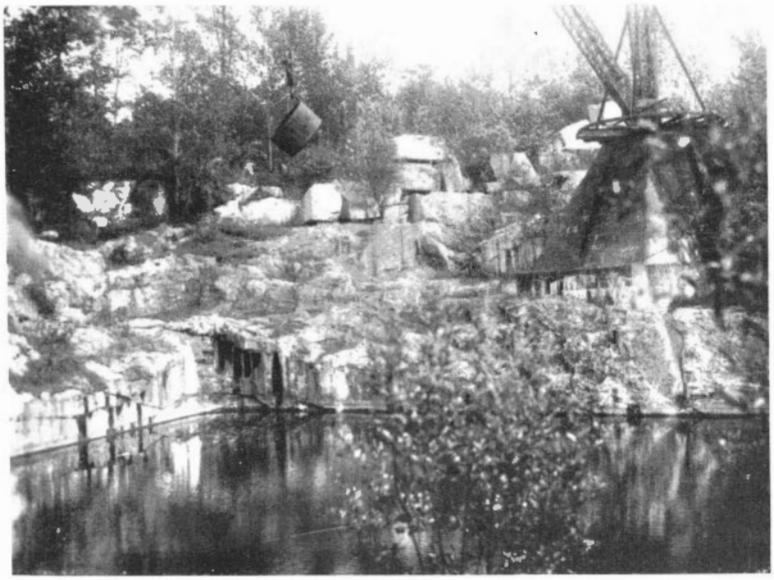
The band of highly metamorphosed limestone or marble that crosses Shefford county, passes through the village of South Stukely and is being quarried south of the village for road metal, and formerly was quarried north of the village for marble and for stone for lime burning. Small quarries were also at one time worked near the railway station at South Stukely to obtain stone for making lime.

Quarry of Canadian Rock Products, Ltd., 2020 Union Ave., Montreal. This quarry, from which crushed stone for use on the roads in the vicinity is being produced, is on lot 6, range I, Stukely township, immediately east of the shaft of the old Grand Trunk copper mine, and ¼ mile southwest of the village of South Stukely. The quarry is opened in the band of highly metamorphosed limestone that continues into this county from Brome county (see pages 193 to 195), and which here has a width of over 250 feet. The limestone strikes northeasterly and dips to the northwest at an angle of about 60 degrees. The eastern half of the band consists mostly of medium-grained, light blue calcium limestone, and the western half of yellowish white and bluish white, fine-grained magnesian limestone in which are streaks of dolomite. All is massively bedded. Chloritic schist occurs on both sides, and along the edges of the band some of this rock is interbedded with the limestone. Veins of quartz are also plentiful near the edges, particularly so along the western edge, but the remainder of the limestone is relatively free from this impurity. Sample 236 is representative of the magnesian limestone, and Sample 236A is from the calcium limestone on the east side of the deposit.

[1] Geol. Surv., Canada, Map 571, Montreal Sheet, Eastern Townships Map (1895).



A. Quarry of Canadian Rock Products, Ltd., South Stukely, Shefford county.



B. Inactive quarry of Dominion Marble Company at South Stukely, Shefford county.

The quarry is being worked into the western face of a high knoll of the limestone and only the fine-grained magnesian variety is quarried. A face 30 to 50 feet in height and 100 feet in length is worked. (Plate XXXII A, page 233). Stripping is done with a gasoline-driven, dragline scraper mounted on caterpillar treads, and drilling is done with jack-hammers, 20-foot holes being drilled. The blasted rock is loaded by hand into horse-drawn dump carts for transportation to the crushing plant nearby. This plant has a capacity of 50 tons per hour.

On the hillside east of the Canadian Pacific railway, ½ mile southwest of South Stukely station, the same band of metamorphosed limestone that is being quarried by Canadian Rock Products, Ltd., again outcrops. A width of 120 feet of fine-grained, pale bluish, massively bedded calcium limestone, veined with white quartz, is here exposed. The band strikes N. 50° E. and dips to the northwest at an angle of 80 degrees. Sample 235 was taken from this exposure but it does not include any of the quartz veins.

Quarries of Dominion Marble Co., Ltd., P.O. Box 1163, Montreal. These quarries, which have not been operated since 1914, are on lot 8, range II, Stukely township, ¾ mile north of the village of South Stukely, and were formerly connected with the Canadian Pacific railway at South Stukely by a spur track. They are opened in the same band of metamorphosed limestone, or marble, that is being quarried 1¼ miles to the southwest by Canadian Rock Products, Ltd. The band of marble has a maximum width of 200 feet at the site of the quarries and strikes N. 45° E. and dips to the northwest at an angle of 80 degrees. The marble is described in detail by Parks.[1] In general it may be said that the stone is white to bluish white in colour, is massively bedded, and is veined and clouded with green, brown, mauve, and yellow, and contains occasional crystals of pyrite and chalcopyrite, particularly along joint planes. Part is of the calcium type and part is dolomitic, the two varieties being interbanded in an irregular fashion and in such proportions that a channel sample taken across a quarriable width has the composition of a magnesian limestone. The dolomite is more prevalent on the eastern side of the band, where, in addition to being interbedded with the calcium limestone, it is also present in yellow veins. A nearly vertical dyke of igneous rock, 2 feet 6 inches thick, strikes N. 70° W. across the band. Sample 237 was taken across 150 feet of marble on the western side of the band, and Sample 237A across 35 feet on the eastern side.

Two quarries have been opened The larger of the two (Plate XXXII B, page 233), on the western side of the band, is in the form of an equilateral triangle with sides 150 feet long and is over 35 feet deep, though it is now partly filled with water. The other quarry which is slightly north and east of the first-mentioned quarry is 75 feet long (parallel to the strike), 35 feet wide, and 6 to 8 feet deep exclusive of soil, which is 5 feet deep. The marble was extracted with channelling machines, and large

[1] Parks, W. A.: Mines Branch Rept. No. 279, pp. 203-209 (1914).

blocks were obtained even from the surface rock. Prior to the opening of the marble quarries the stone was used for making lime in two small stone kilns, the ruins of which are still on the property.

Lawrenceville

Two miles southwest of Lawrenceville, on the west side of the road going to South Stukely, outcrops of highly metamorphosed, fine- to medium-grained, white and light blue calcium limestone, much fractured and veined with white calcite, are seen at intervals for about ½ mile. The limestone band is 200 feet wide and is enclosed in a greenish schist. It strikes N. 40° E. and dips at an angle of 65 degrees to the northwest. Along the western edge where the limestone merges gradually into the schistose rock, veins of milky quartz are numerous in both limestone and schist. On the eastern side the contact is very sharp and distinct and is possibly a faulted contact. On lot 13, range VII, Stukely township, Delphis Beauregard has opened a small quarry from which building stone and stone for lime burning have been obtained. This quarry is 250 feet in length (parallel to the strike), 80 feet wide, and about 10 feet deep. Sample 238 was taken in the quarry.

Bands of dolomite are reported to occur on lot 8, range VII,[1] Stukely township, and again on lot 8, range VIII,[2] of the same township. Bancroft[3] states that the dolomitic limestone on lot 8, range VII, is bluish grey in colour and is traversed by reticulating veinlets of quartz with a little calcite and chlorite. The band dips steeply to the northwest. The dolomite on lot 8, range VIII, also contains a few small irregular stringers of quartz according to Bancroft.

Racine

A band of white and grey dolomite, about 40 feet thick, is reported by James Richardson[4] to occur on lots 9 and 10, range II, Ely township. Bancroft[5] in referring to the copper mine formerly worked on lot 10 says that the shaft penetrates impure, crystalline dolomitic limestone interstratified with mica schists, striking northeast and dipping to the northwest at an angle of between 60 and 65 degrees. Both limestone and schists are traversed by veins of quartz. This deposit was not seen by the present writer.

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[1] Geol. Surv., Canada, Geology of Canada. 1863. p. 722.
[2] Geol. Surv., Canada, Geology of Canada, 1866, p. 302.
[3] Bancroft, J. A.: Dept. of Colonization, Mines and Fisheries, Quebec. "The Copper Deposits of the Eastern Townships of the Province of Quebec", p. 123 (1915).
[4] Richardson, James: Geol. Surv., Canada, Geology of Canada, 1866, p. 35.
[5] Bancroft, J. A.: Op. cit., p. 127.

Analyses of Shefford County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
235.....	1·32	0·55	1·22	0·17	90·63	6·46	100·35	0·03	50·75	3·09	16 : 1
236.....	3·00	0·78	0·92	0·22	70·64	24·64	100·20	Nil	39·68	11·78	3 : 1
236A.....	2·34	0·43	0·46	0·24	91·45	5·19	100·11	0·09	51·34	2·48	21 : 1
237.....	1·33	0·92	1·44	0·24	81·13	14·70	99·76	0·07	45·43	7·03	6 : 1
237A.....	4·58	0·80	1·09	0·28	67·37	26·67	100·79	Tr.	37·88	12·75	3 : 1
238.....	1·30	0·46	0·75	0·09	93·07	3·80	99·53	0·03	52·12	1·82	29 : 1

235. South Stukely. Outcrops east of the Canadian Pacific railway, ½ mile southwest of South Stukely station.
236. " Quarry of Canadian Rock Products Co.
236A. " Outcrops east of the above quarry.
237. " Dominion Marble Co., Ltd., 150 feet of marble on the western side of the deposit.
237A. " Dominion Marble Co., Ltd., 35 feet of marble on the eastern side of the deposit.
238. Lawrenceville. Quarry on property of Delphis Beauregard, lot 13, range VII, Stukely township.

Sherbrooke County

The little limestone known to occur in this county is impure. Dark, slaty, Ordovician limestones are found south and east of Lennoxville, and a deposit of red and green marble is reported to occur on Orford mountain.

Lennoxville

Dark grey, sandy, slaty calcium limestone of Ordovician age, associated with sandy slates and quartzites is commonly exposed along the Canadian Pacific railway for 4 miles southeast of Lennoxville. Similar stone is also seen at Huntingville and at Milby. It very much resembles the impure limestone exposed in Stanstead county along the east shore of Massawippi lake, and, like this latter, it contains thin streaks or interbeds of black, shiny slate. Sample 239 was taken on lot 7, range V, of Ascot township.

Orford Mountain

The following description of a limestone deposit on lots 10, 11, and 12, range A, Orford township, which is on Orford mountain, north of Fraser lake, is abstracted from Mines Branch Report No. 279, p. 210 (1914), by W. A. Parks.

