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DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN MCLEISH, DIRECTOR

Preliminary Report

on

The Limestones of Quebec and Ontario

BY

M. F. Goudge

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CONTENTS

ILLUSTRATIONS

Photographs

Drawings

THE LIMESTONES OF QUEBEC AND ONTARIO

INTRODUCTORY

In the summer of 1925 a start was made on an investigation of the limestone resources of Canada, the investigation to embrace the occurrences of limestone (including dolomite), the technology of quarrying and lime-burning, and the uses of lime and limestone in the various manufacturing industries.

The territory covered in Quebec during the field season was the Lake St. John region, the north shore of the St. Lawrence river, and that part of the province that lies south of the St. Lawrence river and west of Levis.

In Ontario the territory covered was all that part of the province south of a line from Kingston to Port McNicoll, and most of the province lying east of a line between Kingston and Pembroke.

The field methods employed were as follows: Conditions affecting quarrying were noted; the limestone as exposed in outcrops and in quarries was studied and a channel sample, or its equivalent, was obtained across the strata exposed and at right angles to the bedding. When a difference in physical appearance or in chemical composition (revealed by a test with acid) was noticed, samples of each type of stone were taken. The large samples obtained were crushed to a fineness of one-eighth inch, or less, in a laboratory-size Blake breaker. The crushed samples were cut down by means of a Jones sampler to about one pound in weight. The 1-pound samples were shipped to the Mines Branch laboratory at Ottawa where they were prepared for chemical analysis. Very few of these analyses are available at the time of writing this preliminary report.

Although the greater part of the field work in Quebec and Ontario has been finished, it will be two years and probably more before a final report on the limestones of these provinces can be made available for distribution. In view of this and because of the numerous requests received for information regarding the limestones it was deemed advisable to prepare a preliminary report to give a general idea of the distribution, composition, quality and uses of the limestones of these provinces. To accomplish this as briefly as possible it was found advisable to discuss the limestones primarily according to their geological formation rather than according to their geographical distribution; the latter method involving much repetition of descriptive matter and also the mentioning of individual outcrops and quarries. An index of counties at the end of the report will serve to show in what parts of the report the limestones of any county are described.

In this report the word " limestone," in accord with the common usage, is employed in a twofold sense: First in a general way to denote any rock (including dolomite) in which calcium carbonate is a prominent constituent. In this sense it is used only in the headings and in brief generalizations. Secondly, and commonly throughout the report, to indicate that calcium carbonate greatly predominates in the rock. In connexion with this second usage the adjectives " high-calcium " and " magnesian " are used to define more closely the type of limestone.

Acknowledgments

The present investigation into the economic value of the limestones of Canada could proceed only very slowly were it not for the published reports and geological maps of various writers, who have traversed the same areas, though in most cases with a different object in view. The reports mention the location of outcrops and quarries in the various limestone formations and give information respecting them. Thus the writer was able to map out his itinerary beforehand with the assurance that suitable sections of rock would be found in a certain locality and a great deal of time was saved that otherwise would have been spent in searching for outcrops. The maps showing the distribution of the limestone formations were of service in indicating, in conjunction with the reports, where samples from different horizons could be obtained, as well as in showing the large areas underlain by formations containing no limestone and where no time need be spent. Of the Geological Survey publications relating to southern Ontario and Quebec the reports and maps prepared by the late R. W. Ells, M. Y. Williams, and C. R. Stauffer, were repeatedly consulted. The report, "The Limestones of Ontario," by the late Dr. W. G. Miller, of the Ontario Department of Mines; the Mines Branch publications Nos. 100 and 279 of "The Building and Ornamental Stones of Canada," by W. A. Parks; and the preliminary reports by Howells Fréchette on the limestones of Quebec and Ontario published in the Mines Branch Summary Reports for 1915, 1916, and 1918 were also of the greatest assistance, and indebtedness to these writers is acknowledged.

The sketch maps accompanying this report and showing the approximate distribution of the principal limestone formations have been prepared from maps issued by the Geological Survey.

To the owners and managers of the various properties examined the writer's thanks are due for their willing co-operation and for the furnishing of valuable information.

J. A. O'Leary assisted in the field work and his energetic and efficient work aided very materially the progress of the investigation.

CHAPTER I

THE LIMESTONES OF QUEBEC

The province of Quebec is rich in resources of high-calcium limestone much of which is of the pure quality that is continually finding wider use both as stone and as lime in the manufacturing industries of the country.

The limestones occur principally in the southwestern part of the province with smaller areas in the vicinity of lake St. John, lake Timiskaming, and in the Gaspe peninsula. The soil is relatively thin over the greater part of the limestone areas and the stone is in many places exposed.

The principal quarrying activities are confined to the high-calcium limestones by reason of the fact that the magnesian limestones and dolomites in Quebec are either too impure for any use except as crushed stone or, as is the case with the crystalline dolomites, are more inaccessible. The annual value of the products from the Quebec limestones, including lime and the stone utilized in cement manufacture, is approximately $4,000,000.

Below is a table showing to what system and formation the limestones of Quebec belong. The limestones will be discussed in order commencing with the oldest or the Precambrian limestones.

System	Formation	Composition
Quaternary		Unconsolidated deposits.
Devonian		Very little limestone.
Silurian		Limestones and shales.
Ordovician	Lorraine	Shales
	Utica	"
	Trenton	Limestones
	Black River	"
	Lowville	"
	Chazy	"
	Beekmantown	"
Cambrian	Potsdam	Sandstones.
Precambrian	Grenville series	Crystalline limestones.

PRECAMBRIAN LIMESTONES

Grenville Series

The intensely metamorphosed sedimentary rocks known as the Grenville series which occur in the province of Quebec north of the Ottawa and St. Lawrence rivers, contain in many places areas of crystalline limestone. The limestones occur in belts that have a general northeast-southwest trend and vary in size from insignificant bands only a few feet in width, to areas that are several miles across and are traceable for many miles along their strike. They occur in the rugged upland country from the Black river, in Pontiac district, to St. Thécle in Champlain district, but they have their greatest development in Pontiac and Hull districts.

During the past season only a relatively small proportion of the crystalline limestone outcrops was closely examined but it is planned to spend more time on them during the season of 1926, as it is possible that workable deposits of high-grade dolomite may be discovered.

DESCRIPTION OF THE STONE

In the majority of outcrops examined the limestone was coarse-grained, soft, somewhat friable and greyish white to bluish white in colour. It generally weathers to a very dark grey. The impurities consist of inclusions of granite and gneiss, grains of quartz, tourmaline, pyrite, magnetite, feldspar, pyroxene, and many other minerals as well as flakes of mica and graphite and stringers of quartz. The impurities are sometimes in parallel planes but are generally disseminated throughout the limestone. These visible impurities are, in most cases, present in such quantity as to render the stone worthless for the manufacturing industries.

CHEMICAL COMPOSITION

The crystalline limestones of the Grenville series range in chemical composition from high-calcium limestone, through dolomite, to calcareous magnesite. The magnesite occurs in Grenville township, Argenteuil district, and the majority of the dolomite areas occur from there westward to Pontiac district. As a rule the crystalline dolomites are freer from impurities than are the high-calcium limestones but even they are frequently spoiled by the presence of quartz stringers and siliceous layers.

The magnesite deposits have been fully discussed by M. E. Wilson and for information on that subject the reader is referred to his report.[1]

The following analyses are representative of the better quality of crystalline limestones.

Analyses of Grenville Limestones

—	1	2	3	4	5
Insoluble mineral matter	2·08	4·46	1·84	3·74	5·40
Ferric oxide	0·07	0·28	0·14	0·14	0·19
Alumina	0·32	0·06	0·04	0·08	0·13
Calcium carbonate	52·76	88·48	95·09	93·48	91·29
Magnesium carbonate	44·96	6·56	2·38	0·83	3·11
	100·19	99·84	99·49	98·27	100·12

1. Pontiac district.—R. B. Carswell, Bryson, western quarry.
2. Hull district.—Railroad cut at Farrelton.
3. Hull district.—Lot 16, range III, Aylwin tp.
4. Argenteuil district.—"Lane's Purchase", lot 17, range IV, north of Lachute.
5. Champlain district.—The Marble Company of Canada, Ltd., quarry, 3 miles northwest of St. Thécle.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Reports for 1914 and 1915.

[1] Wilson, M. E.: "Magnesite Deposits of Grenville District, Argenteuil County, Que.," Geol. Surv., Canada, Mem. 98 (1917).

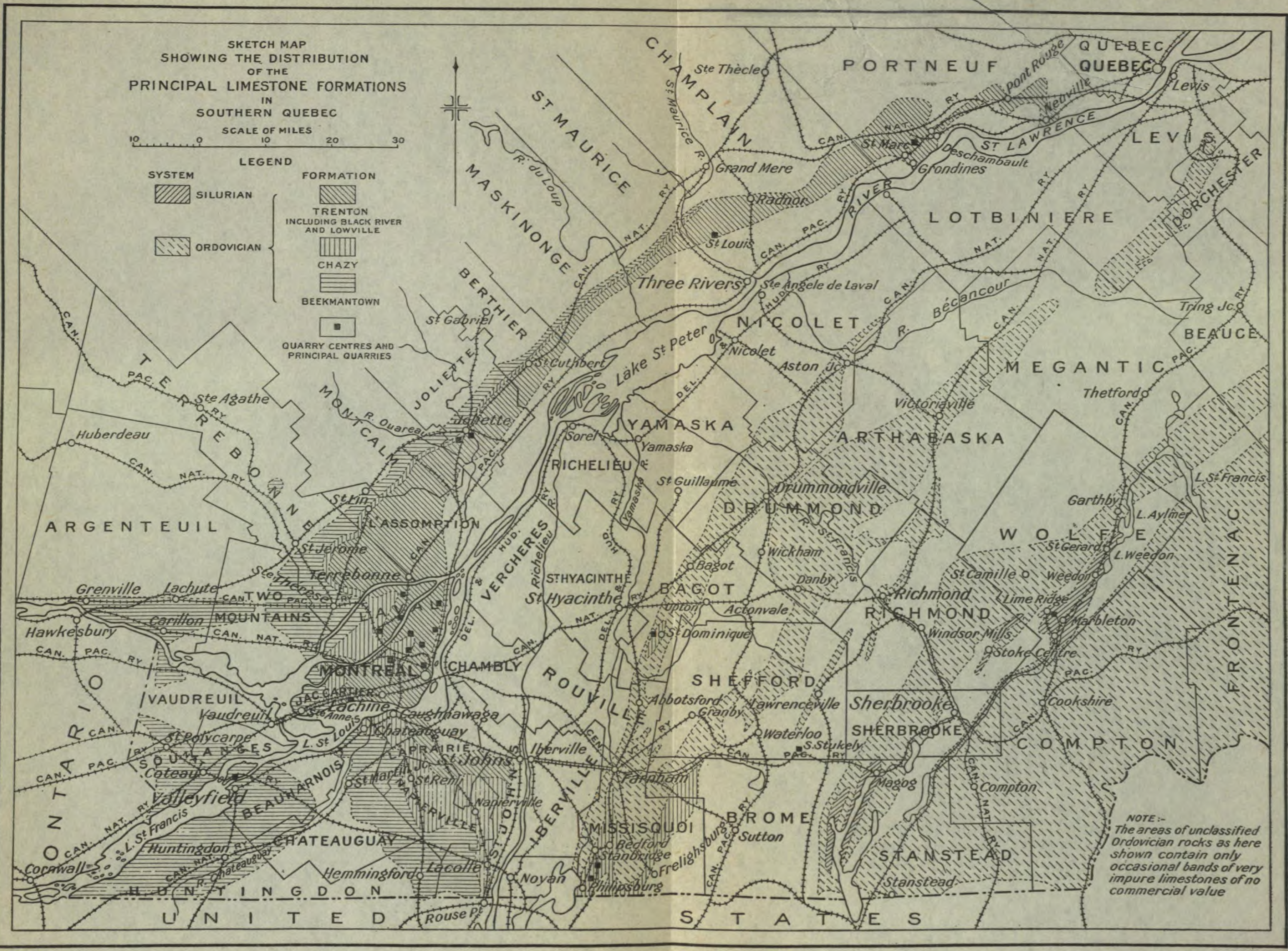


Figure 1. Sketch map showing distribution of the principal limestone formations in southern Quebec.

QUARRIES AND USES

Very little use has been made of the crystalline limestones except as a decorative stone; quarries have been operated at Portage du Fort, Pontiac district, at L'Annonciation, Labelle district, and at St. Thècle, Champlain district. A small amount was formerly burned for lime at Portage du Fort, and many years ago a small quarry was opened in a crystalline limestone band, 2½ miles north of Grenville village, Argenteuil district, to supply limestone for use in a pulp mill but it proved unsatisfactory, due to flakes of mica and graphite being carried into the pulp.

The crystalline limestones are generally too soft and friable to be of value for use as crushed stone or road metal.

Other Precambrian Limestones

The strip of Precambrian schistose rocks that extends northeasterly and southwesterly through Brome and Shefford districts, contains a band of crystalline limestone which is exposed at intervals from southeast of Brome lake, through South Stukely, to near Lawrenceville in Stukely township. The limestone band varies in width from 150 to 250 feet, has an almost vertical dip and an average trend of N. 30 degrees E.

The stone wherever exposed is highly crystalline and fine-grained, but varies in colour, being light grey in one locality and light blue in another and is in many places mottled with green, mauve, and yellow. Stringers of quartz and inclusions of schist are very noticeable in some exposures, but in the best stone as exposed at the old marble quarry at South Stukely and on lot 13, range VII, Stukely township, these features are noticeable only at the edges of the band. Pyrites is also common near the contact with the schist. The chemical composition is variable, the magnesium carbonate content in some cases varying from 4 to 36 per cent in different parts of the same exposure. The insoluble matter in the better quality stone ranges from 1 to 6 per cent and the iron content is relatively high.

Lime is burned from this stone on lot 13, range VII, Stukely township, but this is the only use being made of it at present. It has been quarried for decorative stone.

ORDOVICIAN LIMESTONES

The Beekmantown Formation

The limestones of the Beekmantown formation where exposed in the province of Quebec, are chiefly impure magnesian limestones and dolomites which grade upwards from the Potsdam sandstone below and merge gradually into the Chazy shales and limestones above. With the exception of some crystalline dolomites of the Grenville series, this formation affords the only supply of dolomite in the province. The Beekmantown stone is as a rule highly siliceous and contains a relatively large amount of iron and alumina and thus is not suitable for producing the magnesian lime favoured for structural purposes. It is possible that small quantities of Beekmantown dolomite sufficiently pure to be used for the manufacture of lime and for chemical purposes may be found in Quebec but no considerable tonnage can be expected. The thickness of the Beekmantown in Quebec has been estimated as being between 300 and 450 feet.[1]

DESCRIPTION OF THE STONE

In appearance the stone is finely granular and varies from a blue-grey to a brownish grey in colour. It weathers quickly and deeply to a dirty brown. The bottom beds of this limestone formation are, as a rule, two feet or more in thickness, are quite sandy and have no shale partings. The middle beds in many localities contain small crystals of pink dolomite and calcite. These beds are also comparatively free from sand grains. Towards the top of the formation in some localities layers of shale occur between the beds, the shale layers increasing and the limestone beds decreasing in thickness until the Chazy shale is reached. In other localities these shaly layers are not represented and the Chazy limestone overlies the Beekmantown. The upper beds of the Beekmantown are fine-grained and are generally sandy. This description of the physical appearance refers to the typical outcrops of the stone in the Ottawa-St. Lawrence Rivers region where the Beekmantown is exposed in an unaltered state. As noted below the appearance is quite different in localities where the formation has been subjected to metamorphism.

DISTRIBUTION

The Beekmantown formation is extensively exposed in southern Quebec near the junction of the Ottawa and St. Lawrence rivers. Here, associated with the Potsdam sandstone, it occurs in flat-lying beds over a wide area extending from the Archæan escarpment southerly to the International Boundary, outcropping in the districts of Huntingdon, Chateauguay, St. Johns, Beauharnois, Jacques Cartier, Soulanges, Vaudreuil, Argenteuil, Two Mountains and Terrebonne. From the northern part of this main area a long narrow strip of Beekmantown extends continuously along the base of the Archæan escarpment in a northeasterly direction through L'Assomption, Montcalm, Joliette, Berthier, Maskinonge and St. Maurice districts, and terminates in Champlain district a few miles west of the St. Maurice river.

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

A small area of Beekmantown surrounded by the crystalline Archæan rocks is exposed a few miles east of Shawbridge, Terrebonne district.

A ridge of what is apparently Beekmantown dolomite surrounded by Chazy limestone occurs in Joliette district, south of the Bayonne river, about 3 miles west of Ste. Elizabeth.

The Beekmantown formation also outcrops in the vicinity of Philipsburg, Missisquoi district. Here metamorphic agencies have altered much of the rock, although in places it does not seem to have been greatly changed. The altered stone is in places completely crystalline and the colour varies from a very light blue-grey to a creamy brown. The grain is sometimes

[1] Geol. Surv., Canada, Ann. Rept., Vol. XIV, pt. O, p. 20 (1901).

extremely fine. The strata are generally inclined, the dip varying from 10 to 45 degrees. Although the appearance of this rock is quite different from the typical Beekmantown, the chemical composition is not dissimilar. The country in this district is hilly, rock exposures are abundant and the conditions for quarrying are good. In addition to the magnesian stone in this area there are large quantities of very pure high-calcium limestone. The change from magnesian stone to high-calcium limestone is frequently very abrupt. Fossils are absent in the crystalline high-calcium limestone and it is not certain whether it should be assigned to the upper Beekmantown or to the lower Chazy. The probabilities are, however, that the high-calcium limestone belongs to the Chazy formation and it will be discussed under that heading in this report.

CHEMICAL COMPOSITION

No generalization is possible regarding the chemical composition except that it may be stated that the stone is all more or less impure. One might expect that the strata would become less and less magnesian in composition as the top of the formation was approached, but judging from observations made during the 1925 investigation such is not the case and strata of a highly magnesian composition occur all through the formation with the stratum above or below, often containing only a small proportion of magnesium carbonate or magnesia. In addition to this vertical dissimilarity in composition there was noticed in the Philipsburg area a variation in the composition of the same stratum at different places, as shown by the fact that in one place the rock would effervesce freely when tested with hydrochloric acid while in the same stratum 15 or 20 feet distant no effervescence would occur when the same acid was applied. As a rule the bottom beds of the formation have a high silica and iron content, whereas in the top beds considerable alumina is present in addition to the iron and silica.

The following analyses have been selected from those available as representing the various grades of the Beekmantown limestones.

Analyses of Beekmantown Limestones

—	1	2	3	4	5
Insoluble mineral matter	6·70	7·64	3·40	15·30	11·20
Ferric oxide	1·13	0·93	0·86	0·86	0·78
Alumina	2·40	1·33	0·60	0·38	0·72
Calcium carbonate	61·16	57·85	52·23	45·53	74·34
Magnesium carbonate	25·91	31·22	41·80	36·62	13·46
	97·30	98·97	98·89	98·69	100·50
—	6	7	8	9	10
Insoluble mineral matter	18·80	46·50	7·80	20·00	14·78
Ferric oxide	0·55	not det.	0·43	not det.	0·96
Alumina	1·45	not det.	0·57	not det.	1·44
Calcium carbonate	45·44	28·04	53·21	48·48	50·12
Magnesium carbonate	33·15	20·24	38·25	28·85	32·12
	99·39	94·78	100·26	97·33	99·42

1. Terrebonne district.—Quarry one-half mile south of Ste. Thérèse station.
2. Huntingdon district.—Top 6 feet in quarry 2 miles west of Huntingdon.
3. Huntingdon district.—Bottom 5 feet in quarry 2 miles west of Huntingdon.
4. Huntingdon district.—Ross, Church & Company quarry, 3 miles west of Huntingdon.
5. L'Assomption district.—Ubald Hogue quarry, 1 mile west of St. Lin.
6. Argenteuil district.—Quarry on land of Geo. Fraser, south of Lachute.
7. Beauharnois district.—City quarry at Valleyfield.
8. Missisquoi district.—Outcrop opposite cemetery three-quarters of a mile south of Philipsburg on Highgate road.
9. Missisquoi district.—Outcrop on lot 2, range IX, Stanbridge tp.
10. Missisquoi district.—Dark blue stone outcropping on lot 4, West Parish, St. Armand tp.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Reports for 1914, 1915 and 1918.

