ONTARIO
DEPARTMENT OF MINES

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The Limestone Industries of Ontario

By

D. F. Hewitt

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Explanatory Notes and Glossaries of Terms

SCHEDULE FOR ROCK DESCRIPTION

The schedule for rock description used in this report is as follows:

Rock name, qualifying adjective or essential varietal characteristics; colour; grain size or crystallinity; bedding; characteristic features of structure, texture, or mineralogy such as cross-lamination, vugs, stylolites, pyrite, etc.; fossils.

Example: Limestone: shaly; brownish grey,[1] medium grey weathering; aphanitic; medium bedded; stylolites, calcite crystals; abundant *Tetradium*.

CRYSTALLINITY CLASSIFICATION

Coarse Crystalline	Over 5 millimetres.
Medium Crystalline	1–5 millimetres.
Fine Crystalline	0.2–1 millimetres.
Aphanitic	Under 0.2 millimetres; not detectable with the naked eye.
Microcrystalline	0.05–0.2 millimetres; aphanitic with crystals detectable under 10× hand lens (= lithographic).
Cryptocrystalline	Under 0.05 millimetres; individual crystals only detectable under microscopic examination (= lithographic).

GRAIN-SIZE CLASSIFICATION (WENTWORTH CLASSIFICATION FOR CLASTIC FRAGMENTS)

Boulder	Over 256 millimetres (or 10⅛ ins.).
Cobble	64–256 millimetres (2½–10⅛ ins.).
Pebble	4–64 millimetres (⅜–2½ ins.).
Granule	2–4 millimetres (⅜₁₆–⅜ ins.).
Very Coarse-Grained	1–2 millimetres.
Coarse-Grained	0.5–1 millimetres.
Medium-Grained	0.25–0.5 millimetres.
Fine-Grained	0.125–0.25 millimetres.
Very Fine-Grained	0.0625–0.125 millimetres.
Silt	0.004–0.0625 millimetres (settles rapidly in water).

BEDDING CLASSIFICATION

Massive-Bedded	Beds over 36 inches thick.
Thick-Bedded	12–36 inches.
Medium-Bedded	4–12 inches.
Thin-Bedded	2–4 inches.
Very Thin-Bedded	½–2 inches.
Platy	₁₆–½ inch.
Fissile	Less than ₁₆ inch.

[1]Colours follow the Rock Colour Chart as drawn up by the Rock Colour Chart Committee of the United States Geological Survey, the Geological Society of America, and other organizations.

CLASSIFICATION OF LIMESTONE AND DOLOMITE

The following classification is suitable for laboratory work:

Term Used	Calcite	Dolomite	MgO*
	percent	percent	percent
Limestone	95–100	0–5	0 - 1.1
Magnesian limestone	90–95	5–10	1.1- 2.1
Dolomitic limestone	50–90	10–50	2.1–10.8
Calcitic ~~limestone~~ dolomite	10–50	50–90	10.8–19.5
Dolomite	0–10	90–100	19.5–21.6

The following field classification is also used in this report:

Field Term	Dolomite	MgO	CaO	CaO:MgO*
	percent	percent	percent	
Limestone	0- 10	0 - 2.1	56.0 -53.54	greater than 27:1
Dolomitic limestone	10- 50	2.1–10.8	53.54–44.5	from 27:1 to 4:1
Dolomite	50–100	10.8–21.6	44.5 -30.4	from 4:1 to 1.4:1

*The CaO and MgO limits are true only if dealing with a pure stone; if impurities are present the CaO:MgO ratio is used.

The following terms are used for chemical limestone and dolomite:

High-Calcium Limestone. Limestone that contains less than 3 percent impurities (silica, iron, alumina, and other insolubles) and less than 2 percent magnesium carbonate.

High-Purity Dolomite. Dolomite that contains less than 3 percent impurities and at least 97 percent combined calcium and magnesium carbonates.

CLASSIFICATION OF CLASTIC LIMESTONES BY SIZE GRADATION

Calcirudite. A limestone composed of detrital calcium carbonate fragments predominantly larger than 4 millimetres in diameter. Also used for limestone conglomerate in some cases where limestone pebbles occur in a calcarenite or calcilutite matrix.

Calcarenite. A limestone composed of clastic calcite grains and sorted fossil debris of sand size: i.e. the calcareous equivalent of a sandstone; frequently shows cross-lamination.

Coquinoid Calcarenite. Calcarenite composed predominantly of sorted or partially sorted fossil debris, generally of sand-to-granule size. The matrix may be calcarenite to calcilutite.