The belt of marble on this property appears to be about 100 feet wide. It is of very irregular shape and lies between greenish schistose rocks, large inclusions of which occur in the marble. The marble is of two general types—a red and a green, both varieties being irregularly distributed. The red is fine-grained and is traversed by veinlets of white calcite and by parting planes in which a small quantity of altered basic minerals occurs, principally sericite and greenish actinolite. The green variety differs from the red in that the green component, which is sub-

ordinate in the red variety, is here so abundant that the red colour is seen only in spots, and veinlets of white calcite are strongly developed. In fact it is a mixture of white calcite and green actinolite with a minor amount of red calcite.

This deposit was not examined by the present writer but judging from Parks' description it consists of impure calcium limestone. In 1905 a few blocks were quarried from the deposit and sawn into slabs but no further work has been done.

Analysis of Sherbrooke County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
239.....	32·88	1·19	1·75	0·17	58·80	3·97	98·76	0·17	33·02	1·90	17 : 1

239. Lennoxville. Outcrops on lot 7, range V, Ascot township.

Stanstead County

Impure calcium limestone is rather widely distributed in Stanstead county, but deposits of pure limestone are rare. Thin, steeply dipping, lenticular limestone deposits, associated with slate are found in a Silurian outlier occupying the northern part of the basin of lake Memphremagog. This limestone has been quarried in several places, in the past, for flagstone and for making lime for local use. Ordovician limestone, also in lenticular, steeply dipping deposits, and for the most part very siliceous, is found extensively developed east and south of Massawippi lake where it is associated with slate and sandstone. Recently (until 1931) a quarry for road metal was worked in a deposit of this limestone 2 miles southeast of the village of Ayers Cliff, and formerly small amounts of the limestone were quarried in a number of localities for flagstone, foundation stone, and for making lime. For the latter use, however, the limestone, containing as it usually does from 30 to over 50 per cent silica, is far too impure for use in the modern lime industry. The purest deposit of limestone seen in the county is that on Magoon point in lake Memphremagog where it was formerly quarried for making lime.

Magog

Several outcrops of impure calcium limestone occur nearby, but the deposits are small and too variable in composition to be of much economic value.

On lot 1, range XVI of Magog township, which is on the west side of Cherry river, about 3 miles by road northwest of the town, thinly bedded, siliceous, fine-grained, dark grey, calcium limestone, interbedded with shale, was formerly quarried in small quantity for making lime. The beds strike northeast and dip to the southeast at an angle of 70 degrees. There are very few outcrops and the extent of the deposit could not be ascertained.

A. Slaty Ordovician limestone in quarry formerly operated by Eastern Townships Paving Company, Ltd., on lot 28, range XIV, Stanstead township, Stanstead county.

B. Differential weathering in laminated Silurian or Devonian limestone formerly quarried for flagstone at Bishop Crossing, Wolfe county.

This limestone is within the area of Silurian rocks shown on the southwest sheet of the Eastern Townships Map issued by the Geological Survey in 1895. Sample 205, which was taken from the small quarry, consisted of only a few fragments of the limestone.

Very sandy and shaly calcium limestone of Ordovician age is exposed in the cutting on the Canadian Pacific railway on lot 4, range XV, Magog township.

Along the road on the west side of lake Memphremagog on lot 10, range XIV, Magog township, 4½ miles southwest of the town of Magog by road, is another exposure of very sandy, thin-bedded, Ordovician calcareous rock in which are many crystals of pyrite. The analysis of a rough sample taken from the outcrop showed 77 per cent silica.

On the east side of lake Memphremagog thinly bedded, slaty, Silurian limestone striking northeast and dipping steeply to the northwest is exposed in several places along the road to Oliver.

Oliver

A band of impure, thin-bedded, dark blue-grey, slaty Silurian calcium limestone striking N. 54° E. and dipping to the northwest at an angle of 75 degrees is exposed on a hilltop just north of Oliver on lot 9, range XV, Magog township. A partial analysis of a sample taken from the band showed it to contain 16 per cent total impurities. This band has a width across the strike of more than 200 feet.

Concerning the limestones in the vicinity of Oliver, Ells[1] states that they have been used locally for flagstone.

Georgeville

The Silurian strata in the vicinity of Georgeville consist largely of limestone, and outcrops are plentiful along the lake shore road both north and south of the village. Formerly lime for local use was made in many small kilns, and the limestone was also utilized for flagstone, but it has not been quarried in recent years.

One-half mile north of Georgeville, fine-grained, dark blue, thinly bedded, sandy limestone, striking N. 42° E. and dipping to the northwest at an angle of 70 degrees, is exposed over a width of more than 900 feet. On the east side of the lake shore road, on lot 27, range II, Stanstead township, this limestone was once quarried on a small scale for making lime. Sample 206 was taken from the strata exposed in the quarry and from adjacent outcrops. Limestone of similar character is seen at intervals along the road toward Georgeville and for about 1 mile south of the village. In places it is interbedded with a graphitic slate.

Along the road south from Georgeville and about 1 mile distant from the village, a purer grade of limestone is seen in a small outcrop on the south face of the hill just north of the brook that empties into Macpherson bay. The limestone here is of a lighter shade of blue and is veined with white calcite. Sample 207 was taken from this outcrop.

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[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept. 1886, pt. I, p. 69.

One-half mile farther south, light blue, sandy, finely granular limestone, veined with white calcite, striking N. 30° E. and dipping to the northwest at an angle of 75 degrees, forms low cliffs around the shores of Macpherson bay. Some of the limestone is similar in purity to that from which Sample 207 was taken, but on the average this limestone is much more siliceous (due to the presence of sand) as is shown by the analysis of Sample 208 which was taken from 100 feet of strata exposed on the shore midway around the bay.

Magoon Point

A deposit of Silurian marble, or metamorphosed limestone, which was at one time extensively quarried for the making of lime, occurs on lot 12, range II, Stanstead township, near the tip of Magoon point, which is the promontory between Fitch bay and lake Memphremagog proper. The stone is a banded light blue, fine-grained, calcium limestone, much veined with white calcite and is rather soft and friable in places. It occurs in a lenticular band 30 to 100 feet wide enclosed in a grey-blue slate which is also veined to some extent with white calcite. The strike is N. 30° E. and the dip is vertical. The quarry, which has not been worked for many years, was opened on the top of a hill and is 500 feet long and 30 to 100 feet in width. It is now nearly full of water and very little stone is to be seen. Sample 209 was taken from the small width of stone exposed in the south end of the quarry. When the quarry was in operation part of the output was made into lime in a nearby kiln, and part was shipped to other kilns on the shores of lake Memphremagog.

North Hatley-Ayers Cliff

Between North Hatley and Ayers Cliff, fine-grained, thinly bedded, very siliceous, blue, Ordovician limestone interstratified with blue slate is extensively exposed along the east and south shores of Massawippi lake, and to the east and south of the lake, bands of similar limestone are plentiful within a distance of 3 miles. In places the limestone is banded light blue and dark blue, but the darker colour predominates. Even the dark limestones have a banded structure. All is of a slaty nature and only rarely are the beds as much as 6 inches thick. The general strike of the st ata is northeast and the dip is very steep, frequently being vertical. Pyrite is plentiful in much of the limestone. There are no quarries in operation at the present time but the limestone has been quarried for road metal within recent years and formerly was used for flagstone, foundation stone, and, in one or two localities, for making lime. Sample 211 was taken from outcrops along the highway to Stanstead on lots 15 and 16, ranges II and III, Hatley township.

Quarry formerly operated by Eastern Townships Paving Co., Ltd., Sherbrooke This quarry (Plate XXXIII A, page 238), which was worked for crushed stone for constructing local roads, is on lot 28, range XIV, Stanstead township, about 2 miles southeast of the village of Ayers Cliff. It was last worked in 1931. The stone is a very siliceous, thin-bedded, blue, slaty limestone containing many cubes of pyrite, and is sparingly veined across the bedding with white calcite. The strike is northeast and the dip is at

an angle of 70 degrees to the southeast. The beds are all much mashed and the bedding planes have a satiny sheen. The quarry is of the hillside type and is opened on the hillside between Nigger river and the highway between Lennoxville and Stanstead. It is 200 feet long, has been worked for 100 feet easterly into the hillside across the stratification, and has a face of 40 feet at the back. The crushing plant is situated nearby. Sample 210 was taken in this quarry.

At the village of Massawippi, evenly bedded, steeply dipping, siliceous blue limestone is to be seen in road cuts. Fréchette[1] gives the following partial analysis of a sample of limestone taken on lot 6, range IV, Hatley township, which is just north of Massawippi:—

	Per cent
Insoluble	50·00
Lime	24·55
Magnesia	1·53

In the same report Fréchette also gives the following partial analyses of limestone deposits in Stanstead county that were not seen by the present writer:—

	1. Per cent	2. Per cent
Insoluble	37·28	54·16
Lime	31·00	20·86
Magnesia	2·40	2·70

1. Deposit on lot 11, range V, Stanstead township.
2. Limestone in bed of river on lot 5, range V, Barnston township.

Analyses of Stanstead County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
205	5 10	0·29	0·61	n.d.	92·39	1·38	99·77	0·09	51·74	0·66	78 : 1
206	12·00	0·44	0·66	0·22	84·82	1·71	99·85	Tr.	47·50	0·82	58 : 1
207	4·72	0·88	2·92	0·02	88·43	2·34	99·31	0·02	49·53	1·12	44 : 1
208	16·76	1·82	3·70	0·28	73·47	3·25	99·28	0·06	41·30	1·55	27 : 1
209	1·72	0·62	0·32	0·04	91·68	4·79	99·17	0·02	51·36	2·29	22 : 1
210	40·36	1·39	1·93	0·17	51·41	3·70	98·96	0·25	28·88	1·77	17 : 1
211	43·06	1·12	2·21	0·15	49·21	3·01	98·76	0·10	27·64	1·44	19 : 1

205.	Magog.	Abandoned quarry on lot 1, range XVI, Magog township.
206.	Georgeville.	Abandoned quarry on lot 27, range II, Stanstead township.
207.	"	Outcrop 1 mile south of the village and just north of the brook emptying into Macpherson bay.
208.	"	Shore of Macpherson bay.
209.	Magoon point.	Abandoned quarry formerly worked for stone for making lime.
210.	Ayers Cliff.	Quarry of Eastern Townships Paving Co.
211.	North Hatley.	Outcrops on lots 15 and 16, ranges II and III, Hatley township.