QUARRIES AND USES

During 1925 the only quarries operated at all continuously in the Beekmantown were three small quarries near Valleyfield. Crushed stone was the chief product along with a small amount of foundation stone.

The uses of Beekmantown limestones are few at present and will probably remain so. The high percentage of impurities precludes its general use in the lime industry as well as in the processes of manufacturing industries requiring limestone.

Many of the sandy layers, where obtainable in suitable thickness, provide good quality flagstones, but the demand for flagstones has waned to the point of extinction.

The high iron content and the susceptibility of the stone to rapid weathering make it undesirable as a building stone except for rough architecture and foundations. It is suitable for rubble and rip-rap.

It is as crushed stone that the Beekmantown limestone finds its principal application. It makes a good quality road metal especially if used with a bituminous binder. It is also suitable for railroad ballast and for aggregate in concrete work.

Limestones of Probable Beekmantown Age

Isolated bands of dolomites and magnesian limestones associated with slaty shales, and probably of Beekmantown age, occur in Missisquoi district between St. Armand and Sweetsburg, in Brome district near East Farnham, in Bagot district near Upton, and in Beauce district between St. Joseph and Beauceville. (Plate I A). The stone in most of these bands is impure and stringers of quartz are common.

The Chazy Formation

The Chazy formation succeeds the Beekmantown. In its normal development in Quebec, the Chazy formation consists of shales and sandstones in the basal portion, and of relatively pure limestones in the upper part with a zone of sandy limestone between. The total thickness of the Chazy formation is placed at 300 feet.[1] The shaly and sandy beds are as a rule poorly developed and are frequently absent, the limestones resting on the underlying Beekmantown dolomites in many localities. The Chazy merges very gradually into the overlying Trenton, there being in many places no distinct line of demarcation between the two formations.

DESCRIPTION OF THE STONE

The Chazy limestones as exposed in Quebec exhibit two principal types, one type prevailing in flat-lying, undisturbed strata (Plate III A) whereas the other type is exhibited in crumpled and metamorphosed strata which in many places have a steep dip. (Plate I B.)

The undisturbed strata consist largely of semi-crystalline stone in which the grain varies from medium and coarse in the thick middle and lower beds to a very fine grain in the thinner beds at the top of the series. The prevailing colour is a blue-grey, though occasionally there is a brownish tinge to the stone. The coarse-grained stone is always lighter in colour than is the fine-grained. A characteristic and widespread feature is the presence of specks of red calcite and of bits of red fossils. In some localities the specks are so numerous as to give a pinkish tinge to the rock. Fossils, both well preserved and fragmentary, are very numerous, some strata being composed almost entirely of fossil shells. Shale partings between the various strata are infrequent and when they do occur they are usually thin. Very thin, irregular shaly streaks, however, occur throughout some of the beds and, when they are very numerous, they give the stone a nodular appearance especially on the weathered surface. On exposure to the weather the stone assumes a light grey colour but the alteration does not penetrate to any depth.

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

The other type of Chazy limestone, exposed in an area where the rocks have been subjected to great pressure and other metamorphic agencies, varies considerably in its appearance. Descriptions of the varieties of this metamorphosed stone will be found on succeeding pages.

DISTRIBUTION

Exposures of typical Chazy limestone occur principally in three areas in southern Quebec and in each area the stone has distinctive characteristics.

1. It occurs in a band of varying width along the eastern limit of the Beekmantown from near Napierville to Ste. Rose on Ile Jèsus, being occasionally exposed in the districts of St. Johns (in vicinity of Grande Ligne and Stottsville), Napierville (near Napierville town) and Laprairie (near St. Isidore Junction and Caughnawaga) and extensively exposed in Jacques Cartier and Laval districts. From Ste. Rose to a few miles east of the St. Maurice river the Chazy occurs as a very narrow band bordering on the southeast edge of the Beekmantown and is occasionally exposed, generally in river valleys, in the districts of Terrebonne, L'Assomption, Montcalm, Joliette, Berthier, Maskinonge, St. Maurice, and Champlain. The strata in this area lie almost horizontally and the stone is of the semi-crystalline blue-grey variety previously described.

Similar Chazy limestone occurs west of Hull, and on Allumette island, Pontiac district. The Chazy is also to be seen near Grenville.

2. In the Mystic-Philipsburg area, Missisquoi district, are many exposures of very pure Chazy limestone. The strata are frequently much folded and faulted and in some localities the stone has been highly altered by metamorphic agencies. The alteration is most noticeable in a band of very pure high-calcium limestone over 200 feet thick, which is exposed at intervals along the western slope of a prominent ridge that extends 4 miles from southeast of Philipsburg northerly to Morgan Corners. The pure limestone band which dips easterly 20 degrees at Philipsburg and southeasterly 45 degrees at Morgan Corners, is underlain by impure dolomite (probably Beekmantown) and on its upper limit grades gradually into an impure, blue, nodular limestone containing much shale. Near Philipsburg the limestone has been altered to a fine-grained, light grey marble that in places is mottled and streaked with green, yellow, and pink (Plate I B). The underlying dolomite is also crystalline but the overlying shaly limestone is scarcely altered. At Morgan Corners the altering agencies have been less active, the limestone is semi-crystalline, fine-grained, dove-grey in colour and much veined and blotched with milk-white calcite (Plate II A). Neither the underlying dolomite nor the overlying shaly limestone are much altered.

Between Morgan Corners and lot 7, range VII, and lot 7, range VIII, of Stanbridge township only faulted and folded shaly limestones and limestones with dolomite bands are exposed, but on these lots the pure, dove-grey limestone occurs over a considerable area along the west side of a low ridge. It is considerably folded and contains a few inclusions of brown-weathering limestone thus showing traces of a brecciated phase that is well developed in similar limestone in the neighbourhood of Mystic. Transparent sand grains occur in the upper beds of the stone exposed on these lots.

Two miles due east from this locality on lot 4 of range VI and on lots 3 and 4 of range VII, Stanbridge township, very similar, pure, fine-grained, grey limestone veined with white calcite is exposed in a low ridge. The limestone here is associated with slaty shales.

North of and in the vicinity of Mystic are outcrops of brecciated limestone. In many places it contains considerable shale and is only of a fair degree of purity. Both matrix and fragments are fine-grained and dove-grey in colour and on a freshly broken surface can rarely be distinguished one from the other, but on the weathered surface the angular fragments show up very distinctly, being much lighter in colour than the matrix. Veins of white calcite cut across both fragments and matrix.

Another variety of limestone common in this area is one in which layers of pure limestone occur interbanded with very impure shaly stone. (Plate II B.)

3. In the vicinity of La Carrière and St. Dominique, Bagot district, limestones identified by their fossils as being of Chazy age[1] outcrop on the western slope of a broad ridge. At the base of the ridge the strata are much fractured and sometimes dip vertically. Diabase dykes occur in places. The limestone is fine-grained, light grey in colour and fairly pure. Calcite veins and blotches are common and occasional thin magnesian bands occur.

Towards the top of the ridge the strata are less disturbed and are in many places of great thickness, 15 feet being the thickness of a single bed in one quarry (Plate III B). The stone is of medium grain, very dark grey, almost black in colour, and contains a network of thin shaly streaks. Pyrite crystals are noticeable in places. Folds are common and calcite veins occur in fracture zones.

At the summit of the ridge and southerly towards St. Pie the stone is very fine-grained and varies, according to locality, from a dove-grey to a dark blue in colour. The beds are of medium thickness. Some few veins of calcite occur.

CHEMICAL COMPOSITION

The Chazy limestones are predominantly high-calcium in chemical composition although an occasional magnesian belt does occur. The magnesian strata seem to occur only at certain horizons and localities and consequently there are many places where great thicknesses of pure high-calcium limestone can be worked.

The magnesian beds do not approach a dolomite in composition, as highest magnesium carbonate content of any one stratum shown by analyses at present available, is 24·45 per cent, and over a succession of strata the highest percentage on record is 11·11.

[1] Geol. Surv., Canada, vol. VII, pt. J, pp. 115-117 (1895).

Analyses of Chazy Limestones

—	1	2	3	4	5	6
Insoluble mineral matter	2·72	3·76	4·66	1·70	4·94	1·44
Ferric oxide	0·71	0·14	1·43	0·46	1·36	0·64
Alumina	0·17	0·06	0·57	0·16	1·34	0·12
Calcium carbonate	85·35	91·60	89·10	96·43	81·69	95·93
Magnesium carbonate	10·24	3·44	3·97	1·69	11·11	1·58
	99·19	99·00	99·73	100·44	100·44	99·71

—	7	8	9	10	11	12
Insoluble mineral matter	1·14	0·28	1·50	5·46	2·54	1·00
Ferric oxide	0·14	trace	trace	0·27	0·17	0·14
Alumina	0·06	0·04	0·10	0·13	0·13	0·02
Calcium carbonate	96·25	98·93	95·80	90·53	88·69	96·43
Magnesium carbonate	1·44	1·07	1·90	1·81	6·43	1·67
	99·03	100·32	99·30	98·20	97·96	99·26

1. St. Johns district.—Otis quarry, north of Grande Ligne. Top 10 feet.
2. Napierville district.—Outcrop on land of A. Fortin, 1 mile southwest of Napierville.
3. Laprairie district.—Indian quarry, Caughnawaga.
4. Jacques Cartier district.—Old quarry south of Ste. Geneviève.
5. Laval district.—Mme. Gauthier quarry, 1 mile east of St. Martin.
6. Laval district.—Jos. Monette quarry, Bélanger.
7. Missisquoi district.—Spalls from marble quarry of the Wallace Sandstone Quarries, Ltd., at Philipsburg.
8. Missisquoi district.—Canada Carbide Co., Ltd., quarry, Morgan Corners.
9. Missisquoi district.—Outcrop on lot 3, range VII, Stanbridge tp.
10. Missisquoi district.—Outcrop of brecciated limestone near Mystic.
11. Bagot district.—Levis Loisel quarry at bottom of ridge north of La Carrière.
12. Bagot district.—Lapointe Bros. quarry near top of ridge at La Carrière.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Reports for 1914 and 1915.

QUARRIES AND USES

During the year 1925, 19 quarries, including some of the largest and best equipped building stone quarries in the province, were operated in the Chazy limestones.

Building Stone. The centres of the building stone industry are at Villeray on the island of Montreal, and at Bélanger and Cap St. Martin on Ile Jésus. The St. Dominique area also produces building stone. Decorative stone of excellent quality is obtained from the Philipsburg area.

The stone used for building purposes is the coarse-grained variety. It weathers to a pleasing grey colour, is easily worked, and the heavy beds yield blocks of large dimensions. As stated by Dr. Parks[1] the most serious defect in this high-grade building stone "is the presence of thin

[1] Parks, W. A.: Mines Branch, Dept. of Mines, Canada, Rept. 279, p. 69 (1914).

clayey bands which are present to a greater or less extent in all the quarries. It may be said that the best stone irrespective of the quarry from which it is derived, is that in which a minimum of these clayey partings is present".

Crushed Stone. A considerable amount of crushed stone is produced from the Chazy limestones, the impure fine-grained stone providing the best material, but, generally speaking, the coarser grained Chazy limestones are too soft for road metal. The chief centres of production are at Cap St. Martin on Ile Jésus, at St. Laurent and Villeray on the island of Montreal, and at St. Dominique, Bagot district.

Lime. The Chazy in Quebec would in many localities yield a high-calcium lime suitable for chemical purposes, but none of it is so utilized at present. The only kilns operating in 1925 were those in the vicinity of St. Dominique, Bagot district, and a small pot kiln near Ste. Thérèse, Terrebonne district. These supplied lime for local building purposes.

Stone for Chemical Purposes. Much of the Chazy limestone will meet the most exacting requirements of the chemical and metallurgical industries. The pure stone at Morgan Corners, Missisquoi district, is extensively quarried by the Canada Carbide Company, Ltd., for use in the manufacture of calcium carbide. A small amount of waste stone from the marble and building stone quarries is shipped to pulp mills.

The Trenton Series

The limestones of the Trenton series, which includes the Lowville, Black River, and Trenton formations, overlie the Chazy limestones and are in turn succeeded by the Utica shales.

In Quebec the Lowville and Black River formations forming the base of the series are very poorly represented and in many areas are absent. The stone is very similar in appearance and composition to that of the Trenton formation and in this report the three formations will be considered under the term " Trenton."

Trenton limestones are found in widely separated parts of the province and as may be expected, a sedimentary formation having such a wide distribution will exhibit different characteristics even at the same horizon, in different localities. The following description of the Trenton limestones refers in a general way to the normal development of the stone and is not applicable to every locality. The principal local variations are mentioned in dealing with the various areas.

The thickness in the vicinity of Montreal has been estimated by Logan to be about 600 feet.[1]

DESCRIPTION OF THE STONE

The basal beds of the Trenton consist of very fine-grained, light grey and light brownish grey stone that is scarcely distinguishable in appearance from the underlying Chazy limestone. Considerable black chert occurs in one zone near the base. Higher up in the series the limestone becomes coarser grained and thin shale partings occur between the strata. At one horizon the stone is coarse-grained, of a light brownish grey colour,

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

very pure and heavily bedded. Towards the top the strata become thinner, fine-grained, brownish-blue in colour, and siliceous, partings of dark brown bituminous shale increase in thickness and the limestone beds become nodular and increasingly thin until, at the top of the formation, the shale predominates. All of the stone weathers to a blue and finally to a grey. The brownish tints in the Trenton limestones are much more pronounced than in the Chazy.

DISTRIBUTION

A supposedly continuous belt of Trenton limestone extends from St. Johns, St. Johns district, to the St. Lawrence river, across the island of Montreal, Ile Jésus, and thence parallels the St. Lawrence, at some distance inland, to Neuville, Portneuf district.

Numerous Trenton outliers, i.e. detached masses of Trenton that have escaped erosion and are now surrounded by older rocks, are found over a wide area. These outliers occur in the districts of Quebec, Montmorency, Hull, Pontiac, Charlevoix, Lake St. John, and Chicoutimi.

The occurrences will be dealt with separately.

The band of Trenton limestone that extends from St. Johns to the vicinity of Neuville, Portneuf district, does not differ a great deal in character throughout its extent and the general description previously given applies fairly closely.

In St. Johns and Laprairie districts the Trenton belt as mapped by Dr. Ells, averages about 2½ miles in width. Deep soil covers most of the rock and in only two localities were rock exposures noted, one of these was 2½ miles west of St. Johns city and the other, 2 miles north of St. Jacques-le-Mineur, Laprairie district.

On the island of Montreal the Trenton is well exposed in quarries and outcrops. It is nearly all fine-grained, the coarse-grained variety not being represented. Black chert occurs in places.

On Ile Jésus an extensive area of medium-coarse-grained stone occurs as well as the fine-grained. The beds are over 6 feet thick in places (Plate IV B). These thick beds, as a rule, contain thin irregular shale streaks.

From Terrebonne district northeastward to the St. Maurice river the rock is generally deeply covered by drift and outcrops are seen only in the river valleys.

At Joliette the overburden is thin and extensive quarrying is carried on in the Trenton; the rock here contains some lenses and nodules of black chert. The grain varies from fine to medium. The beds are variable in thickness but are frequently heavy.

Northeastward from the St. Maurice river the covering of drift is not so deep and outcrops are more common. The stone varies from thinly bedded, fine-grained, impure, dark blue limestone occasionally containing chert and silicified fossils along with much interbedded shale, to a heavily bedded, pure, coarse-grained, light brownish grey limestone containing only a few thin irregular shale streaks. This coarse-grained stone is well exposed in the vicinity of St. Marc des Carrières and Neuville (Plate VI A).

The strata are horizontal or inclined only at a low angle throughout all this area.

The Trenton outlier in Quebec district extends from Lorette easterly to Beauport and Montmorency Falls. The stone is chiefly thinly bedded, fine-grained, dark brownish blue and impure with numerous shale partings.

The Chateau Richer and the St. Joachim outliers in Montmorency district consist of a similar type of stone with the exception that the stone is harder and more siliceous (Plate IV A). The strata in these outliers are much affected by faults and folds.

The Hull district outlier at Hull is composed for the most part of fine- to medium-grained limestones in strata varying from a few inches to several feet in thickness and separated by shale partings. At one horizon, black chert in the form of thin lenses and nodules is very noticeable. Irregular shale streaks occur throughout some of the stone.

The outlier on Allumette island, Pontiac district, was not visited, but according to available information the stone is of the fine-grained variety and belongs to the Black River formation.

The Charlevoix district outlier at Baie St. Paul occurs in the valley of Gouffre river. The limestone is impure, fine-grained and has many thin shale beds. It is underlain by shales and sandstones and is, as a rule, inclined at a steep angle (Plate V A). Three small pot kilns are operated occasionally near Baie St. Paul and their output, together with a small quantity of agricultural limestone, constitute the only products from the limestone of this area.

The Murray Bay outlier contains no limestone sufficiently pure to be of interest in this report. Much shale and sandstone occur. The beds are as a rule much faulted and folded. No use is made of stone.

Around the southern and western shores of lake St. John the Trenton limestone occurs in the lowland in a belt varying from a few hundred yards to several miles in width. Outcrops were noted chiefly in the river valleys and along the lake shore between St. Felicien and Chambord Junction (Plate V B). The overburden is usually very heavy. The stone contains numerous thin irregular shale layers. Some solid beds of fine-grained and medium-grained stone occur particularly at Val Jalbert. Black bituminous shale partings are common especially in the upper beds. The limestone is overlain in some places by black Utica shales and everywhere appears to be underlain by the Archæan gneiss and granite.

At Ste. Anne, across the Saguenay river from Chicoutimi, fine-grained, brownish blue Trenton limestone occurs, and from there northward to Chutes des Galets on the Shipshaw river outcrops of similar stone occur at intervals with outcrops of igneous rock intervening. At Chutes des Galets, below the falls, 50 to 75 feet of nodular limestone is exposed.

Near Bagotville are small areas of fine-grained Trenton surrounded by granite.

Judging from the appearance of the stone and from a few available analyses, the limestone of the Lake St. John and Saguenay River districts is rather high in silica and low in magnesium carbonate. In the past the pulp mills of the district used the local stone but at present their requirements are imported. Lime was formerly burned in various localities but now is being burned only at Ste. Anne de Chicoutimi. Numerous small quarries have been opened to supply local demands for crushed stone but none were operating in 1925.

CHEMICAL COMPOSITION

The Trenton limestones are predominantly high-calcium limestones although occasional magnesian bands do occur as near St. Johns and Montreal (see analyses).

The chief impurity is silica and in a general way this varies in amount according to the horizon of the stone, being at a maximum of 10 to 15 per cent in the fine-grained dark blue beds near the top of the formation and at a minimum of 0·40 to 1·00 per cent in the heavy coarse-grained beds supposedly near the middle of the series, and again increasing in the strata near the base where it runs from 5 to 10 per cent.

The following analyses have been selected from those available to give a general idea of the composition of the Trenton limestones in various localities and to show the variations in composition.