Calcisiltite. A limestone composed of silt-size carbonate grains: midway in size between calcarenite (sand) and calcilutite (clay). Generally has a gritty feel or texture in contrast to calcilutite.

Calcilutite. A laminated limestone composed of clay-size and clay-to-silt size carbonate material of probable detrital origin; it results from lithification of calcium carbonate mud.

GLOSSARY OF GEOLOGICAL TERMS

Argillaceous. Clayey or containing clay or shaly material.

Bioherm. A mound-like or dome-like mass of reef-rock composed of sedentary organisms such as corals, algae, crinoids, stromatoporoids, etc., having a massive, non-bedded, porous lithology, surrounded by, and enclosed in, bedded limestone or dolomite of different lithologic character.

Biostrome. A massive tabular, flat, or lenticular mass of reef-rock rarely over 15 feet thick, composed of sedentary organisms such as corals, algae, crinoids, stromatoporoids, etc., enclosed in bedded limestone of different lithologic character.

Cherty. Carrying sparse to abundant nodules, lenses, or stringers of chert, a variety of microcrystalline to chalcedonic silica with conchoidal fracture.

Coquinoid. Characterized by abundant content of fossil debris.

Cross-Bedding. Bedding characterized by included minor beds that are oblique and inclined to the main stratification.

Cross-Lamination. Laminations confined to single beds and inclined to the general stratification.

Facies. Areally segregated parts of differing lithology belonging to any genetically related body of sedimentary deposits.

Reef. A massive limestone composed of sedentary organisms such as corals, algae, crinoids, bryozoa, etc., which developed in place as thick flat sheets (biostromes) or mounds or ridges (bioherms) on the sea floor. Usually enclosed in bedded limestone (or dolomite) of somewhat different lithology.

Shaly Partings. Thin laminae of shale between limestone beds.

Siltstone. A rock composed of over 50 percent silt-sized clastic grains.

Stylolite. Thin zig-zag irregular seams developed in limestone, usually coated with bituminous or shaly material.

GLOSSARY OF COMMERCIAL STONE TERMS

Riprap. Large angular blocks of quarry stone from 1 cubic foot (about 200 pounds) up to 10–12 tons in size. When riprap is individually placed and fitted on the face of a revetment wall, dike, breakwater, or pier, it is often termed "armour stone."

Rubble. Angular blocks of quarry stone from 5 inches to one foot in diameter, often with one smooth rock face, are termed rubble. This size of stone is also known as "man-sized" or "one-man stone," because it can be handled by one man, and is sometimes used for armour stone, walls, lime kiln feed or "tower stone" for pulp and paper mills.

Cut Stone or Dimension Stone. Stone cut or sawn into blocks of specified shape and size from large mill blocks. Commonly used for exterior and interior building stone.

Ashlar. Rectangular blocks of building stone up to about 1 foot or more in size, bounded by sawn, planed, or planar rock surfaces, used in walls or building facings. Split Faced-Ashlar is produced by splitting the stone in a guillotine to give a natural rock face. Even-Course Ashlar uses blocks of equal height for each course, although the blocks in the course may be of random length. Random Ashlar uses blocks of differing size and heights, giving irregularly and unequally spaced joints in the wall.

Ashlar is commonly produced in Ontario from 4- to 12-inch beds cut by saw or guillotine.

Flagstone. Large flat pieces of stone 1 to 3 inches in thickness generally rectangular in shape. Random Flagstone is irregularly shaped.

CRUSHED STONE

Crusher Run. Stone run through a crusher set to produce stone of a maximum 7/8-inch size would be termed 7/8-inch or 3/4-inch crusher and would consist of crushed stone of a maximum size, but containing a complete range of sizes from 7/8-inch to fines. There may be specification of the percentage and range of fines tolerated in crusher run.

Granular Base Course. The 3/4-inch crusher run used for the thick crushed stone base layer of a road or highway is termed "granular base course" or G.B.C. by the Ontario Department of Highways.

Traffic Bound. The 3/4-inch crusher run or granular base course used for traffic-bound gravel roads in which the surface is compacted by traffic is known as Traffic-Bound or T.B. The term is synonymous with granular base course or 3/4-inch crusher run.

Clear Stone. Stone accurately sized by screening, to remove sizes of stone larger and smaller than specified, is termed Clear stone, in contrast to crusher run, which contains a variety of sizes. Various sizes of clear stone, e.g. 1-inch stone, 3/4-inch stone, etc., may be blended to customer's specifications.