[1] Fréchette, Howells: Mines Branch Sum. Rept. 1915, p, 52.

Wolfe County

The most of the readily accessible limestone resources of this county are found within an area of Silurian or Devonian rocks that occupies the valley of St. Francis river for 24 miles from lake Aylmer to beyond Lime Ridge and Marbleton. According to Ells' map[1] this outlier has a width of 1 mile at lake Aylmer but at its southwestern end it is 6 miles in width, which is the maximum width it attains. It is to be noted that the results of recent work by F. R. Burton in the Lake Aylmer area, published in Part D of the Annual Report of the Quebec Bureau of Mines for 1930, pp. 99-145, have shown that the rocks of the northern part of this area are of Lower Devonian age rather than Silurian, to which latter age they were assigned by Ells. The limestone deposits are apparently lenticular (though some are of large size) and are enclosed in slate. In general they have a steep dip and some are folded. All are metamorphosed to some degree. The limestone is predominantly of the calcium type, but for the most part is siliceous and argillaceous. However, certain large deposits of highly metamorphosed limestone in the vicinities of Lime Ridge and Marbleton consist of pure, high-calcium limestone. Lime Ridge has long been an important lime-producing centre, and one of the largest lime plants in the province is in operation there. Lime was also made in the past from many of the deposits of impure limestone at other places in the area. The production of flagstones from the evenly bedded siliceous Silurian limestone at Bishop Crossing was once an important industry, and attempts have also been made to quarry marble from a large deposit of highly altered limestone at Marbleton. The Quebec Central railway and one of the main highways of the province pass lengthwise of this area of Silurian or Devonian rocks and thus many of the limestone deposits are within a short distance of transportation.

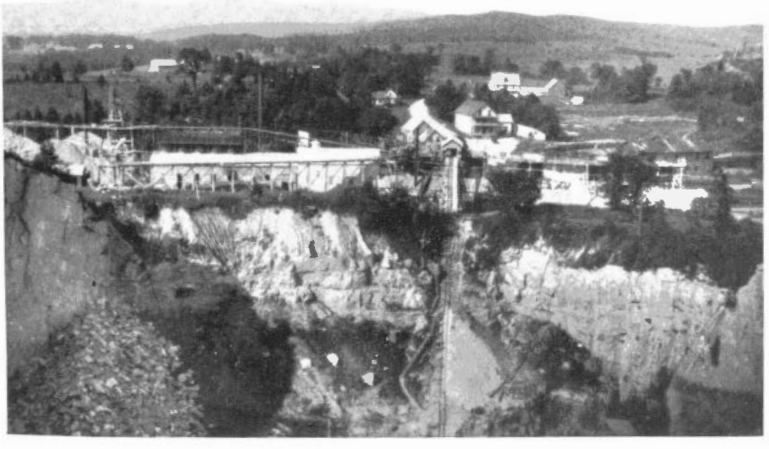
Outside of this area, scattered deposits of limestone are known to occur in places more remote from transportation. Such as were seen east of Weedon and St. Gérard and in the vicinity of Stratford are of relatively small size and are impure. Some of these are dolomitic.

Lime Ridge

Quarry of Dominion Lime Company, Lime Ridge. This quarry (Plate XXXIVA, page 243) is opened on a high mound of metamorphosed, fine-grained, high-calcium limestone just east of the highway passing through the village. It is about 400 feet in diameter at the top, 200 feet in diameter at the bottom, and has been worked to a depth of 275 feet. The deposit appears to be a lenticular mass of limestone that has been folded into a closed syncline. On all sides it is enclosed in a slaty rock, and at both sides and at the back of the quarry the limestone is darker in colour and less pure than that in the bottom and in the front, or southwest wall, of the quarry. The lime plant, however, is built close to the southwest wall of the quarry and very little of the pure stone in that wall is obtainable except by mining. The apparent strike of the strata is N.75°E. and the dip is nearly vertical. The stone now being

[1] Geological map accompanying Ann. Rept. Geol. Surv., Canada, 1886, pt. J.

A. Silurian or Devonian limestone in the quarry of Dominion Lime Company, Ltd., Lime Ridge, Wolfe county. This quarry is 275 feet deep.



B. Plant and quarry of Dominion Lime Company, Ltd., Lime Ridge, Wolfe county.

quarried is the light blue, fine-grained, pure, high-calcium limestone found in the bottom of the quarry and is represented by Sample 244. Stone very similar both in appearance and composition to that in the bottom of the quarry is exposed in the southwest wall; Sample 244A represents this stone across a width of 200 feet. The stone in the northern wall, or the back of the quarry, is finely granular, dark blue in colour, and has streaks of chloritic material in it. It is said to yield a white lime but one that crumbles readily while in the kiln; Sample 244B was taken across the entire exposed width of 250 feet of limestone of this type. In the western wall of the quarry a slaty, dark blue, finely granular limestone is exposed; Sample 244C was taken here. The stone in the eastern wall is more like that in the back of the quarry. All the stone is badly shattered and contains some small crystals and veinlets of white calcite. Despite the shattered nature of the stone and the depth to which the quarry has been worked, there is very little inflow of water except in the springtime.

The quarry is worked by means of a drifter drill mounted on a tripod and is deepened in 22-foot benches. A jackhammer is used for blockholing any large fragments obtained after blasting. Broken stone is loaded by hand into side-dump, steel cars which are hauled one at a time by cable up an incline to the charging-floor of the lime plant, from where the stone may be charged directly to the kilns, or sent to the crushing plant, or shipped in lump form.

Products of this company include the following: lump quicklime (white), crushed quicklime, masons' hydrated lime, finishing hydrated lime, crushed stone for roads, agricultural limestone, asphalt filler, poultry grit and fluxing stone. In addition to the foregoing the company has completed preparations for the manufacture of a special pulverized quicklime for the making of a waterproof lime mortar.

The lime plant consists of 10 vertical, continuous, externally fired, steel kilns, 4 of which are gas-fired from a Bradley gas producer, and in the remainder wood is used for fuel. The total capacity of the plant is 80 tons of quicklime per 24 hours. Hydrating equipment includes a gyratory crusher, a Clyde hydrator having a capacity of 5 tons of hydrate per hour, a Raymond mill, and a bagging machine.

The crushing and pulverizing plant, in which stone too small for lime burning is utilized, is equipped with a rotary drier, screens, Jeffrey hammer mill, and a set of Bradley rolls. The products include crushed stone, poultry grit, and three grades of pulverized limestone—the first of which is ground to such fineness that all passes a 4-mesh screen; the second, all passes a 16-mesh screen; and the third, all passes a 45-mesh screen. The latter material is used for asphalt filler and the two other products are sold for agricultural use.

A spur track 5 miles in length connects the plant with the Quebec Central railway (C.P.R.) at Dudswell Junction. The lime company operates its own locomotive over this line.

Two hundred yards southeast of the quarry and also on the property of the company is an outcrop of blue, fine-grained, high-calcium limestone in which are thin bands of less pure limestone. The full extent of this deposit is not known at present. A small amount of stripping has been done here with a view to opening a quarry should the deposit prove large and of good quality.

Six hundred yards north of the quarry, and also on the property of the company, fine-grained, light blue, crinoidal high-calcium limestone is exposed over a large area west of the highway. Sample 245 consisted of a large number of chips taken over the whole area. Occasional small patches of rusty-weathering, very fine-grained, blue dolomite occur in this deposit, but not in sufficient quantity to appreciably affect the quality of the stone. Similar limestone is also seen on the opposite side of the highway.

Two hundred yards southwest of the quarry, opposite the company's office, fine-grained, blue, high-calcium limestone is exposed across a width of 200 feet in a high knoll. This is directly on the strike of the limestone in the deep quarry and it is possibly part of the same deposit. The limestone in the knoll, however, contains some slaty streaks and also a few veins of white quartz and thus is not so pure as that being quarried.

One-third of a mile southwest of Lime Ridge, thinly and unevenly bedded, impure, slaty, blue, calcium limestone is exposed in a cut on the highway for a distance of 150 feet. It strikes N.90°W. and dips vertically. The uneven bedding planes have a satiny sheen due apparently to the presence of tiny scales of mica. The limestone weathers deeply to a rusty colour and on all outcrops is a spongy coating of residual silica. Sample 243 was taken from unweathered stone in this exposure.

Dominion Station

Dominion Station is 1½ miles south of Lime Ridge and near the upper end of Dudswell pond. It was at this place that the Dominion Lime Company first commenced the burning of lime (1890). Four stone draw-kilns (Plate IVB, page 28) were built on the north side of the brook flowing into Dudswell pond, and a quarry was opened in the ridge of high-calcium limestone on the opposite side of the brook, but, as the stone did not prove entirely satisfactory for making lime, the Dominion Lime Company purchased the plant and property of the Dudswell Lime and Marble Company which was then operating at the site of the present quarry at Lime Ridge.

The limestone at Dominion Station appears to strike nearly east and west and to dip to the north at an angle of 80 degrees. The quarry, which has long been abandoned, is 200 feet long, has been worked 75 to 100 feet into the south side of the ridge and the face is 60 feet high. The limestone exposed therein is fine-grained, light blue in colour, and has a massive structure, though in places it contains slaty zones. Veins of white calcite are fairly numerous. Overburden is fairly heavy along the ridge. Sample 242 is representative of the stone in the quarry. When in operation this quarry was served by a spur track from the branch line of the Quebec Central railway between Lime Ridge and Dudswell Junction.

Bishop Crossing

North of this village and east of Dudswell pond, flagstones, tombstones, and foundation stone were formerly produced in considerable quantity from the evenly bedded, siliceous limestone there exposed, but

there has been no production within recent years. The limestone, which is of either Silurian or Devonian age, lies in remarkably even beds dipping northeasterly at angles of 20 to 25 degrees. The strike of the beds differs somewhat from place to place but the average is N.30°W.

Jointing is rectangular and widely spaced, thus being favourable to the extraction of large slabs. The limestone is very fine-grained, dark bluish grey in colour and has a laminated structure, being composed of thin, alternate layers of dark and lighter coloured material, the darker layers apparently being more siliceous than the others. An occasional thin vein of quartz is also to be seen traversing the stone in a direction oblique to the lamination. On a weathered, vertical surface, such as a joint plane, differential weathering is noticeable, as is illustrated in Plate XXXIIIB, page 238. The country in the immediate vicinity is relatively flat and is covered by clay soil to a depth of 2 to 10 feet.