Analyses of Trenton Limestones

—	1	2	3	4	5	6	7
Insoluble mineral matter	7·68	1·40	1·90	14·00	2·30	6·78	2·00
Ferric oxide	0·61	0·40	0·21	0·40	0·70	0·14	0·19
Alumina	0·08	0·04	0·35	0·10	1·40	1·46	0·15
Calcium carbonate	88·31	90·27	96·25	79·91	93·75	81·41	96·60
Magnesium carbonate	1·38	7·27	1·59	2·75	1·46	9·51	1·04
	98·06	99·38	100·30	97·16	99·61	99·30	99·98

—	8	9	10	11	12	13	14
Insoluble mineral matter	12·04	5·14	11·44	10·60	9·70	1·88	0·40
Ferric oxide	0·54	0·40	0·43	} 0·84	0·87	} 0·39	0·12
Alumina	0·70	0·30	0·15		0·17		0·04
Calcium carbonate	81·75	91·21	82·96	85·02	85·57	96·65	99·14
Magnesium carbonate	2·42	1·52	2·59	1·91	2·19	0·56	0·63
	97·45	98·57	97·57	98·37	98·50	99·48	100·33

1. St. Johns district.—Lord and Hebert quarry, 2½ miles west of St. Johns.
2. Laprairie district.—Brault quarry, 3 miles west of St. Johns.
3. Montreal island.—Soverign Lime Works quarry, Montreal.
4. Montreal island—Canada Cement Company quarry, Pte. aux Trembles.
5. Laval district.—N. Brunet quarry, St. Vincent de Paul, Ile Jésus.
6. Berthier district.—Clement quarry, St. Cuthbert.
7. Joliette district.—Arnaud and Beaudry quarry, Joliette.
8. Quebec district.—E. Verreault quarry, Beauport.
9. Quebec district.—Dacre quarry, Lorette.
10. Montmorency district.—A. A. Baker quarry, Chateau Richer.
11. Charlevoix district.—Railroad cutting, Baie St. Paul.
12. Lake St. John district.—Corporation quarry, Chambord Junction.
13. Hull district.—Laurentian Stone Company quarry, Hull.
14. Portneuf district.—Deschambault Quarry Corporation, St. Marc des Carrières.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Reports for 1914 and 1915.

QUARRIES AND USES

The Trenton is extensively quarried to obtain crushed stone, broken stone, building stone, and stone for lime-burning.

Crushed Stone. Crushed stone for use as road metal, railroad ballast and in concrete work is the principal product from the Trenton limestones in Quebec. The most suitable stone for this purpose is the thin-bedded, dark-coloured, siliceous stone occurring at the base and near the top of the series. The centres of production are near Hull, Montreal, Joliette, Beauport, and Chateau Richer. Numerous small quarries operate from time to time at various other places to supply local demands.

Building Stone. Excellent quality building stone is obtained from the heavy medium-grained and coarse-grained beds of the Trenton at the following centres, St. Marc des Carrières, St. François de Sales, Montreal, Joliette, Hull, and to a lesser extent at St. Dominique.

Lime. The purest grades of Trenton stone afford a high quality lime suitable for chemical purposes. The chief centres of production are at St. Marc des Carrières, St. Louis de France (Champlain district), Joliette, Montreal, and Hull.

Other Uses. Considerable broken stone is produced directly or as spalls in the building stone quarries and is disposed of to the pulp mills. The fines from some of the quarries producing crushed stone and stone for lime are pulverized and utilized as agricultural limestone, and in asphalt mastic.

Unclassified Ordovician Limestones

The sketch map on page 4 shows, east of the Richelieu river, large areas of rock marked as being of Ordovician age but not further classified. The boundaries of these areas were copied from maps issued by the Geological Survey. The rocks are chiefly slates and shales ranging from Chazy to Trenton in age, with which are associated numerous bands of soft slaty limestones. A great many of these limestone bands were examined but they were all found to be very impure.

SILURIAN LIMESTONES

Limestones which have been reported by Dr. Ells as being of Silurian age[1] occur over three areas in south central Quebec.

1. In Weedon and Dudswell townships, Wolfe district.
2. In Stoke township, Richmond district.
3. In Stanstead and Brome districts bordering on and in the vicinity of lake Memphremagog.

The limestones occur in bands associated with sandy slates and shales of the same age. On the sketch map, page 4, the whole area of Silurian rocks is shown, as the limestone bands could not be shown on such a small-scale map.

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. II, pt. J, pp. 7-14 (1886).

The Silurian limestones of Wolfe district occur chiefly along the northwestern edge of the Silurian area extending from the southern end of lake Aylmer to south of Dudswell Junction. The bands have apparent thicknesses of from 100 to 500 feet and dip at a high angle. In the northern part of this area the bands consist mainly of impure, fine-grained, blue slaty limestone, cut by thin veins of white calcite. Small stringers of quartz occasionally occur. In the southern part of the area in the vicinity of Lime Ridge and Marbleton the limestone bands are very highly crystalline and in places very pure, although impure and unaltered stone occurs as well, even in the same bands. The crystalline stone varies from a light grey to a grey-blue in colour. The adjacent semi-crystalline stone is generally of a slaty grey colour. Both are fine-grained. Mere traces of shale partings are noticeable in the highly crystalline stone but thick slaty shale partings occur in the impure stone. Good exposures of the crystalline limestones are to be seen in the quarry of the Dominion Lime Company Limited (Plate VI B), at Lime Ridge, and on lot 21, range VII, Dudswell township. East and southeast of Dudswell lake the Silurian limestones are very sandy and are blue-black in colour.

The Silurian limestone bands in Stoke township, Richmond district, are very impure and apparently of no economic importance.

The limestone bands in Brome and Stanstead districts, around the north end of lake Memphremagog, consist of impure, dark blue slaty stone in which occasional thin bands of calcite occur.

Silurian limestone of good quality is plentiful along the south shore of the Gaspe peninsula.

CHEMICAL COMPOSITION

The chemical composition of the Silurian limestones varies widely. The light-coloured crystalline stone is as a rule a very pure, high-calcium limestone. In the same band and adjacent to the pure light grey stone a mass of siliceous grey-blue stone may occur. The unaltered blue slaty limestone is in many places magnesian and ferruginous. The insoluble material in this variety of stone may be as high as 20 to 40 per cent.

—	1	2	3	4	5	6
Insoluble mineral matter	5·92	1·80	2·00	66·94	6·60	9·78
Ferric oxide	0·35	0·21	0·21	....	0·57	0·64
Alumina	0·16	0·11	0·09	....	0·11	0·52
Calcium carbonate	91·52	96·87	95·71	21·25	90·35	84·28
Magnesium carbonate	1·81	1·34	1·19	4·03	1·52	2·59
	99·76	100·33	99·20	92·22	99·15	97·81

1. Wolfe district.—Small quarry, lot 21, range VII, Weedon tp.
2. Wolfe district.—Dominion Lime Company quarry at Lime Ridge.
3. Wolfe district.—Outcrop on lot 21, range VII, Dudswell tp.
4. Richmond district.—Lot 13, range VII, Stoke tp.
5. Stanstead district.—Outcrop, lot 21, range I, Stanstead tp.
6. Brome district.—Jones farm, lot 24, range X, Potton tp.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1914.

QUARRIES AND USES

Only one quarry is operated at present in the Silurian limestone and that is the large quarry of the Dominion Lime Company, Limited, at Lime Ridge, which is situated in pure limestone. In past years many small pot kilns operated in the three areas above mentioned and used, in some cases, a very impure grade of limestone.

The pure Silurian limestone is suitable for lime-burning, for use in the sulphite process of pulp-making, for agricultural limestone, and for any purpose requiring a high-calcium limestone.

The impure stone in some cases is of the composition desired for natural cement but it is not suitable for much else, being too impure for any chemical use and too soft for use as crushed stone. Good flagstones were formerly obtained in several localities.

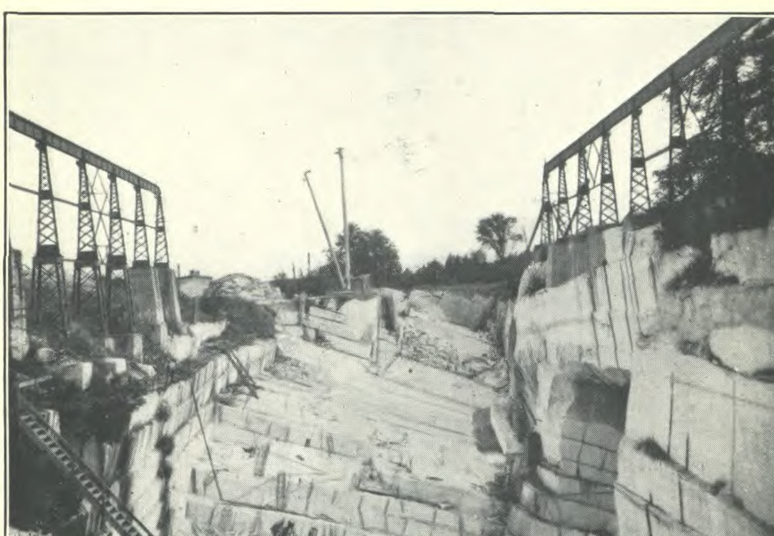
DEVONIAN LIMESTONES

Limestones of the Devonian system are but poorly represented in south central Quebec. A small outlier of rather impure limestone classed as Devonian[1] occurs on a hilltop 1,200 feet north of the Chaudière river, just below the village of St. George, Beauce district. The amount of limestone available is probably very small. The stone is light blue, fine-grained, fossiliferous, and much veined with calcite. Considerable pyrite is visible in places. No analysis is yet available.

[1] Geol Surv., Canada, Ann. Rept., vol. III, pt. K, pp. 9-10 (1887).

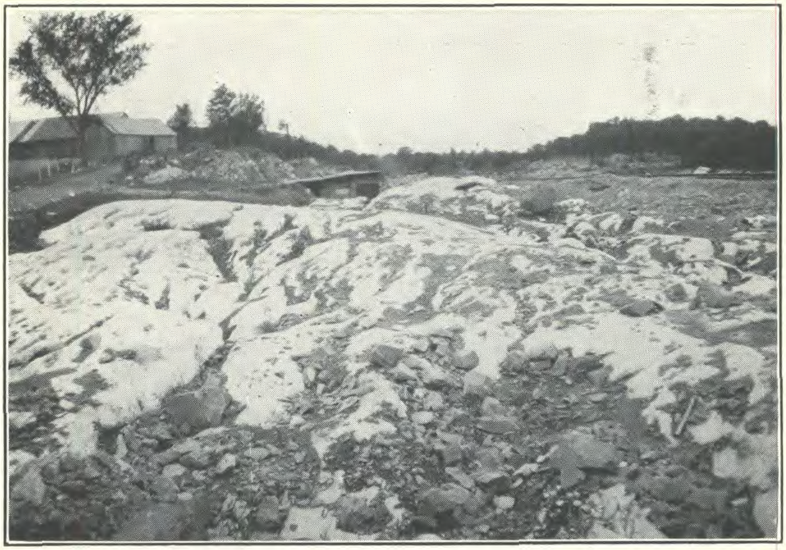
PLATE I

A. Band of crystalline Beekmantown limestone (marble), near Beauceville, Beauce district.



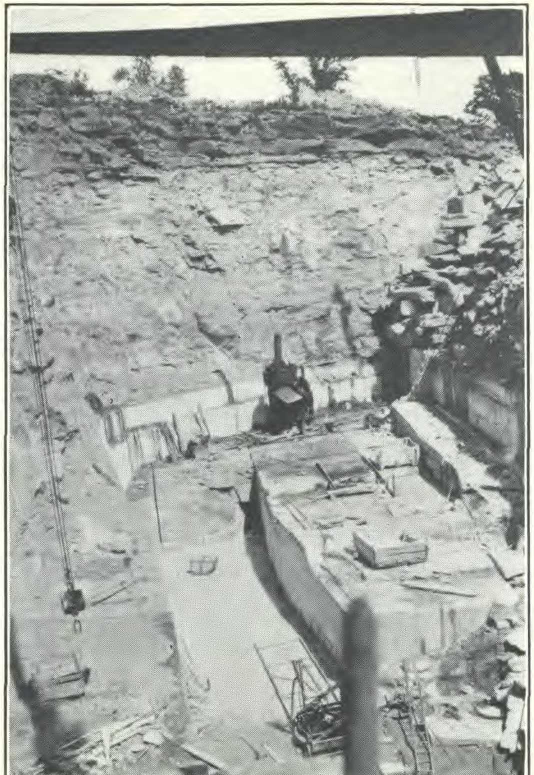
B. Crystalline Chazy (?) limestone (marble) quarried for decorative stone by the Wallace Sandstone Quarries Ltd., at Philipsburg, Missisquoi district.

PLATE II

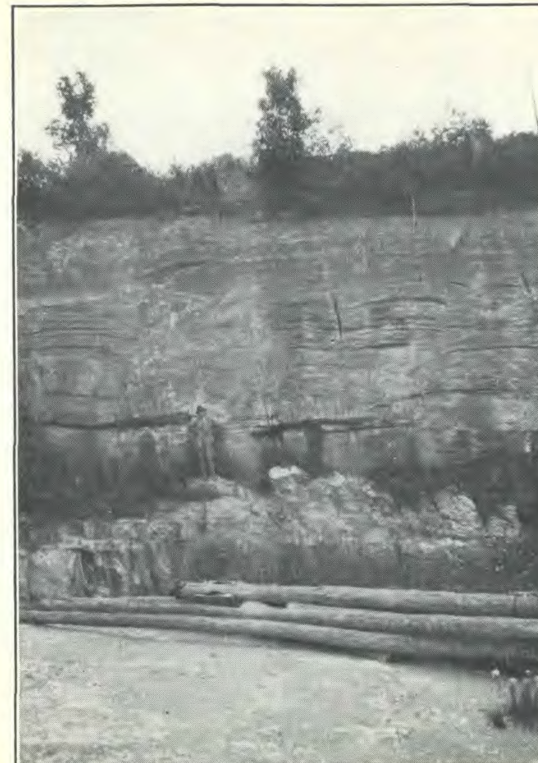


A. Weathered surface of semi-crystalline Chazy (?) limestone, quarry of the Canada Carbide Co., Ltd., near Bedford, Missisquoi district.

B. Outcrop of banded Chazy limestone near Stanbridge, Missisquoi district. The dark bands are impure, shaly limestone; the light-coloured bands are pure limestone.

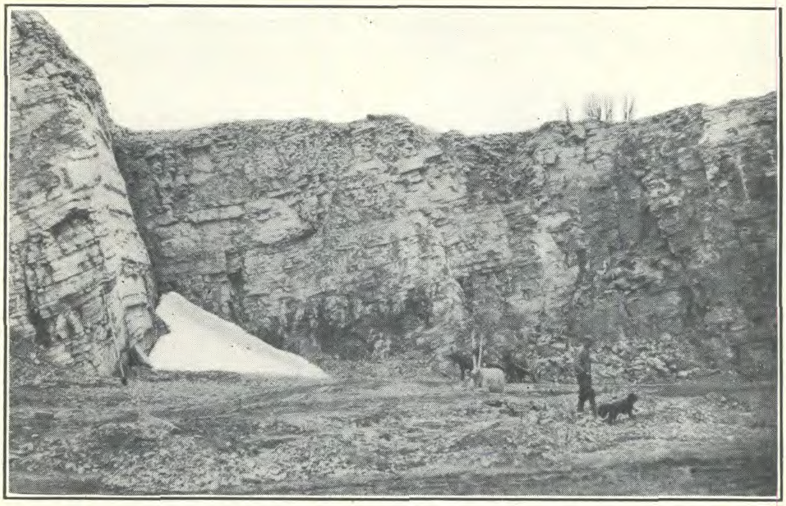


A. Heavily bedded Chazy limestone, Quinlan quarry, Bélanger, Laval district.

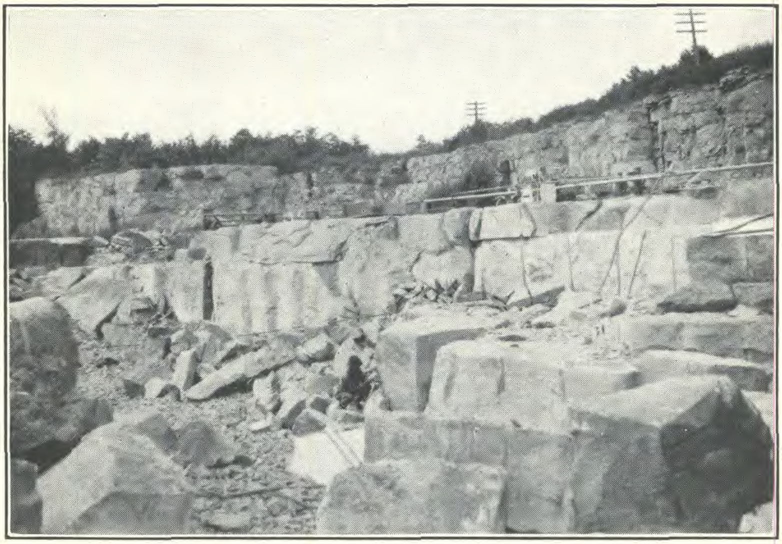


B. Very heavily bedded Chazy limestone in quarry formerly operated by the Grand Trunk Railway, St. Dominique, Bagot district.

PLATE IV

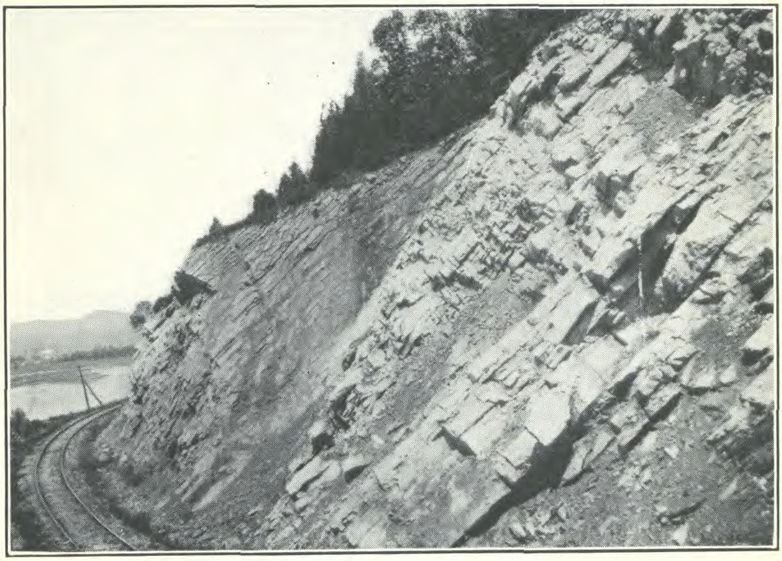


A. Thinly bedded Trenton limestone, A. A. Baker quarry, Chateau Richer, Montmorency district.

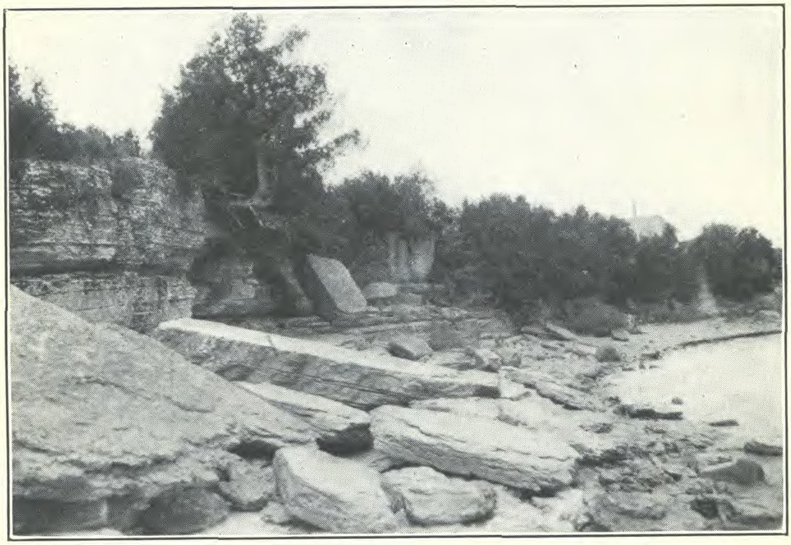


B. Heavily bedded Trenton limestone, quarry of Montreal Cut Stone Ltd., south of St. François de Sales, Laval district.

PLATE V



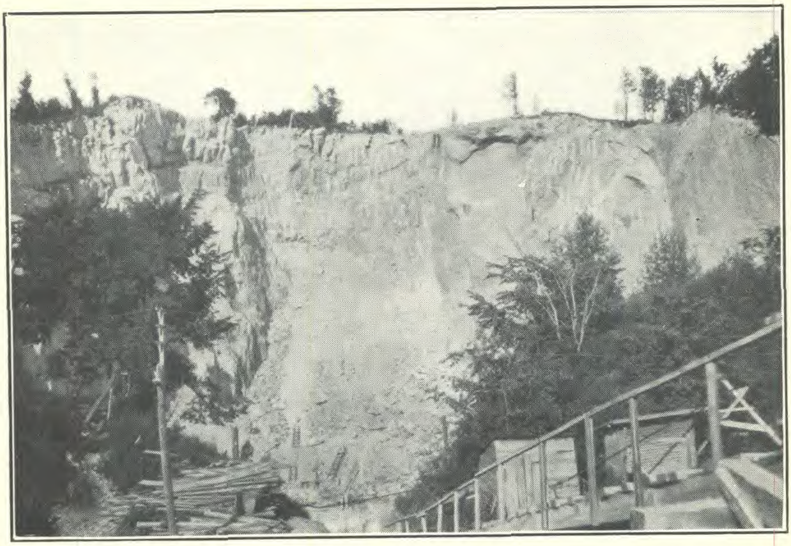
A. Trenton limestone near Baie St. Paul, Charlevoix district.