SIZES

The common commercial stone sizes are approximately as follows but may vary considerably from quarry to quarry, depending on the stone shape and number of sizes produced:

Nominal Stone Size	Passes Screen	Retained on Screen
2-in. stone	2 1/2-in.	1 3/4- to 1 7/8-in.
1 1/2-in. stone	1 3/4- to 1 7/8-in.	1 1/4-in.
1-in. stone	1 1/4-in.	7/8- to 3/4-in.
3/4-in. stone	1 1/4- to 1-in.	5/8-in.
5/8-in. stone	3/4-in.	1/2-in.
1/2-in. stone	5/8-in.	5/16- to 3/8-in.
3/8-in. stone	1/2-in.	1/4-in.
Chips (1/4-in. stone)	5/16-in.	1/8-in.
Screenings	minus 1/8-in.	

Table of Contents

Industrial Mineral Circular No. 5

MAP CASE
(At Back of Circular)

Map No. 1960c—Ontario Limestone Industries. Scale, 1 inch to 20 miles.

Map No. 1960d—Detroit River Limestone of the Beachville Area, Showing Drift Thickness. Scale, 1 inch to 1 mile.

Geological Quarry Sections, Reference Sections, and Diamond-Drilling Information, Black River–Trenton Groups, Georgian Bay–Lake Ontario Area.

Geological Quarry Sections, Bois Blanc and Bertie-Akron Formations, Hagersville–Lake Ontario Area.

Geological Reference Sections and Quarry Sections, Lockport-Amabel Formations, Niagara Falls–Dundas–Georgetown Area.

References

Since the following references occur repeatedly throughout, they are given here rather than as footnotes in the body of the report:

THOMAS E. BOLTON, *Silurian Stratigraphy and Paleontology of the Niagara Escarpment in Ontario*, Geol. Surv. Can., Memoir No. 289, 1957.

M. F. GOUDGE, *Limestones of Canada—Part IV, Ontario*, Can. Dept. Mines and Resources, Bureau of Mines, Bull. No. 781, 1938.

G. MARSHALL KAY, "Stratigraphy of the Trenton Group," *Bulletin*, Geol. Soc. Amer., Vol. 48, 1937, pp. 233–302.

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THE LIMESTONE INDUSTRIES OF ONTARIO

BY

D. F. Hewitt

I. Introduction

In the eight years since 1950, the production of limestone in Ontario has tripled. This marked expansion has been due to increased activity in the construction, chemical, and metallurgical industries, which are the chief users of limestone and limestone products. Production from the limestone industries now surpasses that of all other industrial minerals in tonnage and value.

Limestone and dolomite have a very important place in our industrial economy, and their uses are many and varied. The chief use, both directly and indirectly, is in the construction industry, where, as well as being an excellent building stone, it provides crushed stone for aggregate and is the primary raw material for the lime and portland cement industries. Limestone is the most common stone used for metallurgical flux, and large amounts are used in blast furnaces and open-hearth steel production. Dolomite is also used to some extent in refractories. In the chemical industry, lime is the most important alkali and is used in a variety of chemicals such as soda ash, calcium chloride, calcium cyanamide, and calcium carbide. Smaller amounts of limestone and lime are used in the glass, pulp and paper, sugar refining, and tannery industries, as well as for cyanidation in the gold mining industry. Recently there has been a large demand for lime in the uranium mills of the Blind River and Bancroft areas, and the capacity of the Ontario lime industry has been increased to meet these requirements.

In Ontario, available limestone and dolomite resources are adequate for most requirements of industry. The three geological horizons most widely used are the Black River–Trenton limestones extending across southern Ontario from Midland, on Georgian Bay, to Kingston, on Lake Ontario; the Guelph–Lockport dolomite forming the Niagara escarpment extending from Niagara Falls through Hamilton to the Bruce Peninsula; and the Middle Devonian limestones extending from Fort Erie through London and Woodstock to Lake Huron.

The outlook for the limestone industries of Ontario is excellent, and a continued expansion of limestone quarrying in the province is to be expected. In 1954 one quarry passed the 1,000,000-ton-per-year production rate, but in 1958 there were five quarries each producing over 1,000,000 tons of stone per year, with production in some cases exceeding 1,500,000 tons.

Although limestone is plentiful for most requirements, the supply of certain grades of stone, such as high-purity calcium limestone for the chemical industry, is limited, and it must be emphasized that this type of limestone is a wasting asset and should be regarded as such. With the physical and chemical specifications for stone becoming more detailed and more stringent, careful prospecting of favourable stone horizons is frequently required to find suitable stone.