W. A. Parks[1] says in part regarding these deposits:—

The formation strikes N.10°E. and dips 22° to the southeast (E.10°S.). The bedding is remarkably even in layers from 2 to 10 inches thick. Very clean joints strike exactly with the formation and dip 50° to the westward (W.10°N.): these joints vary from 2 to 30 feet apart but average about 6 feet and cut the rock into excellent strips. The cross joints strike E.30°N. and are infrequent. Occasional irregular cracks cross diagonally but in the quarries they are usually very widely spaced. It is the multiplication of these irregular fractures that renders the stone useless over considerable areas.

The remarkably even bedding and clean jointing make the quarrying of flags very easy. The thicker beds are easily split to a desirable size in the case of the stone from near the surface, but this ability to cleave decreases with depth. Along the strike, continuous strips were observed having a length of 128 feet. Slabs 11 feet by 12 feet and 7 inches thick have been shipped.

Numerous small quarries have been opened along the strike of the beds for more than a mile, but in most of them the rock is largely hidden by debris. Sample 241 was taken from the rock exposed in several quarries formerly worked by Wm. Bentley on lot 15, range V, Dudswell township, which is near the southern end of the area.

Marbleton

There are many outcrops of metamorphosed limestone or marble in this neighbourhood, but some of the most extensive are just north of Silver lake on lots 21 and 22, ranges VII and VIII of Dudswell township. A very small quarry was long ago opened on lot 22, range VII, with the object of producing marble, but the stone proved to be unsound. The limestone, or marble, is exposed in a band 800 feet wide striking N.75°E. from the shore of Silver lake and dipping to the north at an angle of 70 degrees. It is flanked on either side by blue, calcareous, slaty rock that weathers brown. Outcrops occur for ¼ mile easterly from the shore of the lake, after which the rock is covered with soil. The limestone is all fine-grained and highly fossiliferous, crinoid stems being prominent especially along the southern edge of the belt, and crinoids are also to be seen in the calcareous, slaty rock to the south. There is a considerable variation in the character of the limestone in the 800-foot band—some is

[1] Parks, W. A.: Mines Branch Rept. 279, p. 109 (1914).

blue, some is nearly white, and some is mottled blue and white. Streaks of yellow magnesian limestone are, in places along the south side of the band, interbedded with the blue and white limestone, which is predominantly high-calcium in composition. Much of the limestone has a laminated structure parallel to the strike, and in this direction too it is veined with white calcite. Occasional narrow veins of quartz are also to be seen. The rock is exposed in a series of ridges paralleling the strike, with the intervening rock hidden by a shallow depth of soil, and it is possible that in the concealed areas the rock is less pure than on the ridges, as is often the case in limestone deposits. Sample 246 was taken from the ridges exposed in the central 600 feet of the limestone band at a place 400 feet or so east of the lake, and represents the best stone. Near the lake the limestone is not so pure as where the sample was obtained, however, provided the stone between the ridges is similar to that exposed, there is a very large tonnage of pure limestone available in the central part of the deposit. The deposit is 2½ miles from the railway at Lime Ridge.

A small quarry, 60 feet long, 50 feet wide and 3 to 4 feet deep was at one time worked near the southern edge of the band where the high-calcium limestone is interbedded to some extent with yellow magnesian limestone. The entire deposit is now owned by the Dominion Lime Company of Lime Ridge.

Outcrops of marble are also to be seen along the road between the above deposit and the village of Marbleton. Some is of good quality and some is very impure.

Along the highway, 4½ miles northeast of Marbleton, on lot 3, range VI, Weedon township, heavily bedded, fine-grained, blue, siliceous limestone, striking N.60°E. and dipping to the southeast at an angle of 38 degrees, is exposed. Thin veins of quartz cut diagonally across the stratification. Sample 247 was taken from a 15-foot thickness of the limestone exposed along the road. As the analysis shows, this stone is very impure. Outcrops of similarly impure limestone, some of which is slaty, are common along the highway between Marbleton and Weedon Centre.

Weedon

Three miles by road east of Weedon station, on lot 17, range III, Weedon township, impure, fine-grained, dolomitic limestone is exposed in a knoll 100 feet in length and 15 to 20 feet in height, along the road to the Weedon mine. A sample taken here by Howells Fréchette had the following analysis[1]:—

	Per cent
Insoluble	20·00
Lime	31·15
Magnesia	11·66

St. Gérard (Lake Weedon Station)

Southwest of St. Gérard, on lot 22, range VII, Weedon township, is a band of thinly laminated, very fine-grained, light blue, fossiliferous, calcium limestone about 120 feet thick enclosed in blue calcareous slate. The strike is N.60°E. and the dip is nearly vertical. The stone, some of which is conglom-

[1] Mines Branch Sum. Rept. 1915, p. 52.

cratic, is veined with white calcite and contains a few veins of quartz. In places thin bands of impure, brown-weathering dolomite are interbedded with the calcium stone. Many years ago this limestone was quarried for making lime, the quarry being opened in the southwest end of a low hill into which it was worked for a distance of 100 feet along the strike across a width of 115 feet. The central 20 to 30 feet of the band is slaty and more impure than the remainder and has been left standing in the quarry. Sample 248 was taken from this quarry excluding the central band of slaty limestone.

On the northern part of lot 26, range VII, Weedon township, fine-grained, blue, partly metamorphosed, crinoidal calcium limestone in beds up to 12 inches thick, with partings of dark blue slate, is exposed along the northwest side of a low hill and, until 1907, was quarried for making lime in a nearby stone kiln. The limestone strikes N. 55° E. and dips vertically. It is apparently a lenticular deposit enclosed in a calcareous slate. Where quarried, the band, including some beds of slate, has an exposed thickness of 150 feet. Small veins of white calcite traverse limestone and slate alike. The old quarry is 150 feet long, parallel to the strike, and has been worked into the hillside for about 25 feet, giving a face 10 to 20 feet in height. Sample 249 was taken across the strata exposed. The overburden is only a few inches deep on the ridge. The property is owned by Richmond Brière of St. Gérard who states that the lime produced was dark in colour but was very strong. The property is 1 mile from St. Gérard station on the Quebec Central railway.

On lot 27, range VII, Weedon township, just east of the old road between St. Gérard and Garthby, a lenticular deposit of blue, slaty, calcium limestone enclosed in calcareous slate is exposed. Slaty partings also occur in the limestone and, in places, compose 15 per cent of the deposit. The strike is N. 55° E. and the dip is vertical.

Between the Quebec Central railway and Bull-frog bay on lake Aylmer a fine-grained, slaty, light blue calcium limestone, veined with white calcite and enclosed in calcareous slate is exposed on lot 3, range C, Garthby township, at an elevation of 40 feet above the lake. The strike is N. 55° E. and the dip is vertical. Sample 250 represents this stone.

Two and one-half miles northeast of St. Gérard and about 200 feet southeast of the road going northeasterly between ranges IV and V of Stratford township, and on lot 22 of range V, is a hillock of brecciated, fine-grained magnesian limestone, 125 feet long, 65 feet wide and 20 to 25 feet in height. A few veinlets of quartz traverse the limestone, and it is obviously impure. Sample 251 was taken from this outcrop.

Garthby

One and a half miles west of Garthby, on lot 50, range IIIN, Garthby township, very slaty calcium limestone is exposed and was formerly quarried for making lime. Similar limestone is also seen in several other places along the road to the southwest. This limestone is in the area marked Ordovician in the geological map of the district that accompanies Part J of the Annual Report of the Geological Survey for 1886.

At the tip of Long point in lake Aylmer, thinly bedded, siliceous, blue calcium limestone of Silurian or Devonian age is exposed in several places. It strikes N. 40° E. and dips to the southeast at 80 degrees.

Stratford

Between lake Aylmer and Stratford, several outcrops of impure limestone were observed along the road from St. Gérard to Stratford, particularly on lot 28, range II S.W. of Stratford township and again near Stratford village. F. R. Burton gives the following information on a limestone deposit southwest of Stratford "The limestone band outcrops at a bend in the road southwest of Stratford village along the line between ranges VII and VIII south, lot 3. The rock is greyish-white and fine-grained. In thin section it was found to consist almost entirely of recrystallized calcite, with only 1 or 2 per cent of quartz, sericite, and hematite or limonite."

Analyses of Wolfe County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
241.....	31·14	0·45	1·11	0·09	62·79	3·79	99·37	0·06	35·21	1·81	19 : 1
242.....	1·92	0·24	0·75	0·07	94·77	2·05	99·80	Tr.	53·11	0·98	54 : 1
243.....	23·50	1·24	3·06	0·04	62·64	4·20	94·68	0·19	35·10	2·01	17 : 1
244.....	0·45	0·22	0·35	0·02	97·92	0·51	99·47	0·02	54·88	0·24	229 : 1
244A.....	0·34	0·30	0·24	0·02	97·48	0·88	99·26	0·01	54·59	0·42	130 : 1
244B.....	1·28	0·33	0·49	0·02	97·38	0·82	100·32	0·04	54·53	0·39	140 : 1
244C.....	5·38	0·45	0·97	0·04	91·52	1·70	100·06	0·06	51·25	0·81	63 : 1
245.....	1·14	0·17	0·34	0·02	97·27	1·21	100·15	Tr.	54·48	0·58	94 : 1
246.....	1·50	0·37	0·63	0·04	96·30	1·30	100·14	Tr.	53·95	0·62	87 : 1
247.....	29·92	0·98	1·54	0·07	63·23	3·60	99·34	0·02	35·45	1·72	21 : 1
248.....	6·08	0·45	1·48	0·02	87·87	3·30	99·20	Tr.	49·22	1·58	31 : 1
249.....	8·30	0·85	1·17	0·04	87·93	1·60	99·89	0·03	49·26	0·76	65 : 1
250.....	9·72	0·39	0·49	Tr.	88·04	1·74	100·38	Tr.	49·30	0·83	59 : 1
251.....	13·69	1·62	2·41	0·04	51·87	28·64	98·27	0·08	29·08	13·69	2·12 : 1

241.	Bishop Crossing.	Flagstone quarries formerly worked on lot 15, range V, Dudswell township.
242.	Dominion Station.	Abandoned quarry on lot 13, range VI, Dudswell township.
243.	Lime Ridge.	Thinly bedded limestone in road cut ⅓ mile south of the village.
244.	"	Bottom level in quarry of Dominion Lime Co.
244A.	"	Southwest wall in same quarry.
244B.	"	Northern wall in same quarry.
244C.	"	Western wall in same quarry.
245.	"	Outcrops 600 yards north of the quarry of the Dominion Lime Co.
246.	Marbleton.	Deposit on lots 21 and 22, ranges VII and VIII, Dudswell township.
247.	"	Outcrops on lot 3, range VI, Weedon township, along the highway 4½ miles northeast of Marbleton.
248.	St. Gérard.	Abandoned quarry on lot 22, range VII, Weedon township.
249.	"	Abandoned quarry on lot 26, range VII, Weedon township.
250.	"	Outcrop on lot 3, range C, Garthby township.
251.	"	Outcrop on lot 22, range V, Stratford township.