B. Nodular, heavily bedded Trenton limestone, Pointe Bleue, Lake St. John district.

PLATE VI

A. Weathered outcrop of Trenton limestone, Neuville, Portneuf district.



B. Silurian limestone, quarry of the Dominion Lime Co., Ltd., Lime Ridge, Wolfe district.

CHAPTER II

THE LIMESTONES OF ONTARIO

The limestones of Ontario include high-calcium limestones, magnesian limestones, and dolomites which range in chemical composition from the very pure, down to the most impure grades. These limestones are found chiefly in that part of the province south of the Ottawa river and lake Nipissing. In the northern part of the area metamorphic rocks containing bands of crystalline limestones occur, the remaining and greater part of the area is underlain by sedimentary rocks in which are formations of great thickness and extent composed entirely of bedded limestones. Over the southern part of the Ontario peninsula the rocks are deeply covered by soil and exposures of limestone are rare, and usually are to be seen only in the deep river valleys. Over the central part of the peninsula and as far north as the Ottawa river the soil covering is much thinner and the limestones are exposed in prominent escarpments and ridges which provide excellent quarry sites.

An idea of the value of these limestone resources may be gathered from the fact that from them there is annually obtained products such as lime, building stone, crushed stone and stone for cement manufacture that approximate $5,000,000 in value. This is but a tithe of the value of products that could be obtained were the demand to arise.

The Ontario limestones occur in formations which range from Precambrian to Devonian in age. Below is a table showing the various limestone-bearing formations in their relation to other formations and in the order in which they occur in the geological time scale. This table was prepared for this report by E. M. Kindle of the Geological Survey for the express purpose of showing the relative age of the formations in Ontario. Only the principal divisions are shown, the table not being intended to show a complete series of the various sub-divisions of rocks that have been recognized in the province. The various limestones will be briefly considered in the order of their geological age commencing with the oldest.

System	Formation	Composition
Quaternary		Unconsolidated deposits.
Cretaceous (?)		Coarse sands and high-grade clays.
Devonian	Port Lambton	Shales.
	Huron	"
	Hamilton	Shales and thin limestones.
	Delaware	Limestones.
	Onondaga	"
	Oriskany	Sandstones.
	Detroit River	Limestones (and dolomites).
Silurian	Bertie-Akron	Limestones (dolomites).
	Salina	Shale, salt, gypsum, limestones.
	Guelph	Limestones (dolomites).
	Lockport	" "
	Rochester	Shales.
	Clinton	Limestones (dolomites).
	Medina-Cataract	Sandstones and dolomites.
Ordovician	Queenston	Shales.
	Lorraine	"
	Utica	"
	Collingwood	"
	Trenton	Limestones.
	Black River	"
	Chazy	"
	Beekmantown	"
Cambrian	Potsdam	Sandstones.
Precambrian	Grenville series	Crystalline limestones and schists.
	Igneous rocks.	

PRECAMBRIAN LIMESTONES

Grenville Series

The crystalline limestones of the Grenville series are extensively exposed in that part of Ontario lying between the Ottawa river and a line from Midland to Kingston, and west of a line from Brockville to Ottawa.

During the present investigation only a few of the crystalline limestones have been examined and sampled, but the preliminary work has shown that, although impure stone predominates (Plate VII A), some large deposits of pure, high-calcium limestone, magnesian limestone and dolomite occur.

The crystalline limestones are generally coarse-grained, soft and friable. The colours are white, grey and occasionally pinkish. A blue-and-grey striped variety is also common (Plate VII B). The impurities occur in grains either disseminated throughout the stone or in parallel planes. These impurities in addition to enclosed masses of schist and quartzite include graphite, galena, pyrite, magnetite, apatite, etc., as well as many silicate minerals such as mica, hornblende, pyroxene, tremolite, etc. Veins of quartz are common in many deposits of what would otherwise be pure dolomite.

CHEMICAL COMPOSITION

As above stated, the Grenville crystalline limestones range in chemical composition from high-calcium limestone to dolomite. The dolomites appear to contain less impurities than do the high-calcium limestones. The following analyses give an idea of the composition of the purer varieties of these limestones.

Analyses of Grenville Limestones

—	1	2	3	4	5	6
Insoluble mineral matter	1·40	0·40	2·80	4·10	1·00	2·04
Ferric oxide	0·64	0·28	0·42	0·56	0·81	0·10
Alumina	2·76	0·32	0·78	0·84	0·69	0·10
Calcium carbonate	90·66	55·04	88·52	55·68	58·20	91·78
Magnesium carbonate	4·39	43·83	7·27	38·93	39·06	5·51
	99·85	99·87	99·79	100·11	99·76	99·53

1. Renfrew county.—Biederman quarry, lot 20, con. XIX, Wilberforce tp.
2. Renfrew county.—Renfrew White Granite Company quarry, lot 19, con. VI, Ross tp.
3. Lanark county.—Small quarry, lot 20, con. V, Ramsay tp.
4. Frontenac county.—Small quarry, lot 9, con. XII, Portland tp.
5. Hastings county.—Spalls from quarry of Ontario Marble Quarries Ltd., lots 29 and 30, con. X, Dungannon tp.
6. Hastings county.—Old quarry south of Madoc.

The samples from which the above analyses were made were all obtained by Howells Fréchette, Mines Branch, Ottawa. The analyses were published in the Mines Branch Summary Reports for 1917 and 1918.

QUARRIES AND USES

At Renfrew, Delta, and Carleton Place, lime is burned from crystalline limestones obtained nearby. A company has undertaken some preliminary development work on a deposit of pink limestone near Perth with a view to erecting a lime plant. At present the crystalline dolomites are attracting attention as being possible sources of stone from which to make magnesian lime for use in the pulp mills in the northern part of the province and in Quebec. Considerable decorative stone was formerly quarried from some of the more compact and prettily marked crystalline limestones.

ORDOVICIAN LIMESTONES

The Beekmantown Formation

The Beekmantown magnesian limestones and dolomites are but poorly represented in Ontario, the maximum thickness of the formation being only about 60 feet.[1] They are underlain by the Potsdam sandstone with no distinct line of separation between the two and are in turn overlain by the Chazy shales.

[1] Parks, W. A., Mines Branch, Dept. of Mines, Canada, Rept. 100, p. 171 (1912).

DESCRIPTION OF THE STONE

The Beekmantown limestones are generally flat-lying, or inclined at only a very slight angle. The bottom beds, which grade upwards from the underlying sandstone, are always very sandy, hard and compact. The thickness is variable, many beds only a few inches thick occurring between strata 10 to 14 inches thick. The colour is usually grey. Crystals of dolomite and calcite occur disseminated throughout the stone and as vug fillings. These crystals are especially characteristic of the middle beds which are finely granular and brown-grey to blue-grey in colour. The thickness of the middle beds rarely exceeds 14 inches except in a few localities where a bed of soft, brown, porous stone occurs which is 2 to 3 feet thick. This thick stratum is apparently in the upper part of the middle section. The upper strata are occasionally sandy, and are fine-grained and thinly bedded. The thin beds are separated by layers of sandy shale which increase rapidly in thickness towards the top of the Beekmantown until they predominate and the formation merges into the Chazy shales.

DISTRIBUTION

The Beekmantown is exposed only in the eastern part of the province where it occurs over a large area extending over all of Grenville county and over parts of Leeds, Lanark, Dundas, Russell and Carleton, with isolated areas in Glengarry, Prescott and Renfrew counties. The location and extent of these areas are shown on the sketch map, Figure 2.

Over the greater part of the main area, exposures ranging in horizon from the basal to the summit beds are fairly frequent. The comparatively pure, brown, porous dolomite was noticed in Grenville county, concessions II and III, Augusta township, and also in Lanark county in concession IX, Beckwith township. Exposures of the sandy stone are the most abundant. The various isolated outcrops in Glengarry, Prescott and Renfrew counties exhibit the usual characteristics of Beekmantown limestone.

CHEMICAL COMPOSITION

The Beekmantown in Ontario consists, in the main, of impure dolomites and magnesian limestones. The composition from stratum to stratum is variable, one stratum being composed of true dolomite whereas the underlying or overlying one may be composed of stone that is only moderately magnesian in composition. The highly magnesian stone is most common. Silica is generally high throughout the entire formation, although, as mentioned above, at a certain horizon comparatively pure stone occurs. The iron and alumina content are usually high, the iron throughout the entire formation, and the alumina particularly in the upper part. Analyses on record show that in some localities the alumina content exceeds three per cent.

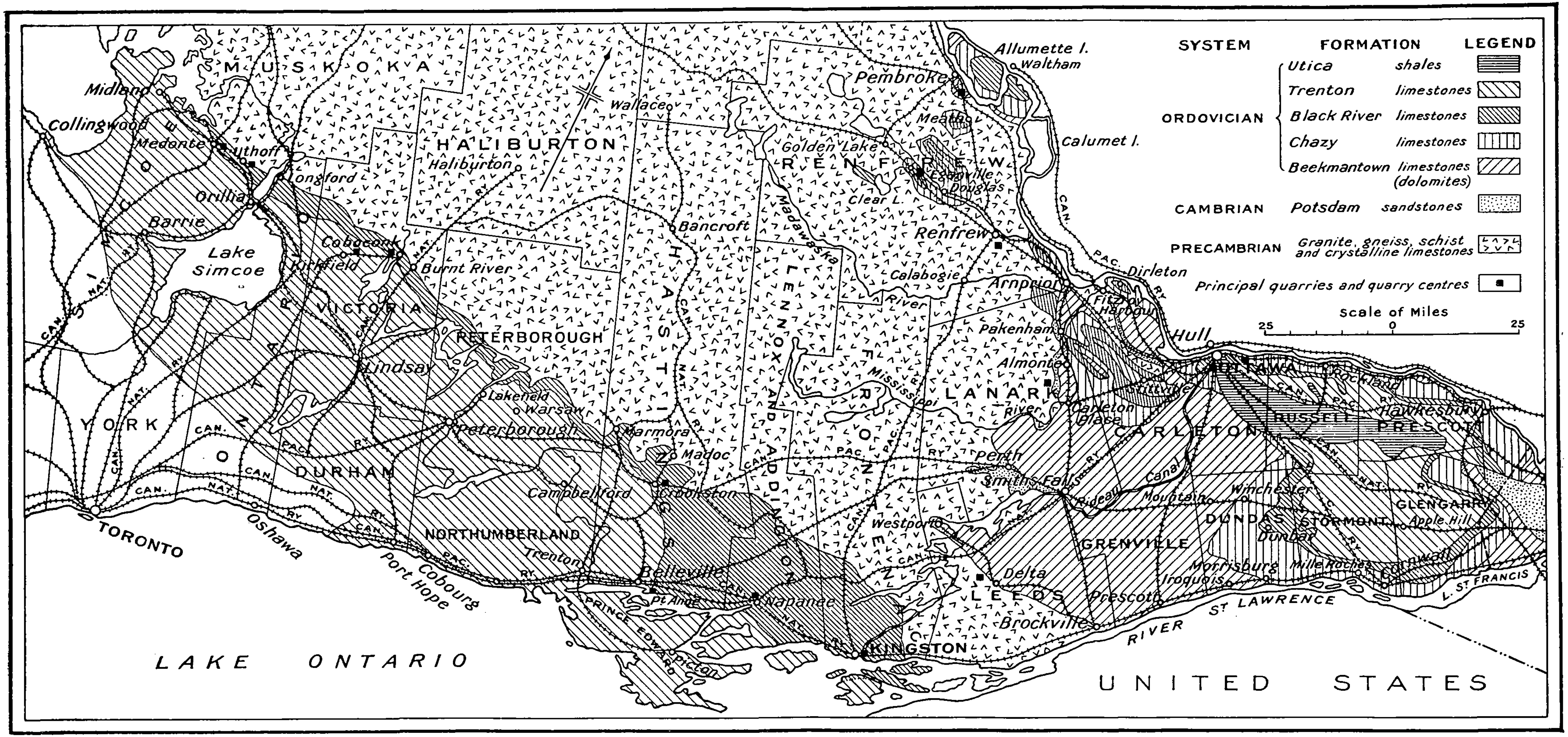


Figure 2. Sketch map showing the distribution of Ordovician limestone formations in Ontario.

Analyses of Beekmantown Limestones

—	1	2	3	4	5
Insoluble mineral matter	2·08	14·35	9·00	2·61	8·00
Ferric oxide	0·69	0·98	0·43	0·98	1·12
Alumina	0·25	0·22	1·17	0·82	1·48
Calcium carbonate	54·80	58·35	49·96	63·88	54·60
Magnesium carbonate	41·30	25·94	38·30	31·51	34·84
	99·12	99·84	98·86	99·80	100·04

1. Lanark county.—McNeely quarry, lot 12, con. X, Beckwith tp.
2. Carleton county.—Gamble quarry, lot 24, con. I, Gloucester tp.
3. Grenville county—Rock cut on C.P.R., lot 2, con. I, Wolford tp.
4. Grenville county.—Quarry, lot 17, con. II, Augusta tp.
5. Leeds county.—Old quarry south of Prescott road, one mile east of Brockville.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1917.

QUARRIES AND USES

Very little stone is now quarried from this formation in Ontario. Numerous small quarries exist which were formerly operated for building stone. The principal areas of activity were in the southern part of Grenville county and in the northwestern part of Dundas county, as well as near Smiths Falls and Carleton Place in Lanark county. During 1925 a small production of crushed stone and building stone was made from some of these quarries. The brown, porous, granular dolomite affords the best building stone from this formation as the other varieties stain badly on exposure to the weather. An excellent quality of crushed stone for roads, ballast and concrete work, is obtained from the hard, siliceous beds. From a chemical and metallurgical standpoint, the Beekmantown is of little value, most of it being too impure for use in these industries.

The Chazy Formation

The Chazy formation succeeds the Beekmantown. It has a maximum thickness of about 200 feet.[1] Shales and sandstones form the lower part, and limestones the upper part of this formation. The maximum thickness of the limestones is about 100 feet, but in most localities it is a great deal less. The shales serve to sharply define the Chazy limestones from the Beekmantown limestones, but lithologically there is no sharp line of distinction between the Chazy limestones and the overlying Black River limestones, the fossils forming the only distinguishing feature.

DESCRIPTION OF THE STONE

The Chazy limestones wherever exposed in Ontario are usually fine-grained, fossiliferous, of medium hardness and vary from dark grey to

[1] Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. XII, pt. J, p. 86 (1899).

brown-grey in colour. All the stone weathers to a light grey. Small crystals of secondary white calcite are common. The usual thickness of the strata is from 6 to 18 inches but beds 5 feet in thickness were noticed in a few localities. The limestone immediately above the shale is sandy. In some places a thick stratum of soft, impure, greenish grey magnesian limestone was noticed above the heavy sandy layers.

DISTRIBUTION

The Chazy limestones and shales occur only in eastern Ontario between the Ottawa river and a line from Morrisburg to Eganville. As may be seen by referring to the sketch map (Figure 2) the distribution is somewhat scattered and there are many isolated occurrences. Generally throughout this area the Chazy is underlain by Beekmantown and overlain by Black River limestones, although in some localities the Chazy apparently rests on the crystalline Precambrian rocks.

The most extensive area of Chazy exposures is the one which, in the form of a curving belt, begins in the southwest corner of Russell county, extends southward to the St. Lawrence river, follows the river eastward and, with occasional breaks, follows the easternmost boundary of the province northerly to the Ottawa river and thence borders the latter river nearly to Ottawa city. The outer edge of this belt is principally Chazy shale. The general dip is at a low angle toward the centre of the rough circle formed by the belt. The country is flat and in the southern and eastern parts the rock is deeply covered by soil, outcrops being infrequent except in Dundas county and near Mille Roches in Stormont county. Wherever seen the limestones are uniformly fine-grained and dark grey to brown-grey in colour. Along the Ottawa river the Chazy limestones are well exposed in a series of ridges that parallel the river. In the vicinity of Hawkesbury the stone is medium-grained and light grey in colour. In the remainder of the exposures it is chiefly fine-grained and brown-grey.

In Lanark and Carleton counties, east of Pakenham, Almonte, and Carleton Place, is a large outlier of Chazy limestones. The stone is chiefly fine-grained and dark in colour. A complete section from the underlying Beekmantown to the overlying Black River is exposed, including the impure magnesian layers that occur just above the shale. Outcrops are numerous.

Southwest of Ottawa is an outlier of Chazy with many outcrops of dark-coloured, fine-grained limestone.

Bordering the Ottawa river, north and east of Fitzroy Harbour, is an outlier of Chazy limestones capped by Black River. The whole succession of the Chazy is well exposed on the river bank which here is over 100 feet high. The stone is all fine-grained. Much of it is light grey and greenish grey in colour. Some of the basal beds are very argillaceous and others are sandy.

In Renfrew county there are four Chazy areas, the locations of which are shown on the sketch map. In all of these the stone is dark-coloured, fine-grained, and medium fine-grained. A quarry is operated in the outlier south of Pembroke, the products being crushed stone and building stone. At Eganville the brown, medium fine-grained stone is quarried for lime-burning.

CHEMICAL COMPOSITION

The upper beds of the Chazy limestones are all high-calcium in their composition, but near the base a belt of magnesian stone occurs. Some of the strata of the upper part of the series are very pure, but usually over a workable thickness the stone is only moderately pure due to the presence of beds which contain considerable silica, much alumina and in some cases undesirable amounts of iron pyrites. No analyses of the magnesian beds near the base of the Chazy limestones are available, but apparently they are always impure, being both argillaceous and ferruginous. The sandy beds are high in silica and other impurities.