In the search for stone the need has increased greatly for a knowledge of practical stratigraphy, sedimentation, and elementary structural geology.

II. Production and Use of Limestone in Ontario

The production and value of limestone produced in Ontario, 1950–58, are given in (1). The figures do not include those for limestone used in the manufacture of lime and cement.

The production and use of limestone in Ontario in 1957, compared with the figures for 1950, are given in (2). As indicated in this table, the four main uses of limestone, namely crushed stone, flux stone, lime, and portland cement, consume 96 percent of the limestone quarried. The crushed stone industry in 1957 used 68.4 percent of the stone, mainly for road construction, concrete aggregate, and railway ballast. Flux stone amounted to 1,345,291 tons or 6.4 percent of the total tonnage. The lime industry burned 1,515,635 tons of limestone and dolomite, or 7.2 percent. The cement industry used 3,001,482 tons, or 14.2 percent of the total.

The average price for crushed stone in 1957 was $1.10 per ton, with prices ranging from as low as 60 cents per ton to $1.85 per ton depending on size, grade, and location. The average price for flux stone was $1.07 per ton. The average price for pulverized stone was $2.73 per ton.

In 1958 there were 49 quarries in operation in Ontario, each producing over 40,000 tons of stone per year, whereas in 1948 there were only 24 quarries each producing over 40,000 tons per year. A list of limestone quarry operations in Ontario in 1957, in order of production, is given in (3).

(1) PRODUCTION OF LIMESTONE IN ONTARIO, 1950–58

Year	Tonnage	Value
1950	5,254,219	$ 6,192,498
1951	7,531,536	8,513,829
1952	7,524,832	8,800,659
1953	8,390,852	10,359,697
1954	9,816,205	11,446,494
1955	12,233,140	14,765,784
1956	15,217,629	19,316,877
1957	16,593,015	19,748,013
1958	15,220,361	18,677,112

(2) PRODUCTION AND USE OF LIMESTONE IN ONTARIO, 1957 AND 1950

Use	1957			1950	
	Tons	Value	Production (by use)	Tons	Value
			percent		
Crushed stone	14,394,129	$15,862,867	68.4	3,808,317	$4,029,853
Flux stone	1,345,291	1,441,218	6.4	467,913	487,954
Building stone	59,549	864,920		40,876	455,788
Riprap	517,250	826,150		32,216	48,360
Pulverized stone*	131,299	358,608		124,948	313,035
Pulp and paper	63,915	136,923		57,178	129,113
Glass industry	11,150	32,948	3.8	5,890	16,730
Sugar industry	11,155	13,887		.....	.....
Other chemical uses	46,020	47,659		1,365	1,050
Granules and grit	4,139	16,170		3,240	28,657
Miscellaneous	9,118	148,211		.....	.....
Total	16,593,015	$19,748,013	.....	4,593,607	$5,619,654
Cement industry	3,001,482	.....	14.2		
Lime industry	1,515,635	.....	7.2		
Grand Total	21,110,132	.....	100.0		

*Includes agricultural limestone and asphalt filler.