LOWER ST. LAWRENCE AND GASPE PENINSULA

The Lower St. Lawrence-Gaspe area is to be understood as including the counties along the south shore of the St. Lawrence from Montmagny county northeastward and including the whole of the Gaspe peninsula. From Montmagny county to Rimouski county, limestone forms a very minor part of the rocks and only thin, lenticular, impure deposits are known to occur. From Rimouski county northeastward, however, limestone is much

more prominent. Large deposits of Silurian and Devonian limestone and small deposits of Carboniferous limestone occur along the south shore of the Gaspe peninsula, and large limestone deposits are also reported to occur in the central part where, however, they are inaccessible at present. Along the north side of the peninsula numerous thin lenticular deposits occur in the steeply dipping Cambrian and Ordovician strata. None of the deposits sampled in this area contains more than 6 per cent magnesium carbonate, and the majority contain less than 1 per cent. Some of the deposits are of a high degree of purity.

Along the south shore of the Gaspe peninsula several small quarries are worked, the products being stone for use in sulphite-pulp mills, agricultural limestone, and lime.

Near Rivière Blanche in Matane county a small deposit of calcium limestone is quarried for making lime for local use.

In the Matapedia valley, rough building stone and lime were formerly produced in several localities from impure Palaeozoic limestone but there has been no production in recent years.

Bonaventure County

Bonaventure county, situated on the south side of the Gaspe peninsula and including within its boundaries most of the north shore of Chaleur bay, is largely underlain by Silurian and Devonian strata which include much limestone, apparently all of the calcium and high-calcium varieties. Along much of the sea coast, and extending inland for 1 to 4 miles, a fringe of Carboniferous conglomerate, containing no limestone of economic value, overlies the Silurian and Devonian strata, but at Black Cape and on the shore in the vicinities of Port Daniel and Gascons this mantle of conglomerate is absent and the Silurian limestones are available on tidewater. The interior of the county is mountainous and uninhabited and the limestone resources of the interior are not at present available.

For a number of years limestone for use in pulp mills has been quarried at Port Daniel and at Gascons. In 1933, two quarries to supply stone to pulp mills in northern New Brunswick were opened near Nouvelle. Smaller quarries have also been worked at several places to obtain limestone for agricultural use, and many years ago stone for local construction and for making into lime to supply the small local demand was quarried from a number of the deposits adjacent to the sea coast. Some of the more highly coloured limestones have attracted attention as being possible sources of marble but, though much of the stone is beautifully coloured, the deposits in general are too badly fractured to yield a high proportion of sound, rectangular blocks.

Deposits of marl are also abundant in this county and the Quebec Bureau of Mines[1] reports that in 1931 and immediately preceding years, 23 deposits had been worked for marl for agricultural purposes, the total recorded production up to that time being 64,295 tons.

[1] Ann. Rept. for 1931, pt. A, pp. 59-60.

Figure 13. Map of Gaspe peninsula showing location of limestone deposits sampled.

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Matapedia-Millstream

Impure, dense-textured, nearly black limestone, generally in steeply dipping beds, is exposed at intervals along the Canadian National railway in the Matapedia valley from Matapedia to beyond Millstream. In most exposures the stone is thin-bedded with partings of dark grey, calcareous shale between the beds, and faults and folds are numerous. On weathering the stone turns brownish grey on the surface and much of it disintegrates to a shaly mass. Many years ago small quantities were quarried for lime burning and for use as local building stone. Sample 257 was taken from the thinly bedded limestone exposed in the railway-cut on the northern outskirts of Matapedia village. In many of the exposures along the valley the limestone is much more impure than this.

Escuminac

On the property of Leslie Edwards on the west side of the Escuminac river, 1½ miles above Escuminac village, a small quarry was worked many years ago to obtain stone with which to construct bridge piers on the Quebec Central railway, now known as the Gaspe branch of the Canadian National railway. The limestone is exposed in beds of variable thickness striking N. 80° W. for about 1 mile along the south side of a ridge and dipping southerly at an angle of 80 degrees. Trap rock occurs north of the limestone ridge and several tongues of the trap rock are to be seen in the limestone. All the limestone is fine-grained, brown-grey in colour, and impure. Scattered all through it are fragments of sandstone and shale, some of which are 3 inches in diameter. Sand grains are also to be seen in much of the stone. Sample 258 is representative of the limestone in the quarry.

Nouvelle

One mile northeast of Nouvelle, or 2½ miles by road, grey, fine-grained, unevenly bedded, high-calcium limestone, striking N. 15° E. and dipping northwesterly at an angle of 70 degrees is exposed in a high ridge extending along the St. Laurent road for about ½ mile. Samples 259 and 259A were taken from outcrops across the ridge in two places and each sample represents about 50 feet of strata. Two quarries adjoining each other have recently been opened in this deposit to supply limestone for use in pulp mills in northern New Brunswick. One quarry is operated by *Messrs. LeClerc & Day* and the other by *H. Z. Arsenault*. An average of a number of analyses made on stone from these quarries by the New Brunswick International Paper Company, Dalhousie, and by the Bathurst Power and Paper Company, is as follows:

	Per cent
Silica and insoluble	0·86
Oxides of iron and alumina	0·81
Calcium oxide	54·72
Magnesium oxide	0·27
Loss on ignition	42·67
	99·33

The stone is hauled by motor truck to Nouvelle and shipped from there by rail.

St. Jules

At St. Jules in the valley of Cascapedia river, 1¾ miles above the bridge on the Gaspe highway, the local Agricultural Co-operative Society operates a small quarry for the production of agricultural limestone. The quarry is opened in a lens of somewhat sandy and shaly conglomeratic Carboniferous limestone, containing many fragments of sandstone, occurring in a ridge largely composed of sandstone and red calcareous conglomerate. The general strike of the strata in the vicinity is northeast-southwest and the prevailing dip is to the southeast at an angle of 12 degrees. The limestone is pulverized in a Type K, Tarvin Pulverizer run by waterpower and having a capacity of 2½ tons per hour. Sample 260 was taken from the stock of pulverized stone.

Other deposits of limestone said to be of better grade are reported to occur farther up Cascapedia river.

Black Cape

Silurian limestones, shales, and sandstones, generally dipping steeply to the southeast, are exposed on the shore of Chaleur bay for 1½ miles west of Black Cape, which itself is composed of volcanic rock. From Black Cape eastward, nearly to Port Daniel bay, red Carboniferous conglomerate overlies the Silurian strata for 2 to 3 miles back from the coast. North of the conglomerate, however, the steeply dipping, Silurian strata are again exposed and limestones are available at many places.

One and one-half miles west of Black Cape, steeply dipping, dense-textured Silurian limestone is exposed in a cutting on the Gaspe branch of the Canadian National railway. Most of it is blue-grey and shaly, but included in the exposure are some bands of thinly bedded, brownish grey, calcium limestone, much veined with light brown calcite and nearly free from shale. Sample 261 was taken from a band of the latter type of limestone 20 feet in thickness. The stone in the remainder of the exposure is much more impure than this.

On the property of J. C. Fear, at Black Cape, a short distance east of the above cutting and north of the railway, a small quarry was opened in a band of impure, blue-grey, Silurian limestone to obtain stone with which to build culverts when the railway in this district was being constructed. The limestone seen in the quarry is heavily bedded, but all through it is a network of shale seams. The beds strike N. 75° W. and dip to the southwest at an angle of 65 degrees. Sample 262 was taken from the 15 feet of strata exposed in the quarry.

On the road going northerly from the Black Cape schoolhouse, Silurian limestone containing considerable red, sandy shale is exposed in a low ridge 0·4 mile north of the school. No sample was taken here.

One and three-quarter miles north of the school and just east of the above road, dense-textured, thinly bedded, dark grey, brown-weathering Silurian limestone was at one time quarried to a small extent on the property of Norman McNair for the making of lime. The limestone contains about 8 per cent of impurities as shown by the analysis of Sample 263 which was taken from the pit and from the neighbouring outcrops.

New Carlisle

Dense-textured, blue-grey Silurian calcium limestone, in which are a great many thin veins of white calcite, is exposed on the property of John Imhoff, 4 miles by road north of New Carlisle. The stone is considerably fractured and occurs in a low ridge trending northeast-southwest. Sample 264 consisted of fragments taken at intervals across 100 feet of strata exposed in the ridge. The analysis of this sample indicates that the stone is a high-calcium limestone containing only slightly over 2 per cent total impurities. Overburden is light over a large area underlain by this limestone and the deposit could be easily quarried, but the haul of 4 miles to the nearest shipping point by rail or by water places the deposit at a disadvantage compared with more readily accessible deposits along the Gaspe coast.

St. Godfroy

High-calcium limestone of Silurian age is also exposed in a gully that cuts through a high ridge, 3½ miles north of St. Godfroy. The limestone is dense-textured, dark blue, and much of it is plentifully veined with white calcite. It occurs in vertically dipping strata that trend N. 65° E. On the south edge of the exposure the limestone is seen to be in contact with a sandstone, and is slightly less pure than the remainder and also has a reddish tint. Sample 265 represents the blue limestone and Sample 265A the red limestone near the sandstone.

Since field work in this district was completed, a small quarry has been opened by *Cercle Agricole de St-Godfroy* to obtain limestone for agricultural use. A pulverizing plant with a capacity of 3 tons per day is operated in connection with the quarry.