Analyses of Chazy Limestones

—	1	2	3	4	5
Insoluble mineral matter	5·60	6·10	2·40	3·40	4·70
Ferric oxide	0·56	0·14	0·43	1·26	0·88
Alumina	1·94	2·06	1·37	2·54	0·32
Calcium carbonate	89·94	87·64	92·04	91·14	92·44
Magnesium carbonate	1·51	3·48	3·33	0·50	1·51
	99·55	99·42	99·57	98·84	99·85

1. Lanark county.—Bottom beds of old quarry north of Almonte.
2. Renfrew county.—Markus quarry, south of Pembroke.
3. Renfrew county.—Standard Chemical Company's quarry, Eganville.
4. Prescott county.—Ross quarry, lot 28, con. I, Hawkesbury East.
5. Dundas county.—Corporation quarry, one-half mile south of C.P.R. station, Winchester.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1917.

QUARRIES AND USES

Very few quarries are now being operated in the Chazy limestones in Ontario. Many quarries were opened for building stone in this formation and much excellent stone was produced, but since the advent of Portland cement they have either been abandoned or worked only at odd intervals to supply local demands. A small amount of building stone is still produced at Pembroke and at Almonte.

Crushed stone is produced at Pembroke and at one or two other places for local use.

Lime for chemical use is produced from Chazy stone at Eganville. Before transportation facilities were well developed, lime was burned in many localities from Chazy limestones.

The Black River Formation

The Black River formation is a geological subdivision of the Trenton series of limestones. This series consists of three formations: 1. Lowville or Bird's Eye, 2. Black River, 3. Trenton. Owing to the difficulty of distinguishing between them and to the fact that they have not been mapped separately the Lowville and Black River will be considered together under the name of Black River in this report. The combined thickness of the two formations in Ontario is from 150 to 200 feet.[1] The Black River limestones overlie the Chazy and are overlain by the Trenton.

DESCRIPTION OF THE STONE

The Black River limestones are predominantly fine-grained and brittle. They contain numerous small crystals and veinlets of colourless calcite. Occasionally, irregular streaks and patches of coarse-grained material occur in the fine-grained beds. These streaks are very apparent on the weathered surface as they weather to a light brown whereas the rest of the stone weathers to a light grey.

The upper part of the formation consists of heavy beds of brownish and dark grey, medium-grained and fine-grained stone which generally contains numerous irregular streaks of shale which, being readily acted upon by weathering agencies, imparts to the weathered surface a shaky or nodular appearance. Silicified fossils and nodules of black chert were noticed in these upper beds in many localities. Thin partings of black or dark brown shale occur between the strata. The lower beds vary in thickness from a few inches to 2 feet. They are all very fine-grained and light in colour, olive-greys and very light browns prevailing. The weathered surface sometimes has pale greenish tints, but is generally nearly white. Considerable pyrite is visible in some of these very fine-grained strata. Partings and thin beds of greenish shale occur at this horizon.

Near the base of the formation magnesian beds occur. Some of these are relatively pure but most are argillaceous and sandy. The impure strata are usually greenish grey in colour, and are quite thick. They are soft and weather rapidly and deeply. At Georgian bay nodules of white chert were noticed in magnesian beds apparently at the base of the formation; these beds are otherwise quite pure.

DISTRIBUTION

In Ontario the limestones of the Black River formation are exposed over two areas which are separated by a wide wedge of Precambrian rocks. These areas are:—

1. The Ottawa-St. Lawrence Rivers area.

2. A belt of country extending from Kingston to near Midland on Georgian bay.

Ottawa-St. Lawrence Rivers Area

The Black River limestones in the Ottawa-St. Lawrence Rivers area as mapped by the late Dr. R. W. Ells, occur in long, sinuous belts and in

[1] Report Royal Commission on Mineral Resources of Ontario, p. 41 (1890).

scattered outliers, in parts of the counties of Prescott, Glengarry, Stormont, Dundas, Russell, Carleton, Lanark and Renfrew, generally underlain by Chazy limestones and sometimes overlain by Trenton (Figure 2). The Black River as exposed in this area is chiefly of the thick-bedded, dark brown, shale-streaked type characteristic of the upper parts of the formations that are exposed in the belt extending westward from Kingston. The light-coloured beds and the impure magnesian strata are seldom represented in this area. The strata are generally flat-lying.

In the eastern part of the province the Black River limestones occur in a narrow belt 2 to 5 miles in width that, although broken in several places by faults, extends from the southwest corner of Russell county to the easternmost part of Ontario and thence parallels the Ottawa river to the city of Ottawa. The greater part of the rock is hidden by drift but it is exposed in the southwest corner of Russell county, again near Mille Roches, Stormont county, where strata 3 to 10 feet thick occur, and again near Glen Robertson, Glengarry county. Along the Ottawa valley the Black River stone is well exposed in low ridges parallel to the river. The stone wherever seen in this area is dark brown and grey in colour and contains irregular shale streaks through it. Much quarrying for building stone was formerly carried on here, but most of the quarries have been abandoned for years.

East of Pakenham and Almonte in Carleton and Lanark counties is a large, irregular-shaped outlier of Black River. The stone is dark-coloured and, as a rule, in heavy beds some of which are fairly free from irregular shale streaks. Near Pakenham flat nodules of black chert were noticed in this stone.

At Dirleton, Carleton county, is a small outlier of thick-bedded, dark brown, fine-grained, Black River stone. Interbedded with the dark brown stone is about 4 feet of grey, medium-grained, pure, high-calcium stone that is quarried for lime-burning. The overburden is very light in this area.

Northwest of Pakenham the brownish, fine-grained, Black River limestones occur over a considerable area.

As may be seen from the sketch map, there are numerous outliers in Renfrew county. In the outlier west of Arnprior, strata are exposed which are characteristic of the Black River formation in the belt extending from Kingston to Midland. The exposures are on the top and side of a cliff facing the Ottawa river. At the top the stone is brownish grey and of medium grain. Irregular shale streaks occur in many of the beds and some black chert was noticed. Midway down the slope very fine-grained, olive-grey and buff-coloured beds occur with thin partings of shale. These are followed by grey, argillaceous, magnesian beds and shale beds. Several quarries were once operated for stone for lime-burning and for building stone in this outlier, but they have been idle for a number of years.

The remaining Black River exposures in Renfrew county exhibit the usual type of stone as is exposed in the Ottawa-St. Lawrence Rivers area. In the neighbourhood of Fourth Chute, west of Douglas, a small amount of building stone is produced. Much of the stone in this vicinity contains silicified fossils and chert.

The Kingston-Midland Belt

The belt of Black River limestones which extends across the province from Kingston to near Midland on Georgian bay is, along the northern edge, in many places exposed in escarpments from 10 to 75 feet, or more, high. The southern edge is largely drift-covered. The belt was not traced throughout its entire length but was examined at places adjacent to rail and water transportation. The geological boundaries of this belt as shown on the sketch map are taken principally from the Geological Map of Canada, prepared in 1864 by Sir William Logan. The northern boundary is very much indented and small outliers are numerous. The southern boundary is particularly hard to define owing to the covering of soil and to the fact that outcrops of Black River limestones occur far south of the main belt, with outcrops of Trenton intervening. The Geological Map of Canada shows the Black River extending in a narrow belt from Crookston to Kingston, but later investigations have proved that most of the drift-covered rock as far south as Belleville and Napanee is of Black River age though outliers of Trenton also occur.

The limestones of this belt have a general southerly dip at a low angle and are overlain by the Trenton. They are generally underlain by a thin layer of gritty shales and sandstones which in turn rest on the crystalline Precambrian rocks. The Chazy limestones are absent from this area unless the impure basal beds may be considered as such.

The general description of the Black River, previously given, applies fairly closely to the succession of strata as exposed in this belt. The impure, magnesian beds are well exposed in the vicinity of Kingston, Marmora, Burnt River, Longford, Medonte and on Midland bay. Black chert was noticed in the upper beds in many localities and white chert occurs in the basal magnesian beds as exposed in the quarry on the shore of Midland bay. The quarries operating in 1925 were in the vicinity of Kingston, Napanee, Point Anne, Crookston (Plate VIII A) and Coboconk.

CHEMICAL COMPOSITION

The greater part of the Black River formation consists of moderately pure, high-calcium limestones. The irregular shaly streaks that characterize much of the upper part of the formation account for the most of the silica and alumina content, and lower the quality of what would otherwise be a very pure, high-calcium limestone. The cherty stone is worthless from a chemical standpoint. The finer-grained, light-coloured stones, although free from shale streaks and generally purer than the dark-coloured stone, as a rule contain small amounts of pyrite. The basal part of the Black River in some localities contains impure magnesian beds.

Analyses of Black River Limestones

—	1	2	3	4	5
Insoluble mineral matter	2·30	4·90	9·70	2·50	2·70
Ferric oxide	0·84	0·41	0·70	0·07	0·56
Alumina	2·36	0·79	0·70	0·30	1·04
Calcium carbonate	91·27	90·66	85·60	94·58	90·66
Magnesium carbonate	3·18	2·88	3·03	1·51	5·15
	99·95	99·64	99·73	99·59	100·11
—	6	7	8	9	10
Insoluble mineral matter	27·60	2·82	1·86	2·85	0·96
Ferric oxide	1·12	0·49	0·28	0·31	0·95 (Ferric oxide and Alumina)
Alumina	1·13	0·23	0·11	0·15	
Calcium carbonate	41·76	95·00	95·94	94·20	96·43
Magnesium carbonate	26·82	1·52	1·57	2·18	1·75
	98·43	100·06	99·76	99·69	100·09

1. Renfrew county.—Canada Lime Company quarry, lot 18, con. XIII, McNab tp.
2. Lanark county.—Outcrop on lot 23, con. XII, Pakenham tp.
3. Carleton county.—Rideau Canal Supply Company quarry on Merivale road west of Ottawa.
4. Glengarry county.—Small quarries lots 6 and 7, con. II, Lochiel tp.
5. Frontenac county.—Barriefield cut east of Kingston, upper fine-grained limestone.
6. Frontenac county.—Barriefield cut east of Kingston, lower impure beds.
7. Peterborough county.—Outcrop on road east of Ontario Rock Company siding near Preneveau.
8. Hastings county.—Outcrop at Marmora, lots 7 and 8, con. IV, Marmora tp.
9. Ontario county.—Light grey, very fine-grained stone in old quarry north of Longford.
10. Victoria county.—Canada Lime Company quarry, Coboconk.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1917.

QUARRIES AND USES

In the past the Black River limestones were largely quarried for building stone, the thick beds providing excellent material for heavy construction, and the thinner beds, which are generally free from the objectionable shaly streaks, making excellent material for houses and other buildings. At present very little building stone is quarried except at Crookston.

Considerable crushed stone is obtained from the limestones of this formation at Kingston, Medonte, Uthoff, and Napanee. Many other quarries have been operated from time to time but they were idle during 1925.

A large amount of lime is produced from the Black River limestones at Coboconk and a small amount at Napanee. The writer was informed that some of the very fine-grained beds cannot be used for lime-burning, as under the action of heat this stone breaks into very small pieces which choke up the kiln.

At Point Anne the Black River limestones are extensively quarried for use in cement manufacture.

Attempts were made to produce lithographic stone from some of the very fine-grained beds, but the difficulty, when an otherwise suitable stone was found, was to obtain sufficiently large slabs free from veinlets and small crystals of calcite.

The Black River limestones on the shore of Midland bay were formerly quarried for flux for use in the blast furnace at Midland.

The Trenton Formation

The Trenton limestones overlie the Black River limestones and are in turn overlain by the Utica shales. The maximum thickness of the Trenton formation in Ontario, as shown by well borings, is about 600 feet.

DESCRIPTION OF THE STONE

In Ontario the Trenton formation consists of fossiliferous, bituminous limestones which are usually of a brownish grey or bluish grey colour. The grain varies from fine to medium. The beds are mostly thin (2 to 6 inches) with occasional ones up to 2 feet. Partings of dark brown shale occur between the limestone beds and a network of shale seams runs through most of the stone; these shale seams are so thick and numerous in most parts of the formation that the limestone is left as small oval-shaped masses surrounded by shale. The rubbly stone is characteristic of the lower 100 feet or so of the formation, after which there is a zone about 100 feet thick, containing strata up to 2 feet and more in thickness. Many of the beds in this zone are somewhat rubbly but many layers occur in which the shale is present only as very thin streaks which do not greatly weaken the stone. Silicified fossils and nodules of chert are common in these heavy beds in many localities, particularly from Peterborough county westward. Above this zone the Trenton is composed largely of rubbly limestones, with occasional heavy beds until near the summit of the formation where the rubbly stone is overlain by shaly limestones and shales (Plate X A).

The above general description does not apply to all localities, but it does apply to the major part of the Trenton as exposed in Ontario. In the eastern part of the province the rubbly character is not so pronounced and some good building stone is obtainable.

DISTRIBUTION

Trenton limestones are found in two separate areas in Ontario. (Figure 2.)

1. In the eastern tip of the province bordered by the Ottawa and St. Lawrence rivers.

2. In a broad belt, averaging 35 miles in width, extending across the province from lake Ontario to Georgian bay.

In the eastern tip of the province Trenton limestones are exposed over one large area and over several smaller areas along the Ottawa valley. The large area which covers most of the country between the Ottawa and

St. Lawrence rivers, east of Ottawa, is underlain by Black River limestones and capped by Utica shales. The country is very flat and the greater part is deeply covered by soil. In Stormont and Glengarry counties very few outcrops were observed. South of Apple Hill, Glengarry county, the thick-bedded, fine-grained stone is exposed in an old quarry, but in the few other exposures the stone is thinly bedded and rubbly. In the northern part of this area near the Ottawa river, exposures are frequent and quarries have been opened near L'Orignal, Plantagenet, Ottawa, and also along the line of the Canadian Pacific railway in Russell and Prescott counties. Much of the stone is rubbly but a number of sound beds from 6 inches to 2 feet in thickness were seen, in which the stone is comparatively free from shale streaks. This type of stone is of fine- to medium-grain and grey in colour.

The small outliers in the Ottawa valley in the vicinity of Stittsville, Carleton county, and Douglas, Renfrew county, are composed chiefly of fine-grained, brown-grey stone through which thin shale streaks are frequent.

The broad belt of Trenton limestones that extends across the province from lake Ontario to Georgian bay, has a general dip to the southwest at a low angle, in which direction it is overlain by the black Utica shales. In the peninsula of Prince Edward county, which is entirely underlain by Trenton, exposures are frequent both along the lake shore and inland. At Massasauga point some of the heavy, compact beds occurring near the base of the formation are exposed in a quarry, but over most of the peninsula the beds are thin and have shale partings. Near Picton, cliffs, 200 feet high, bordering the shore, exhibit the thin-bedded, rubbly stone characteristic of the major part of the formation. These rubbly beds are also well exposed in numerous outcrops and small quarries over the northern and eastern parts of the county. The slaty stone of the upper part of the formation is exposed in a few places in the southern half of the county. Westward in Hastings county some small exposures of thinly-bedded, rubbly limestones were observed in the bed of the Moira river at intervals from Belleville to Latta. In Northumberland county the impure limestone, interstratified with much shale (the upper Trenton), is exposed southwest of the town of Trenton. Elsewhere in this county exposures were noticed only in the northeastern part, chiefly along the Trent river, from Meyersburg to Healey Falls, at which latter place about 60 feet of the Trenton is exposed in a cliff, the bottom beds of which are comparatively free from shale. In Peterborough county the heavy, cherty beds are well exposed along the Indian river, east of Warsaw. Exposures of the rubbly stone also occur south of the Black River belt, north of Lindsay and Peterborough. South of this no exposures were noticed in Durham until the lake shore was reached where the upper Trenton is exposed near Bowmanville. Westward, in Victoria and Ontario counties, exposures of rubbly stone, in many places containing chert, are frequent in the vicinity of Fenelon Falls, Kirkfield (Plate IX B), and along the eastern shore of lake Simcoe. West of lake Simcoe the soil covering is very heavy and no Trenton outcrops were observed except in the neighbourhood of Collingwood where fine-grained, thinly bedded, grey Trenton limestones are exposed. They were formerly quarried for flux.

CHEMICAL COMPOSITION

The Trenton limestones of Ontario, on analysis, show a rather high percentage of insoluble matter. This is due largely to the amount of shale which occurs throughout the formation. When the limestones of the bottom and middle portions of the formation are obtainable free from or containing only a few shale streaks, as near Ottawa, they are shown by analysis to be very pure, high-calcium limestones containing only a very small percentage of magnesium carbonate and insoluble matter. The soft, dull-lustred stone of the upper portion of the formation is, as a rule, very impure.

Analyses of Trenton Limestones

—	1	2	3	4	5
Insoluble mineral matter	6·41	1·80	1·00	0·80	7·90
Ferric oxide	0·56	0·28	0·42	0·28	0·50
Alumina	0·24	0·34	0·78	0·62	0·50
Calcium carbonate	89·59	95·30	95·80	97·00	86·53
Magnesium carbonate	3·80	1·21	1·80	1·80	3·18
	100·60	98·93	99·80	100·50	98·61

—	6	7	8	9
Insoluble mineral matter	4·90	4·78	6·90	11·00
Ferric oxide	0·28	0·53	0·81	1·12
Alumina	0·12	0·35	0·59	1·08
Calcium carbonate	93·51	91·69	89·50	82·90
Magnesium carbonate	0·75	3·00	0·80	3·79
	99·56	100·35	98·60	99·89

1. Glengarry county.—Old quarry 2 miles south of Apple Hill.
2. Carleton county.—Thibeault quarry, east side Rideau river, at Hogsback.
3. Carleton county.—H. Robillard & Son quarry, lot 22, con. I, Gloucester tp., fine-grained stone.
4. Carleton county.—H. Robillard & Son quarry, lot 22, con. I, Gloucester tp., coarse-grained stone.
5. Prince Edward county.—Quarry on lot 52, con. II, W. G. P. Sophiasburg.
6. Peterborough county.—Rock cut on C.P.R., 1 mile east of Havelock.
7. Victoria county.—Kirkfield Crushed Stone, Ltd., quarry, lot 49, con. IX, Eldon tp.
8. Ontario county.—Outcrop on lot 22, con. I, Thorah tp.
9. Simcoe county.—Old quarry of Cramp Steel Company near Collingwood.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1917 and 1918.

QUARRIES AND USES

Throughout the great Trenton area from lake Ontario to Georgian bay the only product obtained is crushed stone, the large quarry at Kirkfield being the chief producer. Several small quarries operated in the eastern counties during 1925 to supply road metal for local use. The fine-grained, siliceous stone is the most suitable for this purpose. In the Ottawa-St. Lawrence area crushed stone is the principal product; a small amount of building stone is also obtained.

Formerly, lime was burned from the Trenton stone in many localities, but at present there is no production. Much of the Trenton limestone where obtainable free from shale would provide a pure high-calcium stone suitable for chemical purposes, but unfortunately the shaly, rubbly material is usually interstratified with the best stone.

Stone for flux was at one time quarried from the Trenton near the towns of Trenton and Collingwood when blast furnaces were being operated at those points. Portland cement was formerly produced at Lakefield, north of Peterborough.

Ordovician Shales

Overlying the Trenton limestones are several thick shale formations, in some of which thin beds of impure limestone occur. These limestones are of no commercial value.

SILURIAN LIMESTONES

A broad belt of rocks of Silurian age consisting of shales, sandstones and dolomites extends across the province from the Niagara river to the Bruce peninsula and to the islands beyond. Another large area of Silurian rocks occurs south of Hudson bay.

In southern Ontario the line of contact between Ordovician and Silurian rocks is well defined by a precipitous and deeply indented cliff, the Niagara escarpment, which extends from the Niagara river to the tip of the Bruce peninsula and is seen again on Manitoulin island. The upper part of this cliff is composed of the hard, resistant Silurian dolomites, and the lower part of soft Ordovician shales. The general dip of all the Silurian strata is southwestward at a low angle.

The geology of the Silurian rocks of southern Ontario has been discussed by M. Y. Williams[1] and reference should be had to his report for details regarding the various formations.