LIMESTONE PRODUCERS IN ONTARIO, 1957

Order of Production	Name	Address
	GROUP 1—OVER 1,000,000 TONS PER YEAR:	
1.	Nelson Crushed Stone Limited	Nelson
2.	Canada Crushed and Cut Stone Limited	Dundas
3.	Limestone Products Limited	Uhthoff
4.	Cyanamid of Canada Limited	Beachville
	GROUP 2—500,000–1,000,000 TONS PER YEAR:	
5.	Canada Cement Company Limited	Belleville
6.	Iroquois Rock Registered	Iroquois
7.	C. A. Pitts General Contractors Limited*	Cornwall Centre
8.	Brunner Mond Canada Limited	Amherstburg
9.	Gypsum Lime and Alabastine Limited	Beachville
10.	Hagersville Quarries Limited	Hagersville
11.	St. Marys Cement Company Limited	St. Marys
12.	Canada Cement Company Limited	Woodstock
	GROUP 3—100,000–500,000 TONS PER YEAR:	
13.	Chemical Lime Limited	Ingersoll
14.	Haldimand Quarries and Construction Limited	Hagersville
15.	Walker Brothers Limited	Thorold
16.	Frazer Duntile Limited	Ottawa
17.	Kirkfield Crushed Stone Limited	Kirkfield
18.	A. Cope and Sons Limited	Hamilton
19.	R. E. Law Crushed Stone Limited	Port Colborne
20.	Ottawa Valley Crushed Stone Limited	Ottawa
21.	Armstrong Brothers	Vinemount
22.	Queenston Quarries Limited	Queenston
23.	Canada Crushed and Cut Stone Limited	Hagersville
24.	Cayuga Quarries Limited	Cayuga
25.	McGinnis and O'Connor Limited	Kingston
26.	Niagara Crushed Stone (Humberstone) Limited	Port Colborne
27.	Canadian Gypsum Company Limited	Guelph
28.	St. Catharines Crushed Stone Limited	St. Catharines
29.	Gypsum, Lime and Alabastine Limited	Glen Christie
30.	Dibblee Construction Limited	Ottawa
31.	Canada Cement Company Limited	Port Colborne
32.	Frontenac Quarries Limited	Kingston
	GROUP 4—40,000–100,000 TONS PER YEAR:	
33.	Roblindale Quarries Limited	Roblindale
34.	Dominion Magnesium Limited	Haleys
35.	Geo. C. Campbell Limited	Ridgemount
36.	Jas. D. Gray and Son	Carlisle
37.	Lake Ontario Portland Cement Company Limited	Picton
38.	Ridgemount Quarries Limited	Ridgemount
39.	Brockville Crushed Stone Limited	Brockville
40.	Rieger Brothers	Pelee Island
41.	Industrial Sand and Gravel Limited	Georgetown
42.	Armstrong Brothers	Ottawa
43.	Dunnville Quarries Limited	Dunnville
Not in Order of Production	GROUP 5—LESS THAN 40,000 TONS IN 1957:	
	Armstrong Brothers	Marmora
	Bertrand Freres	L'Orignal
	J. L. Fulton	Haileybury
	D. Grandmaitre Limited	Ottawa
	Gypsum, Lime and Alabastine Limited	Milton
	Laurentian Stone Limited	Ottawa
	Niagara Cut Stone Limited	Thorold
	Rockwood Lime Company	Rockwood
	Vineland Quarries Limited	Vineland
	C. L. Storey	Napanee
	Bonnechere Lime Limited	Eganville
	Silvertone Black Marble Quarries	Crysler

*Now closed, plant dismantled (Ontario Hydro quarry).

(3) LIMESTONE PRODUCERS IN ONTARIO, 1957—*Continued*

Not in Order of Production	Name	Address
	(The following eight companies quarry Precambrian crystalline limestone and dolomite, often termed marble.)	
	Carleton Lime Products	Carleton Place
	Canadian Dolomite Company	Portage du Fort, Que.†
	Bolenders Limited	Eagle Lake
	Bonter Marble Products	Marmora
	W. F. Bonter Company Limited	Malone
	Canada Talc Industries Limited	Madoc
	Stoklosar Marble Quarries Limited	Madoc
	Jamieson Lime Company Limited	Renfrew
	(The following nine companies came into production in 1958 and 1959).	
	Milton Quarries Limited	Milton
	Lowville Quarries Limited	Lowville
	King City Sand and Crushed Stone Limited	Hamilton
	Halton Quarries Limited	Milton
	Armstrong Brothers Limited	Georgetown
	Peel Sand and Gravel Limited	Georgetown
	Limehouse Crushed Stone and Gravel Limited	Georgetown
	St. Lawrence Cement Company Limited	Colborne
	Blue Star Stone Limited	Ipperwash
	Amherst Quarries Limited	Amherstburg

†Quarry in Ross township, Renfrew county, Ontario.

The largest quarry operations in Ontario have rated production capacities of 500–600 tons per hour and produce at the rate of 4,000–10,000 tons per day, depending on the number of shifts worked. Several of the smaller operations are seasonal, depending largely on the building and road construction industries.

A. THE CEMENT INDUSTRY IN ONTARIO

There has been a large expansion of the portland cement plant capacity in Ontario between 1950 and 1958. In 1950 there were 3 cement plants in operation in Ontario with 5 kilns having a total rated capacity of about 5,500,000 barrels per year. In 1959 there were 6 cement plants with 14 kilns having a total rated capacity of over 17,000,000 barrels per year.

Cement production in Ontario for the period 1950–58 is given in (4).