Marcil

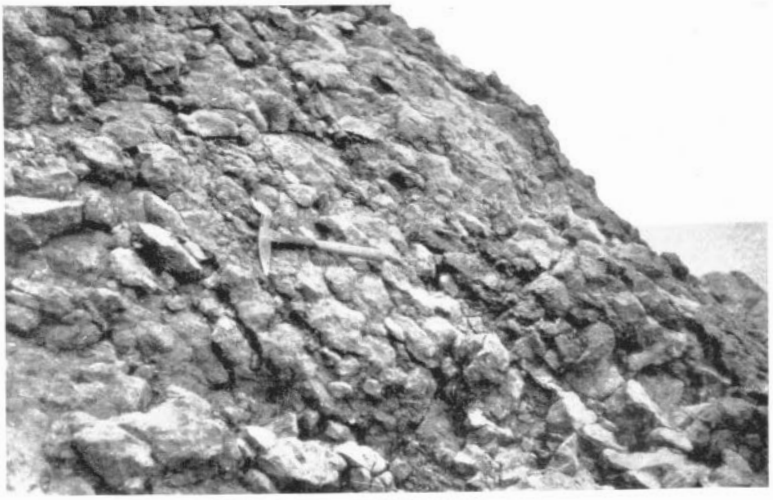
Beginning at a point 1¼ miles back from the shore of Chaleur bay, on the farm of William MacPherson, brownish grey and reddish grey, high-calcium, Silurian limestone is exposed along the crest of a low ridge extending for 2 miles westward parallel to the shore. On the MacPherson property the limestone strikes N. 80° E. and dips steeply to the south. The stone is all fine-grained to dense in texture and occurs in beds of various thicknesses, in some of which are veins of white and brownish calcite. Sample 266 was taken across 200 feet of the limestone exposed on the south side of a low, wooded hill on which the overburden is very light. The Gaspe branch of the Canadian National railway passes but a short distance to the north.

Port Daniel West

From West point at the entrance to Port Daniel bay, steep cliffs of Silurian limestone, in places 300 feet high, extend southwesterly along the coast of Chaleur bay for 1½ miles. The highest elevations are adjacent to the shore, and from the summit of the cliffs the land slopes gently downwards to a valley 1 mile or so inland. The strata composing the cliffs dip seaward at an angle of about 60 degrees, and the average strike (N. 80° W.) is such that, provided there is no faulting or folding, the strata exposed on West point will be found at some distance inland at

PLATE XXXV

A. Quarry formerly worked by Bathurst Power and Paper Company in Silurian limestone at Port Daniel, Bonaventure county.



B. Rubbly Silurian limestone exposed along the sea coast, 800 yards west of West point near Port Daniel.

the western end of the cliffs. All the limestone is fine-grained to dense in texture and is characterized by a low content of magnesium carbonate, but there is a considerable variation in appearance and in purity, as is indicated below.

At West point the limestone is predominantly dark grey, faintly tinted with violet, and occurs in thin beds having a nodular structure (Plate XXXVB, page 254). The limestone band is here about 250 feet in width and on the landward side it is in contact with sandstone. Formerly a small quarry was worked on West point from which limestone was obtained for making lime in local kilns and for shipment to Prince Edward Island. Sample 267 was taken from the strata exposed in the quarry and neighbouring outcrops.

Southwesterly along the shore the same general type of limestone is exposed in cliffs that increase in height in this direction. Sample 268 was taken about 800 yards from West point, from the dark grey, nodular limestone composing the greater part of the cliffs. Beyond this, beds of sandstone and shaly limestone occur interstratified with the high-grade limestone at the water's edge.

The cliffs attain their greatest elevation—300 feet—about 1½ miles southwest of West point, and from there to the southwest they decrease rapidly in height. At the southwest end of the cliffs, exposures of pinkish, fine-grained limestone, much of which contains thin films of red shale, are to be seen for a distance of 700 yards inland from the summit of the cliffs. Sample 269 consisted of chips taken from numerous outcrops on the landward slope. At the summit of the cliffs much of the limestone is reddish in colour and contains more films of red shale than does that on the landward slope. Sample 270 represents the red stone. On the seaward face most of the limestone is medium-grained and is composed largely of fragments of crinoid stems, and also contains occasional fragments of shale and sandstone. Though the matrix of this fossiliferous limestone is nearly white, brick-red shaly material coats most of the fossil fragments and is also distributed in sufficient quantity through the stone to give it all a reddish tint. Some very sandy and shaly beds of limestone are also present in this locality. Sample 270A represents the medium-grained, crinoidal limestone.

Port Daniel

North of the village, Silurian limestone is exposed on the west side of Port Daniel river for ¾ mile and on the east side for 1½ miles above the village. It is all fine-grained, thin-bedded, hard, and rather siliceous, silicified fossils being common, and is mostly dark grey in colour with purplish tints. Sample 271 was taken from 20 feet of strata exposed on a hill top on the west side of the river ¾ mile north of the village, and the analysis may be taken as representative of most of the limestone in the immediate vicinity.

At the head of Port Daniel bay just east of the mouth of Port Daniel river a prominent ridge of Silurian limestone, which can be traced from Gascons to here, terminates on the shore in a cliff, and a cross-section of the steeply dipping strata composing the ridge is exposed for 450 yards along the shore. The strike is N. 40° E. and the dip is to the southeast at

angles varying from 60 degrees to nearly vertical. Much of the limestone in the cliff is sandy and shaly but at about the centre of the section is a series of beds of fine- to coarse-grained, relatively pure, pinkish, fossiliferous limestone aggregating 150 feet in thickness that includes only a few beds and masses of sandy and shaly limestone. At this place a quarry (Plate XXXVA) was worked until recently to supply limestone to the pulp mill of the Bathurst Power and Paper Company at Bathurst, N.B. A face 150 feet long and 125 feet high was worked, and the stone was loaded on scows for transportation to Bathurst. The analysis of Sample 272 shows the quality of stone that can be obtained from the quarry after the interbedded, impure stone has been cobbed out. A short distance inland the sandy and shaly strata observed along the sea front are much less in evidence, and the limestone seen in the walls of the tunnel on the Gaspe branch of the Canadian National railway, which passes through the limestone ridge, is of uniformly good quality.

On the point at the eastern entrance of Port Daniel bay, steeply dipping beds of Silurian limestone project through the mantle of red, Carboniferous conglomerate.

A little more than a mile east of Port Daniel river, the highway to Gaspe passes over the same ridge of Silurian limestone that terminates on Port Daniel bay. Along the highway the limestone is exposed for 300 yards almost at right angles to the strike which is N. 40° E. The angle of dip varies from vertical to 70 degrees to the southeast. On the lower slopes of the ridge, both on the east and west sides, the limestone is impure, thin-bedded, and contains interbeds of shale and sandy limestone, but in the central part of the ridge is a thickness of 600 feet of strata nearly free from shale and sandstone. This purer stone contains many fossil fragments. On the west side of the ridge many of the purer strata are red and reddish grey, streaked and blotched with white calcite and are mostly fine-grained, but toward the top the limestone becomes light grey and medium-grained. On the east slope the purer stone is mostly fine-grained and is of tan and reddish grey colours. Sample 273 was taken from outcrops of reddish stone on the western flank of the ridge over a distance of 100 yards at right angles to the stratification. Sample 273A represents the light grey strata and also some of the reddish and tan strata on the crown and eastern slope of the ridge.

Eastward from here the strike of the strata changes from northeast to easterly and the limestone is exposed on the north side of and parallel to the highway to beyond Gascons.

McInnes Cove

Nodular, shaly, reddish limestone strata striking S. 75° E. and dipping southerly at an angle of 60 degrees are exposed along the shore of McInnes cove on Chaleur bay, east of Port Daniel bay. A short distance inland on higher ground and close by the railway, exposures of calcium limestone of much better quality are visible, and this stone has been quarried in small quantity for local use, chiefly for making lime and agricultural limestone.

Gascons

A great deal of Silurian limestone is exposed in the vicinity of Gascons, both in cliffs along the sea coast and in a ridge north of the railway.

Gaspesian Fertilizer Company, Port Daniel. This company produces pulverized limestone for agricultural purposes and also limestone for use in the manufacture of sulphite pulp. The quarry is near the top of, and at the east end of a ridge of limestone a short distance back from the sea coast west of Gascons (Plate XXXVI B, page 258). The strata composing the ridge dip northerly at a low angle. The top 75 feet consists of very fine-grained, indistinctly bedded, fossiliferous, high-calcium limestone, beneath which is calcium limestone containing films of red shale and lenses of sandstone, and beneath this again is sandy limestone containing silicified fossils. Along the sea coast sandstone is exposed. The quarry is opened near the top of the ridge on the east side of a small gully, and consists of an excavation 10 to 18 feet deep that extends for 200 feet up the side of the ridge. The floor slopes at an angle of 30 degrees, which corresponds to the slope of the hillside. The downhill end of the quarry is in reddish grey limestone containing films of red shale and patches of red sandstone, but the upper part, which is now being worked, is in the light-coloured, high-calcium limestone. Sample 274 represents the pure stone at the upper end of the quarry and Sample 274A the reddish limestone, exclusive of sandstone lenses, at the lower end.

A steam piston drill on tripod mounting is used in quarrying. The quarried stone is taken to a railway spur, at the foot of the ridge, in small cars running on an inclined tramway, the two cars in use being connected by a wire cable wound around a drum at the quarry so that the loaded car in descending pulls up the empty one.

Southeast of the village of Gascons, Silurian limestone is exposed in a cliff which extends along the shore for nearly a mile and which in places is well over 200 feet in height. At both ends shaly and sandy strata are present in the limestone and, on the whole, the limestone is not so pure as that in the vicinity of the quarry of the Gaspesian Fertilizer Company. At the eastern end of the cliffs the strata strike east and west and dip at an angle of 60 degrees to the south. The limestone is reddish grey in colour, fine-grained and, in places, is largely composed of fossil fragments and contains many veinlets of white calcite. The bedding is massive, but all the stone is much fractured. Sample 275 represents a thickness of about 100 feet of strata exposed in a gully near the eastern end of the cliff. Many of the individual beds are much more pure than this. At the western end of the cliff there is considerable variation in the strike and dip of the strata and, also, the beds are much thinner and the stone is less highly coloured, being more of a grey with faint pinkish tints. Sample 276 represents the top 60 feet of strata exposed in a cliff over 200 feet in height.