The Medina-Cataract Formation

The lowest formations in the Silurian system are composed of sandstones, shales and dolomites. In the east the rock at the base of the Silurian is a sandstone, known as the Medina sandstone. In the west, however, at the same horizon, beds of dolomite and shale occur between the sandstones and to this series the name "Cataract" has been given. Following the nomenclature adopted by Williams the term "Medina-Cataract" will be used to designate the basal sandstones, shales, and dolomites of the Silurian system that overlie the eroded Ordovician shales and are in turn overlain by the shales and dolomites of the Clinton formations.

[1] Williams, M. Y.: Geol. Surv., Canada, Mem. 111 (1919).

The Manitoulin Dolomite

The principal dolomite band in the Medina-Cataract formation is known as the Manitoulin dolomite. Other bands of dolomite occur on the Bruce peninsula and on Manitoulin island but that territory has not yet been visited during the field work. The Manitoulin dolomite has its greatest development on Manitoulin island and the Bruce peninsula where, according to Williams, the thickness is 60 feet.[1] The band gradually thins out to the southeast where it also becomes very shaly and otherwise impure.

The rock is grey to blue-grey, medium- to fine-grained, thinly bedded, compact and semi-crystalline. The weathered surface is usually stained a dirty brown and is always very rough, due apparently to the rock being composed of thin layers of unequal hardness (Plate X B). The softer or, perhaps more accurately, the less resistant layers weather rapidly and deeply and leave the hard, resistant layers standing out in a series of narrow ridges parallel to the bedding-planes. Crystals of pyrite, nodules of chert and geodes filled with gypsum are common. Outcrops of this dolomite are seen along the escarpment at intervals from the Bruce peninsula to Stony Creek. At Owen Sound very little shale was observed, but at Credit Forks and southeastward a great deal of shale is interbedded with the dolomite.

In chemical composition the Manitoulin dolomite is impure and, to judge by the available analyses, somewhat variable. The stone is generally argillaceous and the insoluble matter and iron are always high.

Analyses of Manitoulin Dolomite

—	1	2
Insoluble mineral matter	10·70	6·40
Ferric oxide	0·06	1·40
Ferrous carbonate	1·05	not det.
Alumina	0·73	0·20
Calcium carbonate	66·00	51·59
Magnesium carbonate	20·54	40·34

1. Grey county.—Lot 8, con. XI, Collingwood tp. Sampled by M. Y. Williams. Analysis published in Geological Survey of Canada Memoir 111, p. 110 (1919).
2. Grey county.—Oliver Rogers quarry, Owen Sound. Sampled by Howells Fréchette. Analysis published in Mines Branch Summary Report, 1917, p. 46.

The Manitoulin dolomite sometimes forms the capping rock of a secondary escarpment which, in some localities, as at Owen Sound, Credit Forks, and near Collingwood, juts from the lower part of the Niagara escarpment. At these and several other localities it has been quarried at various times. Some extensive quarries are located in this dolomite to the east of Owen Sound where it is quarried chiefly for rubble and crushed stone. Other than for rubble and crushed stone the uses are few. The

[1] Williams, M. Y.: Geol. Surv., Canada, Mem. 111, p. 28 (1919).

differential weathering and the drab colour of the weathered surface make it unsuitable for a building stone. The proportion of soft material causes it to be rated as a poor grade of road metal. Wherever seen from Owen Sound southward it is much too impure to be used for lime-burning.

The Clinton Formation

The name " Clinton " is applied to the thin series of dolomites and shales between the Medina sandstones below and the Rochester shales above. The formation is of very limited distribution and is exposed only on the Niagara peninsula and for a short distance northward. It is generally exposed along the face of the escarpment in such a position as to be inaccessible for quarrying. Two dolomite bands each having a maximum thickness of about 10 feet occur in this formation, the lower known as the Renayles dolomite and the upper as the Irondequoit dolomite. In some localities they are separated by a thin bed of shale but in other localities they adjoin. The Renayles dolomite is generally grey or buff in colour, fine-grained and compact. It is always impure especially at the bottom where it is usually sandy and contains much pyrite. The Irondequoit is semi-crystalline, hard, fine-grained, bluish-grey, porous, and very fossiliferous. It contains some pyrite and is somewhat siliceous. The Renayles dolomite is frequently thinly bedded (Plate XI A) but the Irondequoit is nearly always in thick beds. The dolomite bands decrease in thickness north of Dundas and are not seen in any sections exposed north of Kelso. No use is made of these dolomites. The Irondequoit, where accessible, would provide large-dimension building stone.

The Lockport Formation

The Lockport formation consists of magnesian limestones and dolomites. This formation overlies the Rochester shales and is overlain by the very similar Guelph dolomites. The thickness of the Lockport formation varies from 80 feet at the Niagara river to upwards of 200 feet[1] on Manitoulin island.

DESCRIPTION OF THE STONE

The many excellent sections of Lockport exposed along the face of the escarpment from Queenston to the Bruce peninsula exhibit all the various types of stone that occur in the formation. In the Niagara peninsula there is at the base of the Lockport a band, from 6 to 8 feet thick, of impure, bluish grey, compact, clayey dolomite, usually containing much pyrite and in many places considerable shale. This bed is known as the DeCew waterlime (Plate XI B). Above the DeCew there is a porous, light bluish, fossiliferous, semi-crystalline, magnesian limestone, known as the Gasport, varying from 5 to 25 feet in thickness. This stone which occurs in thick beds (Plate XII A) is free from shale partings, but occasionally contains masses of blue stone, throughout which blue shale is irregularly distributed. These two lower beds are well developed only in the Niagara peninsula and vicinity. Above the Gasport is the heavily bedded, porous, grey and

[1] Williams, M. Y.: Geol. Surv., Canada, Mem. 111, p. 58 (1919).

blue-grey, fine-grained dolomite which constitutes the greater part of the formation. This is succeeded by brownish, thinly bedded, fine-grained, compact dolomite, generally having thin, bituminous partings, and which is everywhere characteristic of the top of the Lockport formation.

In the Hamilton-Dundas area a very impure part of the Lockport formation is to be seen. The waterlime and magnesian limestone at the base are both impure. Above them, instead of the pure dolomite seen elsewhere, is first, a thin bed of shale and then a zone of varying thickness of blue-grey dolomite containing a great deal of chert (Plate XII B). Overlying the very cherty, greyish dolomite is impure dark brown bituminous dolomite interbedded with much shale. Throughout this zone chert nodules occasionally occur and crystals of pyrite, gypsum, galena and zinc blende are common, especially pyrite. Succeeding this shaly zone is about 35 feet of hard, dark brown, fine-grained, thinly bedded dolomite with thin, bituminous shale partings. These are the top beds of the formation. Chert occurs through a thin zone at the very top and some crystals of the minerals previously mentioned were also noticed. Overlying the thin chert zone is the Guelph dolomite.

From Kelso northward, the Lockport is usually pure, the complete sections as exposed along the face of the escarpment (Plate XIII A) consisting almost entirely of grey, blue-grey, or buff, heavily bedded, porous dolomite in which chert was not noticed. Fossils are very numerous in this zone and the stone contains many small cavities. The top beds are always brownish, thinly bedded, fine-grained and compact.

DISTRIBUTION

The Lockport dolomite forms the brow of the Niagara escarpment throughout its entire length and is generally the rock underlying the soil for a distance of from 5 to 10 miles back from the face, except in the deep indentations. The face of the escarpment presents an almost continuous exposure of Lockport from the Niagara river to the tip of the Bruce peninsula. On top of the cuesta, back from the cliff face, exposures of the brownish, upper strata are fairly common in the Niagara peninsula, and also between Dundas and Kelso, in which district the soil covering is thin. North and west of Kelso the Lockport is seen in a few places, usually in the river valleys, especially in the vicinity of Guelph and Orangeville. But from Orangeville almost to Owen Sound rock exposures are very few. From 10 miles southeast of Owen Sound to Cabot head the soil covering is mostly thin and the rock is frequently exposed.

CHEMICAL COMPOSITION

As may be seen by referring to the analyses given below and to the description of the stone previously given, the Lockport dolomites vary considerably in their chemical composition from the Niagara river to Kelso, but from Kelso northwesterly, with the exception of the few bottom beds at Limehouse, the composition is more uniform and the stone is generally pure. Analysis No. 1 is representative of what is believed to be the DeCew bed, except that the iron content as here shown seems to be much too low. Analyses No. 6 and No. 8 show the usual composition of the magnesian limestone band known as the Gasport. Analysis No. 5 shows the composition of the upper part of the Lockport formation in the Dundas area, but, judging from appearances, it is most probable that the upper beds of the Lockport in other localities would not show such a high percentage of impurities. The remaining analyses show the average composition of the greater part of the Lockport formation, and show it to be a pure dolomite.

Analyses of Lockport Limestones

—	1	2	3	4	5
Insoluble mineral matter	10·90	0·81	0·52	1·80	5·00
Ferric oxide	0·70	0·53	0·46	0·60	0·56
Alumina	1·02	0·21	0·12	0·80	0·84
Calcium carbonate	49·25	55·80	54·95	53·54	52·11
Magnesium carbonate	37·80	42·40	43·50	43·16	41·10
	99·67	99·75	99·55	99·90	99·61

—	6	7	8	9
Insoluble mineral matter	2·50	1·60	2·00	0·50
Ferric oxide	0·90	0·71	0·55	0·15
Alumina	0·10	0·49	0·45	0·05
Calcium carbonate	78·88	57·45	68·87	54·60
Magnesium carbonate	15·91	40·00	26·51	44·60
	98·29	100·25	98·38	99·90

1. Halton county.—Bottom strata in old quarry of the Toronto Lime Co., Ltd., at Limehouse.
2. Halton county.—Average of quarry of Toronto Lime Co., Ltd., lot 24, con. IV, Esquesing tp.
3. Halton county.—Average of quarry of D. Robertson & Co., lot 3, con. VII, Nassagaweya tp.
4. Peel county.—Quarry north of Melville Junction (formerly Contractor's Supply Co., Ltd.)
5. Wentworth county.—Lower 30 feet of quarry of Canada Crushed Stone Corporation, Ltd., Dundas.
6. Lincoln county.—Lower 15 feet in quarry of Queenston Quarry Co., Niagara tp.
7. Welland county.—Upper 20 feet of Walker Bros. quarry, Thorold.
8. Welland county.—Lower 20 feet of Walker Bros. quarry, Thorold.
9. Grey county.—Quarry owned by Chalmers Estate, Owen Sound.

The above analyses were made in the laboratory of the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. These analyses were published in the Mines Branch Summary Report for 1917.

QUARRIES AND USES

The many splendid quarry sites available adjacent to towns and cities, together with the various types of stone that can be obtained, have resulted in numerous quarries being opened up in the stone of this formation.

Building Stone. Much desirable building material is obtainable from the Lockport, generally from the lower and upper portions of the formation. The lower beds, particularly the Gasport, are usually thick and are more compact and free from cavities than are the beds in the middle of the formation; from them dimension stone of good quality is quarried near St. David. Formerly several large quarries were operated for the production of heavy building stone between Grimsby and the Niagara river. The stone obtained from the lower strata is generally grey and blue-grey and turns somewhat lighter in colour on exposure to the weather. The thinner bedded material of the upper part of the formation affords good coursing stone, rubble and rip-rap. At Shelburne a light buff, finely-granular, porous stone which is soft and easily worked is quarried for building purposes. It has a very pleasing appearance. In many localities small amounts of stone are obtained to supply local and occasional demands. Much of the stone in the middle part of the formation contains too many cavities to be of value as a high-class building material.

Crushed Stone. The more compact, fine-grained, hard strata of the Lockport formation afford a good quality of crushed stone for use as road metal, railroad ballast and in concrete work. Such stone occurs always near the top of the formation, and in the Niagara peninsula some of the lower beds are of this character. The porous stone is not so desirable for this purpose. The principal operating quarries are at or near Guelph, Waterdown, Dundas, Vinemount, Thorold and St. David. Numerous small quarries are operated intermittently at many other points to supply crushed stone for local roads.

Lime. From Kelso northwesterly the greater part of the Lockport is a pure, porous dolomite that makes excellent magnesian lime such as is desired by many builders and by many sulphite-pulp manufacturers. Large quarries with adjacent lime kilns are operated along the face of the escarpment at Kelso, Christie Siding, Limehouse and Owen Sound. The brown stone at the top of the formation is very pure in some localities and this stone is quarried and burned for lime at Wiarton, Rockwood, and south of Hamilton. The product in every case is lump lime, none being hydrated.

Before the general use of Portland cement the bed of DeCew waterlime was quarried and burned to make natural cement.

The Guelph Formation

Overlying the Lockport dolomites and being in turn overlain by the Salina shales are the dolomites of the Guelph formation. As stated by Williams[1] the thickness of the Guelph is difficult to measure owing to the lack of complete sections, but from the interpretation of boring records and from the measurement of such sections as are available he estimates that over the area from Niagara Falls to Elora the thickness varies from 90 to 140 feet. Northwards even less data are available regarding the thickness of the formation. The general dip is to the southwest at a very low angle.

[1] Williams, M. Y,: Geol. Surv., Canada, Mem. 111, pp. 71, 72 (1919).

DESCRIPTION OF THE STONE

The Guelph dolomites are as a rule very pure, light-coloured, semi-crystalline, porous, fine-grained rocks. The predominant colour is from light brown to buff and grey with lesser amounts of bluish grey stone. The whole formation is fairly uniform in appearance and composition (Plate XIII B). Shale is absent, with the exception of a very little in the strata near the base as is noted below.

The bottom strata are usually dark brown in colour, streaked with black and have very thin partings of black bituminous shale between the beds. Small vugs filled with petroleum sometimes occur and small amounts of sphalerite and galena are common, the sphalerite in some cases filling cavities in, or entirely replacing, some of the fossils. An occasional chert nodule occurs in the bottom few feet. Above this, almost to the top of the formation, is thick-bedded, buff and grey stone, beds of 3 and 4 feet thick being not unusual. Fossils are common and many cavities, large and small, occur lined with crystals of dolomite. The top of the formation, wherever seen, consists of thinly bedded, brown and light brown dolomite. In no place was the contact with the overlying shale observed.

DISTRIBUTION

Owing to the paucity of exposures in the southeast and northwest parts of the area underlain by the Guelph formation, and owing to the similarity in appearance of the Lockport and Guelph dolomites, only the dolomites underlying the lenticular area extending from a few miles south of Galt to a few miles north of Durham were formerly definitely classed as belonging to the Guelph formation. Subsequent work and information obtained from boring records have shown that the Guelph is the underlying rock, from the Niagara river to the foot of the Bruce peninsula (Figure 3). According to Williams[1] this belt averages 5 miles in width in the Niagara peninsula and 13 miles in width from Hamilton to the foot of the Bruce peninsula. In the Bruce peninsula the Guelph occurs only in isolated patches.

In the Niagara peninsula the Guelph dolomites are practically everywhere covered by deep soil. North and west of Dundas, the soil covering is thin and exposures are very frequent especially in the township of Beverly. From there to Fergus and Elora outcrops are not so numerous and those that do occur are chiefly in the river valleys. Northwest of Fergus to the foot of the Bruce peninsula outcrops are very rare and occur only in the river beds.

CHEMICAL COMPOSITION

The Guelph dolomites are remarkably pure and uniform in chemical composition as may be seen by referring to the analyses given below which represent the stone from over a very large area and from various horizons. The only part of the Guelph formation that does not measure up to this high standard of purity is the few feet at the base which, as previously stated, frequently contains small amounts of galena and zinc blende, as well as some bituminous matter which fills small vugs and occurs as a parting between the strata.

[1] Williams, M. Y.: Geol. Surv., Canada, Mem. 111, p. 70 (1919).

Analyses of Guelph Limestones

—	1	2	3	4	5	6
Insoluble mineral matter	1·00	1·00	0·70	0·30	1·00	1·00
Ferric oxide	0·35	0·35	0·14	0·14	0·28	0·21
Alumina	0·05	0·05	0·06	0·06	0·12	0·19
Calcium carbonate	54·60	54·25	53·18	54·60	53·54	53·89
Magnesium carbonate	43·02	43·32	44·02	44·80	45·09	43·01
	99·02	98·97	98·10	99·90	100·03	98·30

1. Wellington county.—James Gow quarry, Fergus.
2. Wellington county.—Quarry of the Alabastine Company, Paris, Ltd., Elora.
3. Wellington county.—Quarry of Standard White Lime Co., Ltd., Guelph.
4. Wellington county.—Quarry of Jas. Ashenhurst, lot 15, con. VI, Erin tp.
5. Waterloo county.—Christie-Henderson & Co., Ltd., 3 miles north of Hespeler.
6. Wentworth county.—Parkes Bros. quarry, lot 8, con. III, Beverly tp.

The above analyses were made in the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1917.

QUARRIES AND USES

Owing to nearness of markets and to good distributing facilities in that section and to the fact that the remainder of the Guelph area is more or less deeply covered with soil, the principal quarries in the Guelph formation are all located within the area between Dundas and Guelph.

Lime. The greatest use being made of the Guelph dolomites is for the manufacture of lime, and for this purpose the stone is quarried and burned on a large scale at Elora, Guelph, and Hespeler, and on a lesser scale at Schaw and Fergus. The lime produced is a pure, magnesian, white lime suitable for any use to which a magnesian lime may be put. At Elora, Guelph, and Hespeler the large lime plants also produce hydrated lime.

Crushed Stone. At Fergus, Elora, Galt, Dundas, and from numerous small quarries throughout Beverly township, crushed stone is produced from the Guelph dolomites for use as road metal, railroad ballast and in concrete work. The finer grained, compact, hard stone usually found at the base and near the top of the formation is best suited for this purpose. At Dundas the lower beds of the Guelph are crushed and used as flux in the basic open-hearth furnaces at Hamilton. The fines resulting from the crushing operation are pulverized to make agricultural limestone.

Building Stone. Some building stone of very good quality is obtainable from the dolomites of the Guelph formation principally from the top and bottom strata, the stone from the main part of the formation containing too many cavities to be classed as a first-class building stone. No quarries were operated solely for building stone in 1925 but a considerable amount was obtained at Guelph from a quarry operated for stone for lime-burning.

The Salina Formation

Overlying the Guelph dolomites is a thick series of shales containing beds of dolomite, gypsum and salt, known as the Salina formation. The bands of dolomite are generally thin, shaly and otherwise impure and are of no commercial value.

The Bertie-Akron Formation

Grading upwards from the shales of the Salina formation is an impure dolomite known as the Bertie waterlime. Above the Bertie is another dolomite band known as the Akron. In many localities the contact between these two dolomites is of a transitional nature and no sharp line of dis-

ERRATUM

On page 48, under "Quarries and Uses", 3rd. paragraph, lines 6 and 7 should read:—

"At Dundas the lower beds of the Guelph are crushed and used for lining the bottoms of the basic open-hearth furnaces at Hamilton."

mottling is not in evidence. Succeeding the mottled band in one exposure at Byng, Haldimand county, is 14 feet or so of thin-bedded, blocky, buff-coloured, earthy dolomite containing a few chert nodules in the lower portion. The term "blocky" used above refers to the structure of the thinly bedded stone much of which, as seen in the exposure, is broken up into cubes two or three inches square; this may be due to weathering.

In the exposures in Bruce county the dolomite is all buff-coloured, shale is practically absent and thick beds 1 to 2 feet thick are common in the upper portions, but the bottom beds are thin.

DISTRIBUTION

Outcrops of the Bertie-Akron formation as mapped by Williams[1] occur along a narrow sinuous belt, 1 to 3 miles in width, extending from Bridgeburg on the Niagara river to Southampton on lake Huron. The location of this belt is shown on the sketch map (Figure 3). In the eastern part exposures are fairly frequent from Bridgeburg as far west as Hagersville, but from there northwesterly to Bruce county except in the vicinity of Innerkip, the rocks are deeply covered by soil and are nowhere exposed. In Bruce county outcrops occur only in the deep river valleys in the townships of Brant and Greenock.