In 1950 the three plants in operation were St. Marys Cement Company at St. Marys, and the Port Colborne and Belleville plants of Canada Cement Company. Since World War II the St. Marys Cement Company plant has been expanded to 4 kilns, while the Belleville plant of Canada Cement Company has been expanded to 3 kilns. In 1956 and 1957 new plants were opened by St. Lawrence Cement Company at Clarkson, and Canada Cement Company at Woodstock. In 1958 production began at the new plant of Lake Ontario Portland Cement Company at Picton.

A list of portland cement companies in operation in 1959, with their rated capacity, is given in (5).

The total rated capacity of the portland cement industry in Ontario is now more than 17,000,000 barrels per year, with sales amounting to just over 13,000,000 barrels in 1958; there appears to be adequate production capacity to meet present requirements and requirements for the immediate future.

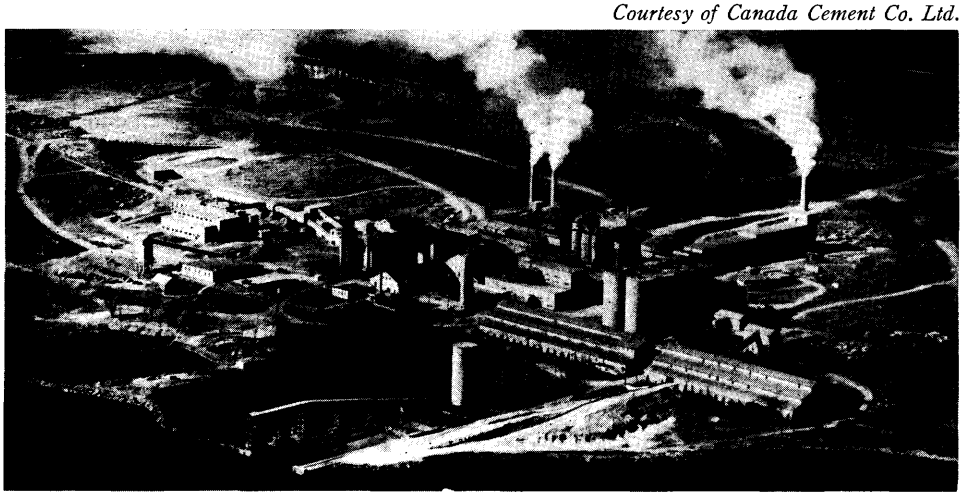
One of the major users of portland cement and aggregate in Ontario over the past decade has been the Hydro-Electric Power Commission of Ontario in its great expansion of hydro-electric power developments. In twelve power development projects completed by Ontario Hydro between 1950 and 1958, including the Robert H. Saunders power station and dam on the St. Lawrence seaway, the Sir Adam Beck No. 2 generating station at Niagara Falls, and the Des Joachim power plant and dam on the Ottawa River, over 16,000,000 barrels of portland cement were used, amounting to about 23 percent of the total Ontario cement production

during the period. The completion of most of this hydro-electric expansion program releases more cement for other markets. The Ontario Department of Highways construction program also uses large quantities of portland cement; reported current consumption ranges from 400,000 to 500,000 barrels per year.

Adequate stone reserves are available in the Black River–Trenton and Detroit River–Delaware limestone horizons to supply raw material for portland cement production for many hundreds of years.

All the cement plants in Ontario with the exception of Lake Ontario Portland Cement Company at Picton are wet-process plants. The kilns are fired with powdered coal.

Courtesy of Canada Cement Co. Ltd.



The Belleville plant of Canada Cement Company Limited, the largest portland cement plant in Ontario, is located at Point Anne, on Lake Ontario, 4 miles east of Belleville.

(4) PRODUCTION OF PORTLAND CEMENT IN ONTARIO, 1950–58

Year	Barrels	Value
1950	5,313,521	$10,953,896
1951	5,438,101	12,494,677
1952	5,577,025	14,142,060
1953	7,078,181	18,497,744
1954	7,208,061	18,958,173
1955	7,762,037	20,309,648
1956	8,288,213	21,455,019
1957	12,639,360	33,505,994
1958*	13,174,120	35,100,337

*Estimated.

(5) PORTLAND CEMENT PRODUCERS IN ONTARIO, 1959

Company	Location	Number of Kilns	Approximate Total Rated Capacity per 24 Hours
			barrels
Canada Cement Company Ltd.	Port Colborne	1	3,000
Canada Cement Company Ltd.	Belleville	3	11,600
Canada Cement Company Ltd.	Woodstock	2	9,400
St. Marys Cement Company Ltd.	St. Marys	4	9,600
St. Lawrence Cement Company Ltd.	Clarkson	2	11,000
Lake Ontario Portland Cement Co.	Picton	2	5,000
Total			49,600

B. THE LIME INDUSTRY IN ONTARIO

The production of lime in Ontario from 1950 to 1958 and a breakdown of the production and uses of lime in Ontario in 1957 are given in (6) and (7).