North of Gascons, about 500 yards from the railway, purplish grey, thin-bedded Silurian limestone, veined to a slight extent with white calcite and in places containing films of red shale, is exposed on the south side of a ridge rising to a height of 200 feet above the railway. The general

PLATE XXXVI

A. Impure Silurian limestone, laminated with red shale, as exposed on the coast east of Port Daniel.

B. Part of the quarry of the Gaspesian Fertilizer Company, in Silurian limestone at Gascons, Bonaventure county.

strike of the strata is N.40°W. and the dip is southerly at angles ranging from 40 to 70 degrees. Sample 277 was taken from outcrops on the south slope of the ridge over a distance of 500 feet across the strike, but there are many soil-covered areas between the outcrops, and thus the sample is not representative of all the stone in the ridge. The ridge extends for a long distance in both directions from where it was sampled, but toward the east the limestone becomes more impure.

Two miles east of Gascons, thinly and unevenly bedded limestone with much interbedded shale is exposed in cuttings along the railway (Gaspe branch, Canadian National railway) and also on the shore of Chaleur bay. The dip and strike of the strata vary widely in the various exposures, but in general the dip is steep. Silicified coral fragments are prominent throughout much of the limestone. Sample 278 represents the better quality of limestone, exclusive of interbedded shale, exposed for 100 feet in the railway cutting 700 feet east of where the highway crosses.

Analyses of Bonaventure County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
257	22·60	2·16	4·82	0·17	63·73	5·76	99·24	0·17	35·78	2·75	13 : 1
258	12·20	1·22	3·02	0·07	81·27	1·01	98·79	Nil	45·55	0·48	95 : 1
259	0·50	0·38	0·08	0·02	98·70	0·44	100·12	Nil	55·28	0·21	263 : 1
259A	1·08	0·18	0·46	0·02	97·66	0·59	99·99	Nil	54·70	0·28	195 : 1
260	10·42	0·47	0·51	0·09	83·48	5·38	100·35	Nil	46·80	2·57	18 : 1
261	2·88	0·67	0·73	0·11	95·09	0·46	99·94	0·01	53·31	0·22	242 : 1
262	11·00	1·37	3·33	0·11	81·76	1·87	99·44	0·04	45·84	0·89	50 : 1
263	6·14	0·87	1·53	0·02	89·45	1·37	99·38	0·23	50·10	0·65	77 : 1
264	1·58	0·27	0·27	Tr.	96·95	0·42	99·49	Nil	54·29	0·20	271 : 1
265	1·80	0·45	0·63	Tr.	96·14	0·59	99·61	Tr.	53·84	0·28	192 : 1
265A	2·22	0·78	0·17	0·02	95·57	0·52	99·28	0·06	53·53	0·25	214 : 1
266	2·48	0·41	0·71	Tr.	94·45	1·03	99·08	Tr.	52·89	0·49	108 : 1
267	2·22	0·87	0·25	0·02	95·48	0·82	99·66	Tr.	53·48	0·39	137 : 1
268	1·04	0·26	0·16	0·11	97·25	0·65	99·47	Nil	54·52	0·31	176 : 1
269	3·28	0·49	1·11	0·07	93·64	0·88	99·47	Tr.	52·47	0·42	125 : 1
270	4·36	0·49	1·17	0·07	92·89	0·88	99·86	Tr.	52·06	0·42	124 : 1
270A	2·78	0·36	0·76	0·02	95·27	0·59	99·78	Nil	53·36	0·28	190 : 1
271	4·30	0·46	1·16	0·02	93·66	0·71	100·31	Tr.	52·46	0·34	154 : 1
272	1·86	0·54	0·18	0·04	96·50	0·59	99·71	Tr.	54·03	0·28	193 : 1
273	6·44	0·64	0·74	0·04	90·64	0·92	99·42	Nil	50·78	0·44	115 : 1
273A	3·02	0·53	0·33	0·02	95·13	0·46	99·49	Tr.	53·28	0·22	242 : 1
274	1·00	0·29	0·23	0·02	97·98	0·53	100·05	Nil	54·88	0·25	219 : 1
274A	2·46	0·73	0·09	0·15	95·70	0·46	99·59	Nil	53·67	0·22	244 : 1
275	6·36	0·60	0·92	0·02	91·07	0·82	99·79	Tr.	51·01	0·39	131 : 1
276	3·44	0·44	0·92	0·13	92·48	1·76	99·17	Tr.	51·86	0·84	62 : 1
277	2·40	0·43	0·63	0·04	95·48	0·88	99·86	0·08	53·49	0·42	127 : 1
278	4·10	0·62	1·74	0·02	91·96	0·63	99·07	Nil	51·51	0·30	172 : 1

257.	Matapedia.	Railway-cut on northern outskirts of the village.
258.	Escuminac.	Quarry on land of Leslie Edwards.
259.	Nouvelle.	Outcrops in ridge now quarried by H. Z. Arsenault and by LeClerc and Day.
259A.	"	Same locality as the above.
260.	St. Jules.	Pulverized limestone from quarry worked by the local agricultural co-operative society.
261.	Black Cape.	Cutting on C.N.R. 1½ miles west of the cape.
262.	"	Quarry on property of J. C. Fear.
263.	"	Quarry on property of Norman McNair.

264.	New Carlisle.	Property of John Imhoff.
265.	St. Godfroy.	Blue limestone in ridge 3½ miles north of the village.
265A.	"	Red limestone in same ridge.
266.	Marcil.	Property of Wm. MacPherson.
267.	Port Daniel West.	Quarry and outcrops on West point.
268.	"	Cliff 800 yards southwest of West point.
269.	"	Outcrops in field near shore, 1½ miles southwest of West point.
270.	"	Red limestone at top of cliff in above locality.
270A.	"	Crinoidal limestone on sea face of cliff at same locality.
271.	Port Daniel.	West side of Port Daniel river ¾ mile above village.
272.	"	Hand-picked stone from quarry formerly worked by Bathurst Power & Paper Co.
273.	"	West flank of ridge on road to Gaspe, 1 mile east of Port Daniel river.
273A.	"	Strata on top and east side of same ridge.
274.	Gascons.	Pure limestone in upper end of quarry of the Gaspesian Fertilizer Company.
274A.	"	Red limestone in lower end of same quarry.
275.	"	Near east end of cliff on the shore southeast of the village.
276.	"	West end of same cliff 1 mile from where Sample 275 was taken.
277.	"	Ridge north of Gascons and 500 yards from the railway.
278.	"	Best quality limestone in railway-cutting 2 miles east of Gascons.

Gaspe County

Gaspe county comprises the tip of the Gaspe peninsula which extends between the St. Lawrence river and Chaleur bay. The interior of the county is mountainous and densely wooded, and settlements are found only along the coast and in the lower valleys of the larger rivers. Ordovician and Devonian limestones are known to be abundant in the vicinities of Percé and Gaspe bay and also in the interior of the county, but aside from a very small production for local use, chiefly for the making of lime, no quarries have been worked and there is little prospective demand for limestone in this area at the present time. The only deposits examined in connection with the present report were those in the vicinity of Percé. So far as known, only calcium limestones occur in this county.

White Head

A nearly vertical band of Ordovician[1] calcium limestone forming a prominent ridge strikes inland at N. 35° W. from the tip of White head (a headland on the eastern end of the Gaspe peninsula, 2 miles south of Percé) across the Gaspe highway and the Irishtown road to the eastern side of White mountain, 2 miles distant, and may extend much farther. Near the coast the lower flanks of the ridge are overlain by red conglomerate of Carboniferous age, but in the part of the ridge above the conglomerate a thickness of 800 feet of thinly bedded limestone is exposed. The central 500 feet of strata, composing the highest part of the ridge, consists of dense-textured, brownish grey calcium limestone containing about 6 per cent total impurities, but on both sides the limestone is much more impure, that on the north side containing a great deal of pinkish chert and that on the south side being very shaly. Three samples were taken from this central zone at a point 350 yards inland from the Gaspe highway—No. 279 from 200 feet of strata on the crown of the ridge; No. 279A from 150 feet of strata adjoining this to the south; and No. 279B from 100 feet of strata just north of the

[1] This limestone was formerly believed to be of Devonian age but as stated in a joint paper by Charles Schuchert and G. A. Cooper, published in vol. 20 of the American Journal of Science, it has now been proved to be of Ordovician age.

crown of the ridge. Limestone of the composition shown by the analyses of these samples could easily be quarried from the ridge, but it is nearly 4 miles to the nearest shipping point on the Gaspe branch of the Canadian National railway. In several places along the ridge small amounts of stone have been quarried in the past for making lime for local use.

Little River

Southwest of White head a small exposure of Carboniferous limestone is seen on the west side of and near the mouth of Little river. The limestone is dipping nearly vertically, is shaly, dense-textured and, when fresh, is blue-grey in colour but it weathers deeply to a brown shade. Though some of the beds may be fairly pure, on the whole the deposit is very argillaceous and it is apparently of small extent.

Percé

The striking scenic feature known as Percé Rock and the picturesque cliffs known as the Murailles are composed of Devonian limestone, much of which is tinted with various shades of brown, red, and purple.

F. J. Alcock of the Geological Survey of Canada, states in a personal communication to the writer, that beginning about 2 miles west of Mal Baie, between Malbaie river and Portage brook, a wide belt of Devonian limestone similar to that composing the Murailles extends westerly into the mountainous interior for several miles.

Gaspe Bay

A generalized description of the limestones that compose the long promontory of Gaspe cape and extend northwesterly therefrom, parallel to and at some distance inland from the north shore of Gaspe bay to Dartmouth river, is given on pages 390-394 of the Geology of Canada (1863). In this description it is stated that most of the limestone in this great belt, the total thickness of which is estimated at about 2,000 feet, is argillaceous and otherwise impure, though at two horizons are beds of limestone suitable for the making of lime. All is thin-bedded and the prevailing dip is to the southwest at an angle of 24 degrees. In places nodules of chert are plentiful.

On the opposite side of Gaspe bay limestone is reported to occur in several places northwest of Gaspe village.

Lemieux Township

In this township, which is at the western edge of Gaspe county, about 25 miles south of the St. Lawrence river, occurrences of Lower Devonian and Silurian limestones are referred to by Alcock[1] as follows: "Limestone occurs associated with shales and slates north of Ste. Anne river. On one of the northern tributaries of the Ste. Anne several exposures of massive grey limestone are traversed by many calcite stringers but no structural planes

[1] Alcock, F. J.: Mem. 144, Geol. Surv., Canada, p. 29 (1926).

were observed nor could the thickness of the bands be determined." The lead and zinc deposits of this area occur in the Lower Devonian limestones and shales.