CHEMICAL COMPOSITION

The lower member of the Bertie-Akron formation represents a more or less gradual transition from the underlying shale to dolomite and, especially in the east where the shaly phase is highly developed, it is very clayey and otherwise impure. In the northwestern part the shale is a negligible quantity and the dolomite is also much purer. The upper part of the formation, the Akron, is generally composed of fairly pure stone except at the very top where small crevices filled with sand occur.

The following analyses will give a general idea as to the chemical composition of the stone of the Bertie-Akron formation.

Analyses of Bertie-Akron Limestones

—	1	2	3	4
Insoluble mineral matter	6·80	8·60	1·20	2·20
Ferric oxide	0·71	0·56	0·32	0·21
Alumina	0·89	0·64	0·28	0·19
Calcium carbonate	50·68	51·75	53·88	53·54
Magnesium carbonate	39·46	38·10	42·42	42·86
	98·54	99·65	98·10	99·00

	5
Silica	3·44
Ferric oxide	1·86
Alumina	2·34
Calcium oxide	26·61
Magnesium oxide	17·47
Ignition loss	44·96
Water	0·35
	97·03

1. Welland county.—Lower 14 feet exposed in quarry, lot 7, con. VIII, Bertie tp. (This analysis includes the Akron dolomite and some of the Bertie waterlime).
2. Haldimand county.—Webber quarry, Byng. Lower 12 feet.
3. Haldimand county.—Winger quarry, Springvale. (Akron dolomite).
4. Bruce county.—Stone burned for lime from bed of brook, lot 2, con. VII, Brant tp.
5. Haldimand county.—Akron dolomite in cutting on Michigan Central railway, 1¼ miles east of Hagersville.

Analyses Nos. 1-4 were made at the Mines Branch, Department of Mines, Ottawa, from samples collected by Howells Fréchette. They were published in the Mines Branch Summary Report 1917. Analysis No. 5 was published in the Annual Report of the Ontario Dept. of Mines 1903, p. 145.

[1] Geol. Surv., Canada, Map 1715, accompanying Mem. 111 (1919).

Figure 3. Sketch map showing the distribution of the Silurian and Devonian limestone formations in southern Ontario.

Lime. The dolomites from this formation are burned for lime on a small scale near Cargill, and were formerly burned at Springvale, Innerkip and at a few other places. The purer stone from the Akron and upper parts of the Bertie is the most suitable and produces a strong, fairly white lime.

Building Stone. The greater part of the Bertie-Akron is too thinly bedded and too brittle except for use as rubble and rip-rap. At Byng, a thick stratum occurring at approximately the contact between the Akron and Bertie was being quarried in 1925 for large-dimension rip-rap and the thinner beds above were quarried for rubble.

Crushed Stone. The stone is generally too soft and too brittle to provide a desirable grade of crushed stone. However, it is quarried for road metal for local use where harder stone is not available.

DEVONIAN LIMESTONES

Overlying the Silurian dolomites and occupying the whole of the southwestern part of the Ontario peninsula are the sandstones, dolomites, limetones and shales belonging to the Devonian system. Another large area of Devonian rocks is found south of James bay.

In the Niagara peninsula the Oriskany sandstone is the basal Devonian formation, but west of Hagersville this sandstone practically disappears and the Onondaga limestones rest on the Silurian dolomites with only a very thin seam of sandy stone between. Farther to the northwest between the Onondaga and the Bertie-Akron formations there is a series of interbedded dolomites and limestones to which the name " Detroit River" has been given. This formation rests on the eroded surface of the Bertie-Akron and it is considered to be of Devonian age.

The Devonian rocks have been studied by Clinton R. Stauffer particularly from the point of view of their fauna. In his report " The Devonian of Southwestern Ontario", Memoir 34 of the Geological Survey of Canada, published in 1915, he describes many of the sections of rock exposed over the Devonian area and to this report reference should be made for details respecting the various outcrops.

The Detroit River Series

The Detroit River series is composed of pure, high-calcium limestones and dolomites. According to United States geologists quoted by Stauffer,[1] the complete series in the states of Michigan, Ohio, and New York has the following subdivisions:

		Feet
Detroit River series	Lucas dolomite	200 +
	Amherstburg dolomite	20
	Anderdon limestone	35 to 50
	Flat Rock dolomite	40 to 100

[1] Stauffer, C. R.: "Geol. Surv., Canada, Mem. 34, p. 273 (1915).

These measurements will naturally differ in Ontario where the upper members have been eroded away to an unknown extent.

At Amherstburg, Essex county, the Onondaga limestone rests directly on the eroded surface of the Anderdon limestone.

DESCRIPTION OF THE STONE

The basal dolomite member of the Detroit River series was seen only in one small exposure at a quarry near Amherstburg. The stone there is light brown in colour and finely granular in texture.

The Anderdon limestone differs considerably in its appearance where exposed in different parts of the country. In some exposures the stone is of a drab colour, in others yellow and occasionally, grey. The stone is generally soft, dull-lustred or earthy, compact, fine-grained and heavily bedded. At Amherstburg, however, the Anderdon limestone is crypto-crystalline, hard, brittle, and breaks with a conchoidal fracture. No shale occurs between the beds.

The dolomite overlying the Anderdon limestone is usually soft, rather porous, brown or buff stone, which is heavily bedded, fine-grained and free from shale.

DISTRIBUTION

The rocks of the Detroit River series, as mapped by Stauffer[1] and Williams[2], occur either as outcrops or beneath the soil in the following areas (Figure 3):—

1. In a narrow belt, 1 to 4 miles wide, adjoining the Bertie-Akron formation from the southwest corner of Brant county northerly to Port Elgin on the shore of lake Huron. This belt of rocks is apparently entirely covered with drift and no exposures of typical Detroit River stone were observed.
2. In a belt along the shore of lake Huron, extending almost continuously from point Douglas to 5 miles south of Goderich. This belt seems to consist entirely of Amherstburg (?) dolomite, exposures of which occur at intervals along the lake shore and in the beds of the Penetangore and Maitland rivers east of Kincardine and Goderich respectively.
3. Over a considerable area in the southwest corner of Essex county, where the Anderdon limestone and the underlying Flat Rock (?) dolomite are exposed in a quarry north of Amherstburg.
4. Over an area which is apparently an inlier, 3 to 4 miles wide, extending from Brussels, Huron county, 30 miles northerly to Chepstowe, Bruce county. The Amherstburg (?) dolomite is the underlying rock and is exposed in the river valleys between Brussels and Wingham and again at Teeswater.
5. The Detroit River series is exposed as small inliers within the Onondaga limestone at Gorrie, St. Mary's, and Beachville. All the exposures are in the river valleys. At Beachville and St. Mary's the pure Anderdon limestone is exposed, whereas at Gorrie the only exposure seen that was possibly of Detroit River age, was one of dolomite.

[1] Geol. Surv., Canada, Map 116A (1914).
[2] Geol. Surv., Canada, Map 1715 (1918).

CHEMICAL COMPOSITION

The Anderdon member of the Detroit River series is composed of pure, high-calcium limestone. At Beachville the quarries located in the Anderdon beds yield some of the purest limestone obtained in the province. Analysis No. 1 shows the composition of this stone. The Anderdon limestone quarried at Amherstburg is also very pure as shown by analysis No. 6. The analysis of the stone from the St. Mary's quarry (analysis No. 2) shows a considerable percentage of magnesium carbonate; this may be in part due to the sample including the upper beds in the quarry which are somewhat magnesian. These upper beds are possibly transitional beds between the Anderdon and the overlying dolomite which has here been eroded away.

The beds overlying the Anderdon limestone vary in composition from magnesian limestone to true dolomite as shown by analyses Nos. 3, 4 and 5. No analyses of the underlying Flat Rock dolomite are available.

Analyses of Detroit River Limestones

—	1	2	3	4	5	6
Insoluble mineral matter	0·48	1·90	1·50	0·60	0·20	1·60
Ferric oxide	0·52 (Ferric oxide and Alumina)	0·45	0·28	0·30	0·28	0·42
Alumina		0·55	1·12	0·90	0·92	0·38
Calcium carbonate	96·79	94·22	57·46	64·28	55·32	97·08
Magnesium carbonate	0·90	3·00	39·05	32·42	42·22	0·56
	98·69	100·12	99·41	98·50	98·94	100·04

1. Oxford county.—Beachville White Lime Co., Ltd., quarry. Analysis made at laboratory of the Steel Company of Canada, Hamilton, of average sample from 12 cars of stone.
2. Perth county.—Quarry of the Standard White Lime Company, St. Mary's Ont.
3. Bruce county.—Old quarry owned by John S. Smith, Inverhuron.
4. Bruce county.—Stone from bed of Penetangore river, con. III S, Kincardine tp.
5. Bruce county.—Quarry of The Alabastine Co., Paris, Ltd., Teeswater.
6. Essex county.—Quarry of Brunner, Mond, Canada, Ltd., Amherstburg.

Analyses Nos. 2-6 inclusive were made at the Mines Branch, Department of Mines, Ottawa, from samples obtained by Howells Fréchette. They were published in the Mines Branch Summary Report for 1917.

QUARRIES AND USES

The pure high-calcium limestone of the Anderdon beds affords a highly desirable stone and lime for use in the chemical and metallurgical industries and for these purposes it is extensively quarried at Beachville and Amherstburg. At Amherstburg the stone is all utilized in the large alkali works nearby, but the Beachville stone and lime are widely shipped for chemical and metallurgical purposes. The Anderdon limestone was formerly burned for lime at St. Mary's but operations have been discontinued for several years, due largely to the expense of removing the heavy overburden. A small amount of building stone has been obtained from the Anderdon beds at various times. None of the Detroit River stone is sufficiently hard to meet the requirements for crushed stone.

The dolomite of the Detroit River series is quarried and burned for lime at Teeswater. Most of the lump lime here produced is hydrated and sold for building purposes. Small amounts of building stone have been obtained for local use from these dolomites.

The Onondaga Formation

The Onondaga is the principal limestone formation of the Devonian system. Boring records and complete sections exposed show it to have a variable thickness of from 30 to 200 feet. At the base of the Onondaga is usually a thin layer of coarse-grained sandstone which rests on the eroded surfaces of the Oriskany sandstone, the Bertie-Akron dolomite, or the Detroit River series, depending on the locality. The Onondaga formation is overlain by the Delaware limestones.

DESCRIPTION OF THE STONE

The Onondaga formation as exposed in Ontario exhibits two main types of stone: one, a high-calcium limestone exposed in a belt of variable width across the province from Fort Erie, at the mouth of the Niagara river, to lake Huron south of Port Elgin; the other, a muddy-brown, magnesian limestone underlying nearly all of Essex county including Pelee and the neighbouring islands.

The high-calcium limestone constituting the belt across the province may be further subdivided into two varieties: one, a hard, fine-grained, dark brownish grey stone containing a great deal of chert (Plate XVI A); the other, a medium- to coarse-grained, semi-crystalline, soft, grey, blue-grey, and buff stone, comparatively free or entirely free from chert. The extremely cherty stone is usually characteristic of the lower part of the formation, though a certain amount of chert seems to occur at all horizons. The chert-free stone apparently occurs as lenses in the cherty stone. East of Goderich a complete section of the Onondaga, which is there only 31 feet thick, is composed of chert-free stone. All of the stone is fossiliferous especially the coarser-grained, grey variety in which large corals are especially abundant. The cavities in these fossils are frequently filled with petroleum.

The magnesian stone exposed in the southernmost part of the province is mostly medium- to fine-grained, soft, dull-lustred and muddy brown in colour, though some is grey. Chert occurs to a small extent in the stone near Amherstburg but on Pelee island none was noticed. This stone is exceptionally thick-bedded (Plate XVI B), beds 10 feet thick occurring in some exposures, but these thick beds are usually split into thinner ones. The top few feet are always rubbly, due probably to weathering action.

DISTRIBUTION

As previously mentioned, the Onondaga limestones occur over two separate areas in southern Ontario, the extent of which areas is shown on the sketch map (Figure 3). Over the crescent-shaped belt of Onondaga limestones extending from lake Erie to lake Huron, rock exposures are frequent only in Welland and Haldimand counties, chiefly along the lake shore and in the river valleys. The cherty stone predominates, though some thick lenses of chert-free limestone occur in the vicinity of Port Colborne and Sherks. West and north of Haldimand county the depth of soil over the rock increases and there are practically no rock exposures to be seen except in the vicinity of Woodstock, St. Mary's, and near Gorrie and Chepstowe in Bruce county. At Woodstock the cherty stone is exposed in the valley of the Thames. At St. Mary's the chert-free Onondaga is to be seen in the large quarries south of the town. A few small exposures of cherty limestone occur in the river valleys near Gorrie and Chepstowe. East of Goderich the Onondaga limestone, capped by the Delaware limestone, outcrops near the bottom of the deep valley of the Maitland river.

Most of Essex county is also deeply covered by drift but magnesian Onondaga limestone is exposed in a large quarry north of Amherstburg and in a small outcrop near the mouth of the Detroit river. On Pelee island outcrops are numerous.

CHEMICAL COMPOSITION

The Onondaga limestones wherever exposed in the belt extending across the province from Fort Erie to Port Elgin, are always more or less siliceous even when obtainable free from chert nodules. Judging from the available analysis the magnesia content is always very low. The cherty stone is of course worthless from the chemical and metallurgical standpoint.

In Essex county, as is shown by analyses Nos. 5-9 given below, the Onondaga stone frequently contains a large percentage of magnesium carbonate, but contains much less silica than does the high-calcium variety. This stone can be classed as a relatively pure magnesian limestone. A few chert nodules occur in this stone at Amherstburg.

Analyses of Onondaga Limestones

—	1[a]	2[a]	3[a]	4[a]	5[b]	6[b]
Insoluble mineral matter	3·50	4·30	6·40	3·40	....	....
Silica	....	....	....	....	2·14	1·81
Ferric oxide	0·42	0·45	0·36	0·28	0·32 (Ferric oxide and Alumina)	0·80 (Ferric oxide and Alumina)
Alumina	1·38	0·35	1·04	0·32		
Calcium carbonate	94·22	92·80	89·94	93·87	72·11	60·89
Magnesium carbonate	0·52	1·51	1·21	1·51	23·07	35·70
Moisture and organic matter	....	....	....	....	2·34	0·80
	100·04	99·41	98·95	99·38	99·98	100·00

—	7[c]	8[c]	9[c]
Insoluble mineral matter	....	....	1·44
Silica	1·38	1·40	0·42 (Silica and Ferric oxide)
Ferric oxide	0·49	0·45	
Alumina	0·45	0·47	....
Lime	51·60	43·06	45·72
Magnesia	2·01	10·05	7·22
Carbon dioxide	42·80	42·28	43·76
Moisture and organic matter	....	....	·72
Sulphur trioxide	0·30	0·32	0·67
Alkalies	....	0·40	....
	99·03	98·43	99·95

1. Welland county.—Quarry on lot 13, Lake Erie front, Bertie tp.
2. Haldimand county.—Quarry on lot 2, con. II, Rainham tp.
3. Haldimand county.—Quarry on lot 1, con. XIV, Walpole tp.
4. Perth county.—Quarry of St. Mary's Cement Co., St. Mary's.
5. Essex county.—Brunner, Mond quarry, Amherstburg, top 12 feet.
6. Essex county.—Brunner, Mond quarry, Amherstburg, second 12 feet.
7. Essex county.—Pelee island, top stone from quarry on west side of island.
8. Essex county.—Pelee island, stone at depth of 8 feet in quarry, west side of island.
9. Essex county.—Pelee island, stone at depth of 12 feet in quarry, north end of island.

[a]. Samples obtained by Howells Fréchette and analysed in the laboratory of the Mines Branch, Department of Mines, Ottawa. Analyses published in Mines Branch Summary Report, 1917.

[b]. Analyses furnished by Brunner, Mond, Canada, Ltd.

[c]. Analyses published by Miller, in "The Limestones of Ontario", Ontario Dept. of Mines, Report 1904, pt. II, p. 43.

QUARRIES AND USES

Crushed Stone. The hard, fine-grained, cherty variety of Onondaga limestone is extensively quarried at Windmill Point, Hagersville, and St. Mary's for crushed stone which is utilized as road metal, railroad ballast, and in concrete work.

Cement. The chert-free Onondaga limestones are quarried on a large scale for use in the manufacture of Portland cement at Port Colborne and at St. Mary's. In these localities the Onondaga contains very little magnesium carbonate and is especially well-suited to this purpose. The cherty stone cannot be utilized in cement manufacture.

Building Stone. Stone suitable for heavy construction was formerly quarried from the heavily bedded, magnesian limestone at Amherstburg and Pelee island; a large quantity of this heavily bedded stone is still available. Desirable building stone is still produced from the greyish, medium-grained, chert-free Onondaga at St. Mary's. The present production is small.

Lime. No lime is now produced from the Onondaga stone. Formerly it was produced on a large scale from the lenses of chert-free stone along the Lake Erie coast. The high-calcium stone is, in general, too high in silica to yield a lime fit for chemical uses.

The chert-free stone was at one time extensively quarried for blast-furnace flux and for use in calcium carbide manufacture, but the discovery of purer, high-calcium limestones led to these quarries being abandoned.

The Delaware Formation

Succeeding the Onondaga formation is another limestone formation known as the Delaware which is in turn overlain by the shales and limestones of the Hamilton formation. The Delaware is not a thick formation, the thickness as deduced from drilling records averaging only about 60 feet, but it occurs, usually beneath a great depth of soil, over a large area in the counties of Elgin, Norfolk, Middlesex, Perth, and Huron. It also underlies a small area at the junction of Essex and Kent counties and occurs as an outlier in Walpole township, Haldimand county. (Figure 3.)

Where seen near Cheapside in Walpole township, the Delaware limestone is very fine-grained, brown in colour, and occurs in thick beds. A great deal of black chert occurs both as thin beds and as nodules throughout the stone. A small quarry for road metal for local use has been opened here.

At St. Mary's the Delaware limestone is the upper rock in the quarries south of the town (Plate XV B). The stone as seen there is very fossiliferous, contains no chert, is fine-grained and is predominantly brownish grey in colour. Some excellent building stone is obtainable and the quarries were formerly operated for that purpose. The principal product now is crushed stone and stone for use in cement manufacture, the Delaware being quarried along with the underlying Onondaga for these purposes.

North of St. Mary's the Delaware limestone is exposed only in a few places, as along the river valleys south of Brussels, near Benmiller, and east of Goderich, and there only in sections of from 2 to 9 feet thick overlying the Onondaga limestones.

No analyses are as yet available but judging from tests that have been made, the Delaware limestones are similar in composition to those of the Onondaga formation.

The Hamilton Formation

The Hamilton formation is largely composed of shales, but at some horizons, beds of limestone occur. These limestones are frequently shaly and generally occur in zones so thin that quarrying operations could not be profitably carried on even if the stone were suitable. The best of the limestone beds are to be seen near Thedford and Arkona. The stone is drab and grey in colour, very fossiliferous, fine-grained, hard and brittle; shale layers are frequent. The thickest belt of limestones was seen in the bed of the brook at Arkona where, at the brink of the falls, a thickness of about 8 feet of beds, separated by brown shale, occurs. A small amount of stone for local building purposes has been quarried at Arkona and Thedford. The shaly, impure limestone occurring at the top of the Hamilton formation is to be seen at Ipperwash beach, Lambton county.

THE ALPENA LIMESTONE

Outcropping east of Wingham, Huron county, and traceable from there northerly to Chepstowe, Bruce county, is a peculiar variety of limestone to which the name " Alpena " has been given. This limestone was formerly considered to be of Onondaga age but as stated by Stauffer, " recent detailed study has shown it to be the equivalent of the middle Hamilton limestone at Alpena, Michigan."[1] It is supposed to be a coral reef which has been built up on top of the dolomite of Detroit River age which can be seen underlying it.