The percentage of total lime production broken down by uses is as follows for 1957 production:

Use	Total Production, 1957 Percent
Chemical industry	50.5
Iron and steel	14.1
Building trade	12.3
Uranium mills	9.9
Pulp and paper	2.4
Glass industry	2.0
Gold milling	1.3
Sugar industry	0.8
Smelters	0.8
Tanneries	0.6
Agriculture	0.2
Insecticides	0.1
Dealer and other uses	5.0
Total	100.0

In 1958, uranium mills used approximately 25 percent of a 1,000,000-ton total lime production.

In 1958 there were 15 lime plants in production in Ontario. The accompanying table (8) lists Ontario lime producers with the rated capacities of their plants.

In 1958, Ontario produced 64 percent of the lime produced in Canada. Ontario's pre-eminent position in the lime industry is largely due to the fact that the high-purity Detroit River calcium limestone is available as a stone source. Detroit River limestone is used by seven Ontario lime plants, which in 1957 produced 83.2 percent of Ontario production. The two quarry centres are at Beachville and Amherstburg. This high-purity calcium lime is the raw material for two large chemical plants, Brunner Mond Canada Limited at Amherstburg, and Cyanamid of Canada Limited at Niagara Falls (with a quarry at Beachville). These plants quarry their own high-purity calcium limestone and together produce for their own consumption about 50 percent of Ontario's lime.

Dolomitic lime, which is used mainly in the building trade, constitutes 15.3 percent of Ontario's production and is produced mainly from the Guelph-Amabel dolomite by four plants operating at Guelph, Hespeler, Rockwood, and Milton.

In 1958 lime production increased markedly owing to the large demand for lime in the Blind River and Bancroft uranium camps to neutralize acid wastes from the acid-leaching plants. Three new rotary kilns were put into operation by lime producers at Beachville in 1957 and 1958 to help meet this new demand for lime. With consumption of lime amounting to 40–60 pounds per ton of uranium ore milled, the total consumption of lime by the mines in the Blind River and Bancroft uranium fields is now over 250,000 tons per year.

Although a few of the older-type stack kilns with external fire-boxes burning coal or wood are still in production, the modern trend is towards gas-fired stack kilns or rotary kilns. The old-type stack kiln may produce 10–15 tons of lime per day. The larger modern gas-fired stack kilns, such as those recently installed by Gypsum, Lime and Alabastine Company Limited at Beachville, can produce up to 200 tons of lime per day with excellent fuel economy. Stack kilns generally use stone feed, 3–9 inches in size. Rotary kilns may use feed as small as ¼–½ inch in size. Rotary kilns generally have a higher rated capacity of 100–300 tons per day, and this, together with the ability to utilize the smaller stone sizes, has led to installation of several new rotary kilns in the past three years in various lime plants in Ontario.

(6) ONTARIO LIME PRODUCTION, 1950–58

Year	Tonnage	Value
1950	571,490	$ 6,030,228
1951	619,769	6,921,916
1952	622,279	6,921,062
1953	659,062	7,714,252
1954	610,591	7,680,739
1955	698,245	8,420,382
1956	673,357	8,258,785
1957	766,143	9,416,868
1958	1,009,916	12,644,925

(7) PRODUCTION AND USE OF LIME IN ONTARIO, 1957

Use	Quicklime		Hydrated Lime		Total Lime	
	tons		tons		tons	
Chemical industry	385,454	$4,147,371	1,613	$ 25,420	387,067	$4,172,791
Iron and steel	107,121	1,233,057	930	12,966	108,051	1,246,023
Building trade	17,531	317,598	76,726	1,574,167	94,257	1,891,765
Uranium mills*	75,257	921,693	320	4,447	75,577	926,140
Pulp and paper	17,882	207,100	555	8,551	18,437	215,651
Glass industry	15,263	197,947	.....	.....	15,263	197,947
Gold milling	7,413	79,153	2,788	38,697	10,201	117,850
Sugar industry	6,340	41,135	.....	.....	6,340	41,135
Smelters	4,225	49,335	1,866	25,932	6,091	75,267
Tanneries	1,326	15,355	3,345	46,482	4,671	61,837
Agriculture	.....	.....	1,701	24,507	1,701	24,507
Insecticides	59	674	435	8,216	494	8,890
Dealers and others	19,861	231,735	18,132	205,330	37,993	437,065
Total	657,732	$7,442,153	108,411	$1,974,715	766,143	$9,416,868

*The tonnage of lime used in 1958 in Ontario uranium mills amounted to 258,079 tons, giving it second place.