Analyses of Gaspe County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
279.....	3·96	0·45	0·23	0·02	92·14	2·10	98·90	0·02	51·61	1·00	52 : 1
279A.....	4·12	0·85	0·99	0·04	91·66	1·51	99·17	0·03	51·35	0·72	71 : 1
279B.....	5·22	0·56	1·52	0·09	90·39	1·95	99·73	0·08	50·67	0·93	54 : 1

279. White head. Sample of 200 feet of strata on the crown of the ridge of limestone that strikes inland from the cape. The sample was taken at a place 350 yards inland from the Gaspe highway.

279A. " Sample of 150 feet of strata adjoining the above on the south slope of the ridge.

279B. " Sample of 100 feet of strata adjoining No. 279 on the north side of the ridge.

L'Islet County

Ells[1] gives the following information regarding limestone occurrences in this county.

. . . . . ." At L'Islet wharf, the associated sandstones contain an interstratified bed of fine limestone conglomerate four to ten feet thick, with small pebbles of limestone and quartz, which shades off into grit.". . . . . .

At the wharf at St. Jean Port Joli, thin beds of hard grey limestone are interstratified with red and green shales.

At St. Roch des Aulnais, bands of greyish limestone associated with black and green shales are repeated at intervals for 1½ miles along the shore.

Matane County

Numerous thin beds and lenses of limestone and dolomite are reported to occur interstratified in the great series of Ordovician and Cambrian (?) shales, sandstone, and conglomerates that underlies that part of the county bordering on the St. Lawrence river. In the Geological Survey Report of Progress, 1876-77, p. 487, the following analysis is given of a very fine-grained, light brownish grey dolomite, veined with calcite, found at Little Métis:—

	Per cent
Carbonate of lime.....	35·46
Carbonate of magnesia.....	26·40
Carbonate of iron.....	4·67
Insoluble matter.....	35·46
	98·72

It will be observed that either the analysis has been wrongly totalled or that a mistake has been made in recording the percentage of one of the constituents, but in any case the dolomite is very impure.

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., Vol. III, pt. 2, p. 67K (1887-88).

Rivière Blanche

Quarry of Octave Gagné, St. Ulric. The following information on this property, which is 2 miles southeast of Rivière Blanche station on the Canadian National railway, was supplied by L. H. Cole, of the Mines Branch, who kindly examined and sampled the quarry at the request of the writer. The quarry is opened on the north side of a gently sloping hill on which a few outcrops of limestone, striking a little west of north and dipping at an angle of 30 degrees to the east, are visible. The limestone is fine-grained, dark grey in colour, and occurs in beds 8 to 16 inches thick interstratified with an equal thickness of shale. Occasional beds of sandstone and limestone conglomerate also occur. In 1934, the quarry was 20 feet in width and was being extended into the hillside along the strike of the strata and a depth of 8 feet of limestone was exposed. Limestone for making lime and for crushing for agricultural use is sorted by hand from the shale. Sample 255 is representative of the limestone used for these purposes.

The lime kiln is a small field kiln lined with firebrick and having a capacity of 5 tons of lime at each burning. Agricultural limestone is made in a small crushing plant.

Analysis of Matane County Limestone

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
255.....	2·82	0·80	0·74	0·13	93·02	1·80	99·31	0·33	52·16	0·86	61 : 1

255. Rivière Blanche. Quarry of Octave Gagné, 2 miles southeast of the village.

Matapedia County

In this county Palæozoic limestone is found on the south shore of lake Matapedia and also along the valley of the Matapedia river, but all seen was impure. Small quarries were formerly worked near Val Brillant and Causapscal, chiefly to obtain stone for construction when the railway in this district was being built. A small quantity of lime for local use has also been made from this stone. The county is largely underlain by strata of Palæozoic age, and it is probable that other limestone deposits occur in places farther removed from the railway, but it is unlikely that any of them are of a high degree of purity.

Val Brillant

One mile northwest of Val Brillant two small quarries have been opened about 300 yards south of lake Matapedia along the edge of a low escarpment of limestone. The escarpment at this place rises about 20 feet above the lake, and limestone strata, striking N. 65° W. and dipping to the

southwest at an angle of 5 degrees, are exposed on both sides of the highway, which is on top of the escarpment. The quarries were opened about 1875, according to residents of the locality, to obtain stone for the building of bridges and culverts on the Intercolonial railway (Canadian National railway). Since this work was finished there has been an occasional small production of building stone for use in the locality and also of stone for making into lime to supply a local demand. The stone available is a fine-grained, hard, dark brownish grey, impure calcium limestone containing thin beds of dark brown shale, which on weathering turn to a greenish shade, whereas the weathered surface of the limestone is light grey. The deposit is naturally heavily bedded, but on exposure the stone tends to split along the shale seams. In the quarry on the land of Octave Héon, 15 feet of limestone is exposed beneath 2 to 5 feet of soil. At the bottom of the face is very siliceous limestone, and two bands of similar stone each about 5 inches thick are to be seen near the top of the face. Sample 256 represents the entire face and Sample 256A the better grade of stone exclusive of the siliceous bands. For the past several years there has been no production from this district.

Causapscal

Impure, thin-bedded, dark grey calcium limestone is exposed 1½ miles north of Causapscal where it has been quarried to a small extent, chiefly for foundation stone. On exposure it weathers to an unattractive yellowish brown. It is much too impure for chemical or metallurgical purposes.

Analyses of Matapedia County Limestones

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO	Ratio of CaO to MgO
256.....	14·26	0·97	3·39	0·02	78·53	1·12	98·29	0·12	43·99	0·54	81 : 1
256A.....	6·82	0·23	2·23	0·02	90·05	0·90	100·25	0·10	50·44	0·43	117 : 1

256. Val Brillant. Entire face of 15 feet of limestone in old quarry on land of Octave Héon.
256A. " Better grade stone available in the same quarry.

Rimouski County

All known deposits of limestone in this county are very siliceous and otherwise impure. An escarpment, composed largely of siliceous Palæozoic limestone and of sandstone, extends for 20 miles in a westerly direction from the village of St. Gabriel to Rimouski river. Near Ste. Blandine this escarpment is about 6 miles south of the Canadian National railway and near St. Gabriel it is 11 miles south. The following extract concerning the

limestone in this escarpment is taken from the report of Messrs. Bailey and McInnes.[1]

Near the eastern extremity of the settlement of St. Gabriel and about ½ mile from where the Rouge stream is crossed by the Taché road are beds of sandstone dipping S.25°W < 20° and directly overlain by beds of dark blue limestone forming together a series of low bluffs along the road leading around the eastern extremity of Mount Commis. The limestones contain fossils, but they are neither so abundant nor so well preserved as where the same beds come out a few miles to the westward, at the falls of the Big Neigette River. This fall, about 100 feet in height, and the very similar one of the Little Neigette, 70 feet, result from the singular abruptness with which the Silurian rocks terminate along their northern edge, forming an escarpment which constitutes a prominent feature in the landscape, and which is partly continuous with Mount Commis, and extends thence and to the westward for a distance of 20 miles, terminating in the ridge of the Bois Brûle, near Ste. Blandine. . . . The limestones are, to some extent, burnt for lime, but are not well suited for the purpose, being quite siliceous and impure. Their dip is S.80°W. at from 1 to 20 degrees.

In the Geology of Canada (1863), page 419, it is stated that this limestone belt appears to strike southerly from the Rimouski river towards lake Temiscouata in Temiscouata county.

The county is entirely underlain by Palæozoic rocks containing beds of impure limestone, and doubtless limestones occur in many localities other than those above-mentioned. A sample of fine-grained siliceous dolomite veined with pale pink secondary dolomite, said to have been taken from a deposit close to the Canadian National railway near Rimouski, was sent to the Mines Branch in 1933, but no further information on the deposit could be obtained.

Temiscouata County

This county, as are Rimouski and Matapedia counties, is underlain by Palæozoic rocks consisting in part of limestone, but no limestone of a high degree of purity is known to occur. In the Geology of Canada (1863), page 421, mention is made of the occurrence of limestone associated with sandstone on mount Wissick, or mount Lennox, on the northeast side of lake Temiscouata. Judging from this description the limestone is mostly, if not all, impure, and furthermore it is not easily accessible. On the northwest side of the lake, just above Sandy point, flaggy limestone interstratified with sandstone is exposed.[2]

[1] Bailey, L. W., McInnes, Wm.: Geol. Surv., Canada, Ann. Rept. 1887-88, vol. III, pt. 2, p. 17M (1889).

[2] Geol. Surv., Canada, Ann. Report, 1890-91, vol. V, pt. I, p. 16M (1892).

SUMMARY

Quebec is abundantly supplied with resources of calcium limestone ranging from the pure high-calcium variety suitable for chemical purposes and for making lime, to the argillaceous type used in the manufacture of Portland cement. There are also large resources of impure dolomite and magnesian limestone, but pure dolomite is found only in scattered deposits of Precambrian age in the hilly country north of the Ottawa river. Among these Precambrian deposits in Argenteuil county are also some of the rare magnesitic dolomite, which consists of a mixture of magnesite and dolomite, and which is being quarried for the making of refractory materials.

The limestones are found principally in the southwestern part of the province near the large centres of population, but other areas occur at lake Timiskaming; lake St. John; Baie St. Paul; Murray Bay; Gaspe peninsula; and on Anticosti island and on the Mingan islands in the Gulf of St. Lawrence.

Deposits of Precambrian, Cambrian, Ordovician, Silurian, Devonian, and Carboniferous ages are available, with the greater part of the production coming from the Ordovician.

The principal quarry centres are at Hull, Kilmar, Montreal, Joliette, St. Marc des Carrières, Quebec city, and Chateau Richer in the territory north of the St. Lawrence river; and south of the river the principal quarry centres are at Philipsburg, Bedford, and Lime Ridge in the Eastern Townships, and near Nouvelle in the Gaspe peninsula. In addition, small quarries are worked in many other places.

The products of the numerous quarries include road metal, concrete aggregate, railway ballast, stone for the manufacture of Portland cement, stone for use in chemical processes (notably for the manufacture of calcium carbide, glass, and sulphite pulp), building stone, marble, stone for making lime, agricultural limestone, stone for refractory products, flux, asphalt filler, terrazzo, stucco dash, poultry grit, stone for making whiting substitute, chips for making artificial stone, and a number of minor products.

The above list of products, though by no means complete, serves to show the importance of the limestone resources to the industrial activities of the province.

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