The Alpena limestone is exposed in knolls which, standing from 15 to 30 feet above the immediate level of the country, offer good quarry sites. How deep the Alpena limestone extends in some localities is problematical, but in several places, as stated above, the buff Detroit River dolomite can be seen at the base of knolls 15 to 30 feet high, so probably 25 feet is the average thickness. This limestone was built up by live corals and consequently is not stratified. It is blue-grey and brown-grey in colour, fine-grained, semi-crystalline, and fairly hard. Cavities are frequent especially in the upper part. The following analysis published by Howells Fréchette, in the Mines Branch Summary Report for 1918, shows that this type of stone as exposed on lot 8, concession A, Carrick township, is a pure, high-calcium limestone.

Analysis of Alpena Limestone

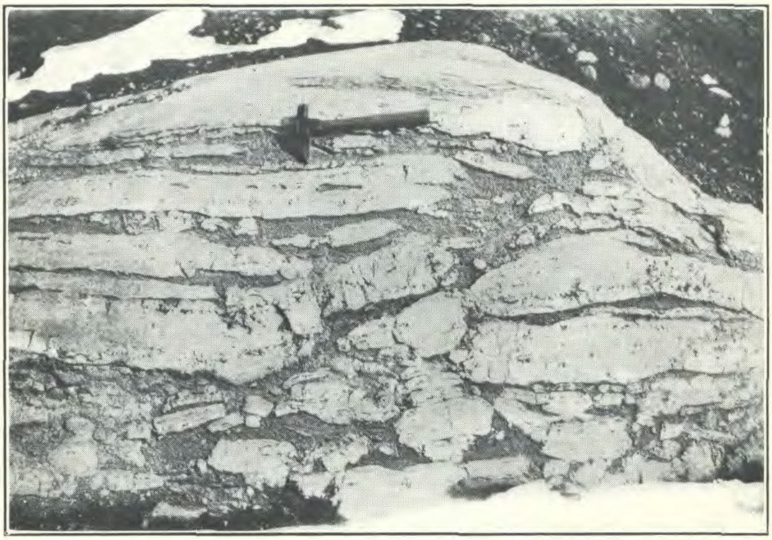
Insoluble mineral matter	0·70
Ferric oxide	0·21
Alumina	0·19
Calcium carbonate	97·08
Magnesium carbonate	1·96
	100·14

A well-equipped quarry was operated in the Alpena limestone, 4 miles south of Walkerville, a few years ago, supplying stone for chemical and metallurgical purposes, but it was not operated during 1925.

Above the Hamilton formation are two shale formations but they contain no limestones.

1 Stauffer, C.R.: Geol. Surv., Canada, Mem. 34, p. 10 (1915).

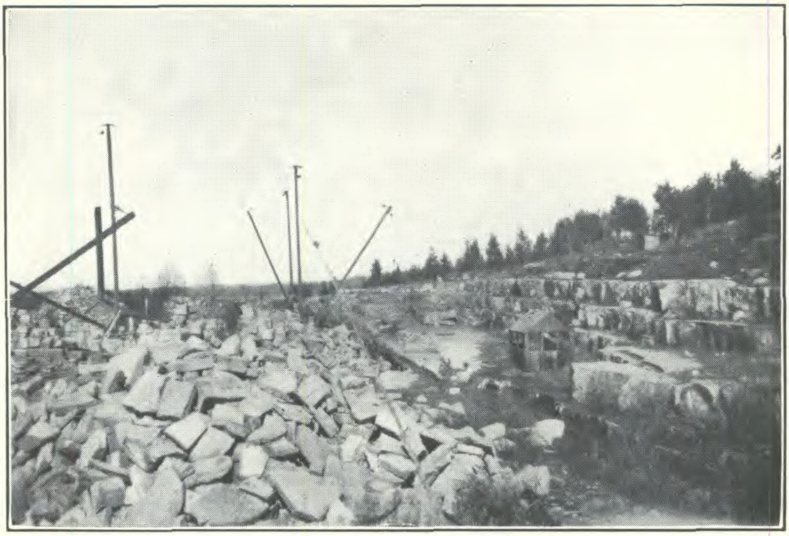
PLATE VII



A. Crystalline Grenville dolomite near Haley Station, Renfrew county. The light-coloured, resistant stone is very siliceous. The dark-coloured stone is pure dolomite.

B. Blue-and-grey striped crystalline Grenville limestone near Arnprior, Renfrew county.

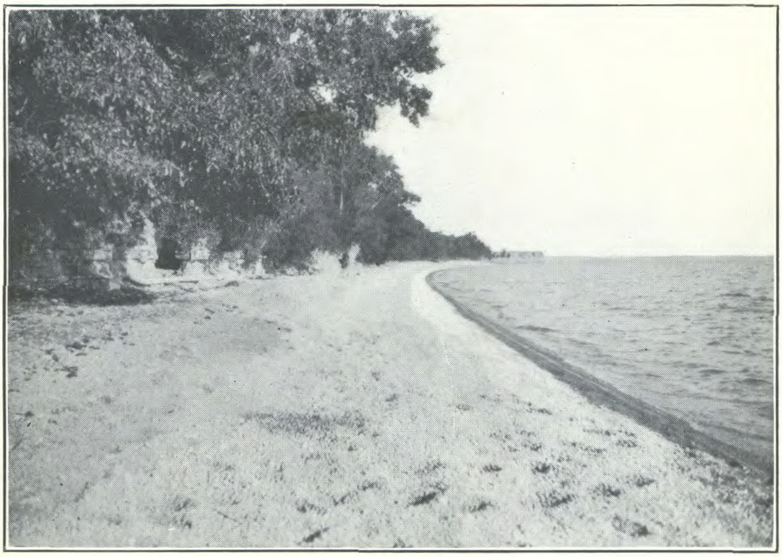
PLATE VIII



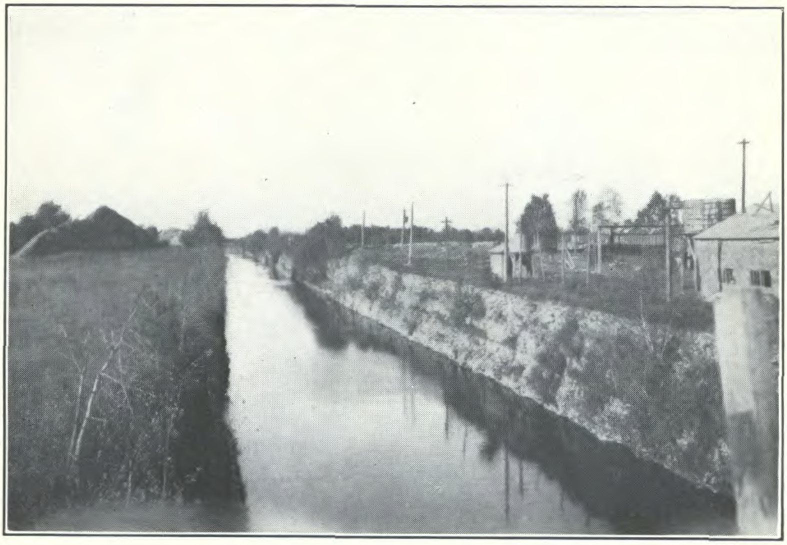
A. Heavily bedded Black River limestone, Crookston, Hastings county.

B. Evenly bedded Black River limestone, near Kingston, Frontenac county.

Plate IX



A. Shingle beach, Half Moon point, Prince Edward county. The pebbles are limestone derived from the cliffs of nodular Trenton limestone along the lake shore.



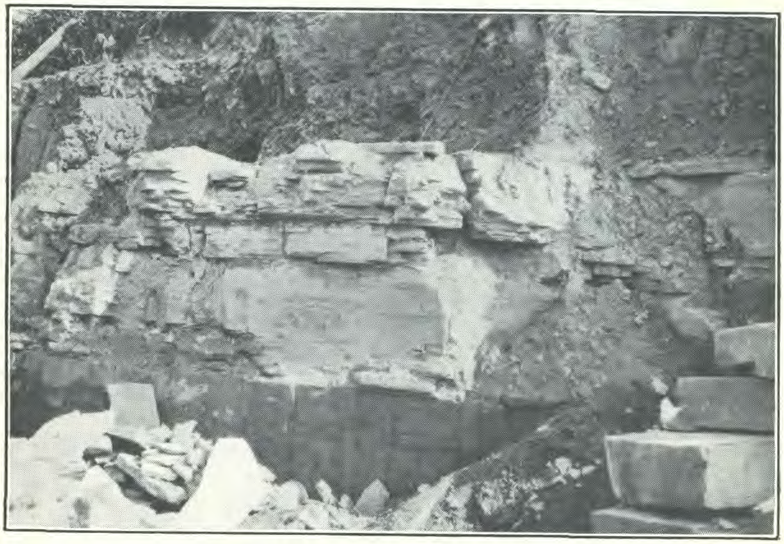
B. The Trent canal near Kirkfield, Victoria county. The canal at this point is cut through thinly bedded, rather rubbly Trenton limestone.

PLATE X

A. Thinly bedded, very shaly Trenton limestone, north of Lindsay, Victoria county.

B. Manitoulin dolomite, showing differential weathering, Owen Sound.

PLATE XI



A. Thinly bedded Renayles dolomite (light-coloured stone) overlying Medina sandstone (dark-coloured stone) near Kelso, Halton county.

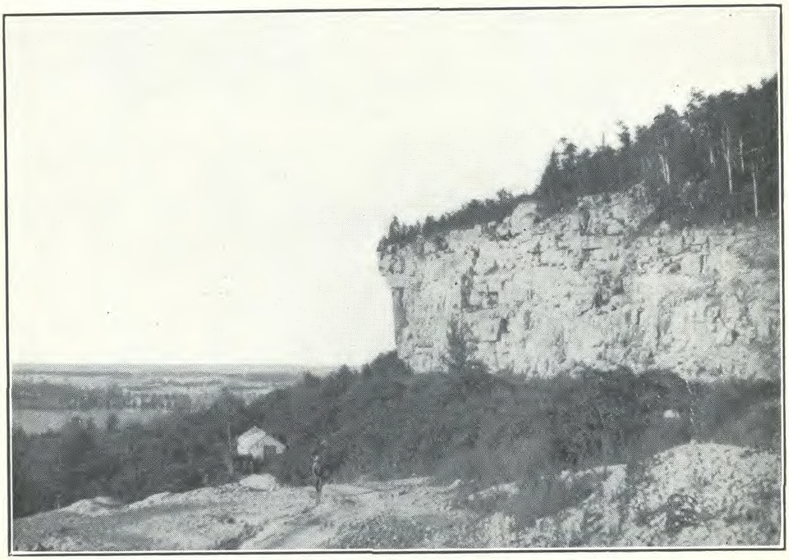
B. Lockport formation. DeCew waterlime (in foreground) overlain by Gasport dolomite, near Grimsby, Lincoln county.

PLATE XII

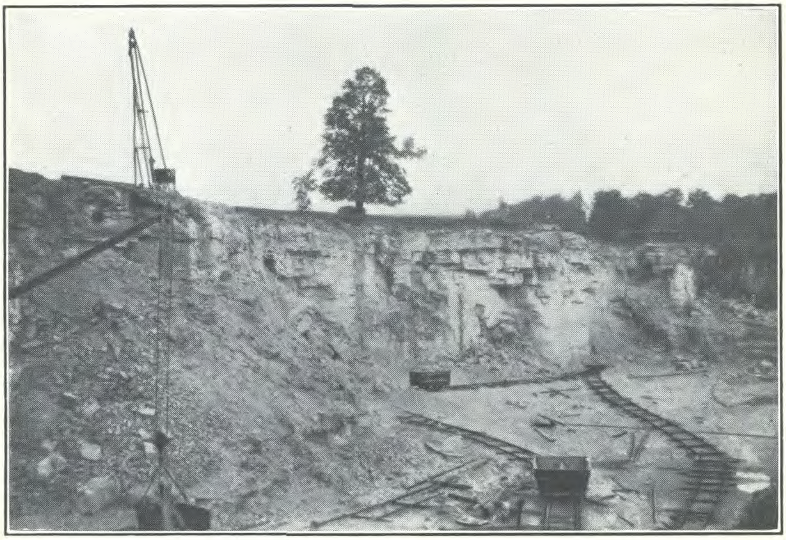
A. Lockport dolomite. Heavily bedded stone (Gasport) at the base of the formation, Queenston Quarry Co., Ltd., St. David, Lincoln county.

B. Cherty Lockport dolomite, near Hamilton. The chert shows as white spots

PLATE XIII



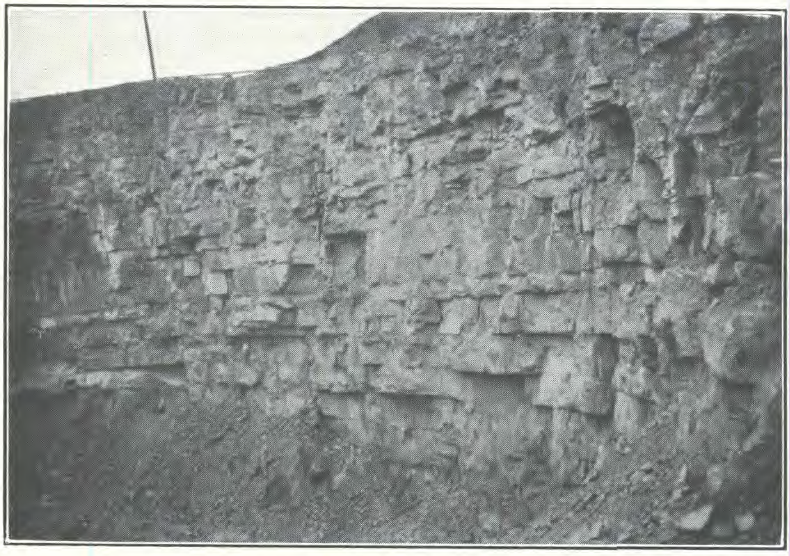
A. Heavily bedded Lockport dolomite forming the brow of the Niagara escarpment, near Kelso, Halton county.



B. Guelph dolomite, Christie-Henderson quarry, Hespeler, Waterloo county.

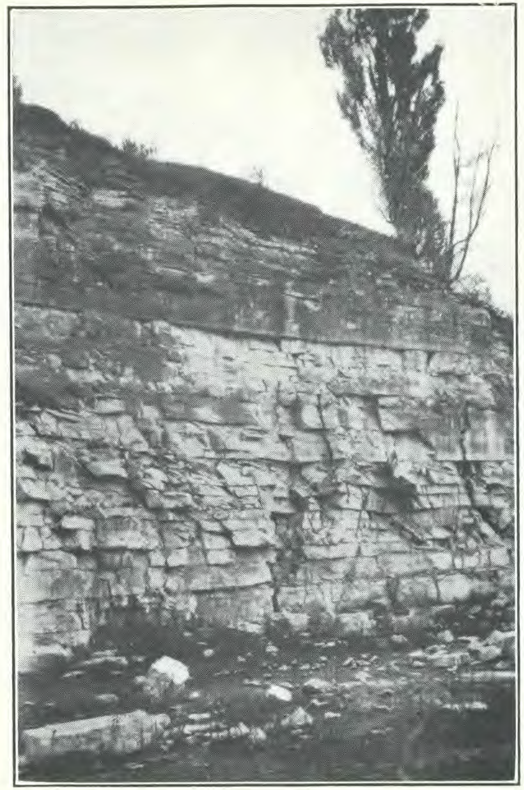
PLATE XIV

A. Evenly bedded Bertie-Akron dolomite, Webber quarry, Byng, Haldimand county



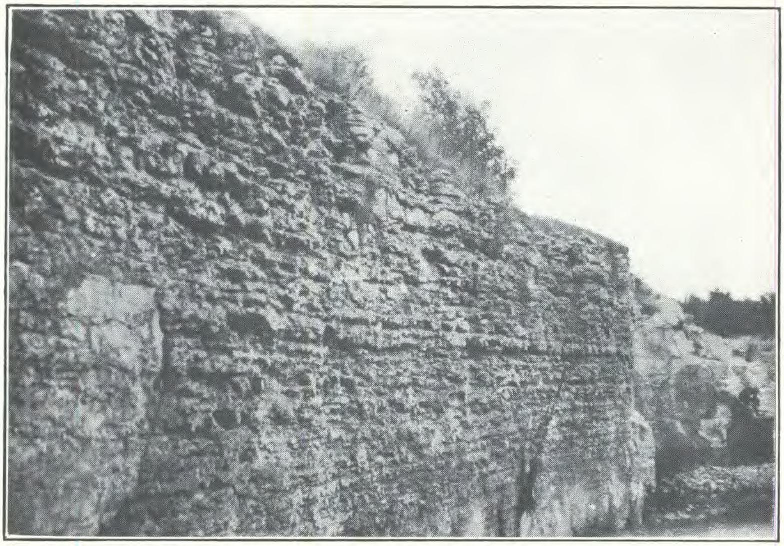
B. Detroit River dolomite (Amherstburg (?)) in quarry of The Alabastine Company, Paris, Ltd., Teeswater, Bruce county.

A. Detroit River limestone (Anderdon), Standard White Lime Co. quarry, Beachville. Oxford county.

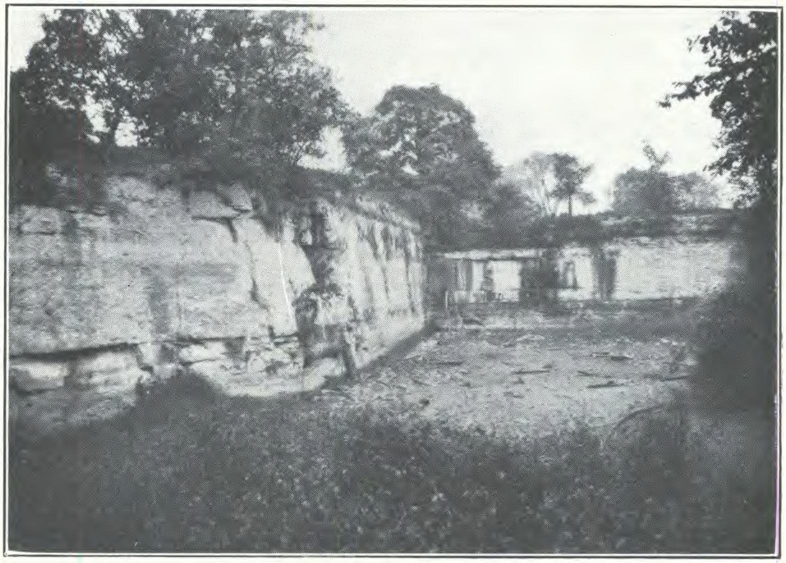


B. Delaware limestone (top 9 feet) overlying evenly bedded Onondaga limestone, Thames quarry, St. Mary's, Perth county.

PLATE XVI



A. Cherty Onondaga limestone, Buel quarry, near Windmill Point, Welland county. The chert resists weathering action and forms projections on a weathered surface.



B. Very heavily bedded, chert-free Onondaga limestone, Pelee island.

INDEX OF DISTRICTS AND COUNTIES

The special index of districts and counties is given to facilitate the finding of the descriptions of the limestones occurring in any one county or district. In this preliminary report mention is made only of the general distribution of the limestone formations, the individual counties not being mentioned in all cases. On this account the names of the counties or districts in which limestone occurs are not included in the general index but will be found in the special index together with the references to the limestone formations occurring therein.

QUEBEC

QUEBEC—*Continued.*

ONTARIO

ONTARIO—*Continued.*

GENERAL INDEX

See also Index of districts and counties