(8) ONTARIO LIME PRODUCERS, 1958

Company	Location	Type of Lime	Number and Type of Kilns	Total Rated Capacity in Tons per 24 Hours
Brunner Mond Canada Ltd.	Amherstburg	Calcium	5: stack	(*)
Bonnechere Lime Co.	Eganville	Calcium	3: stack	45
Canada & Dominion Sugar Co.	Wallaceburg	Calcium	2: stack	90
Canada & Dominion Sugar Co.	Chatham	Calcium	2: stack	90
Canadian Gypsum Co.	Guelph	Dolomitic	13: stack	250
Carleton Lime Products Ltd.	Carleton Place	Calcium	1: stack	9
Chemical Lime Ltd.	Ingersoll	Calcium	3: stack	300
Cobo Minerals Ltd.	Coboconk	Calcium	1: rotary	100
Cyanamid of Canada Ltd.	Beachville	Calcium	1: rotary	335
Cyanamid of Canada Ltd.	Niagara Falls	Calcium	7: rotary	700
Dominion Magnesium Ltd.†	Haleys	Dolomitic	2: rotary	150
Gypsum, Lime and Alabastine	Beachville	Calcium	6: stack 2: rotary	1,240
Gypsum, Lime and Alabastine	Hespeler	Dolomitic	10: stack	220
Gypsum, Lime and Alabastine	Milton	Dolomitic	3: stack	50
Rockwood Lime Co.	Rockwood	Dolomitic	2: stack	35

*Figures not available.
†Dolomitic lime produced for the production of magnesium metal.

III. Specifications and Uses of Limestone and Dolomite

Specifications for limestone and dolomite vary greatly depending on the use to be made of the stone. Initial specifications always include size gradation of stone and may include both size and shape of stone, as for example in the case of concrete aggregate where the absence of flat and elongate particles is desirable. Physical properties such as hardness, strength, density, coefficient of expansion, porosity, permeability, absorption, freedom from fractures, weathering, etc., are important if the stone is to be used for aggregate, building stone, railway ballast, and other "physical" uses. Where the stone is to be used for portland cement, lime, flux stone, chemical stone, pulp and paper, agricultural limestone, etc., the chemical composition may be the most important item of specifications. For some chemical uses such as lime manufacture and flux stone, porosity and permeability may also be important.

This section of the report gives a brief summary of typical specifications for limestone used in various industries for those who are unfamiliar with the subject. Detailed specifications should be obtained from the stone consumers in particular cases, since specifications may vary somewhat from those indicated here. Details of physical and chemical tests are described in *A.S.T.M.* (American Society for Testing Materials) *Standards* and other technical publications such as those of A.A.S.H.O. (American Association of State Highway Officials) and A.R.E.A. (American Railway Engineers Association).

TESTS FOR STONE

The main tests that may be made on commercial stone are the following:

1. Grading tests.
2. Petrographic examination—for presence of deleterious materials, unfavourable structures or textures; etc.
3. Soundness tests:
   a) Magnesium sulphate soundness.
   b) Freezing and thawing tests.
4. Abrasion tests:
   a) Deval abrasion test.
   b) Los Angeles abrasion test.
5. Absorption and porosity tests.
6. Reactivity tests.
7. Incompatibility tests—thermal coefficient of expansion.
8. Loss on washing—percentage of fines.
9. Density.
10. Strength.
11. Stripping tests—surface tension of aggregate.
12. Chemical analysis.

Tests required under specifications for various uses are given below. Many of these tests are not required for certain stone uses.

Grading Tests

Grading tests (see also A.S.T.M. specification, Method C136-46) to determine whether commercial stone meets sizing requirements laid down in specifications, are carried out by sieve analyses, using square-opening sieves. Sieve analyses are generally expressed in one of two ways: either in terms of the weight percentage of the entire sample retained on a given sieve, and passing the next larger sieve; or in terms of the total weight percentage of the sample retained on, or passing, a given sieve in the sieve series used. In concrete aggregate, grading affects the uniformity and workability of the concrete mix and has a pronounced effect on the amount of mixing water required to attain workability and the amount of portland cement required to achieve the necessary strength. In bituminous construction, workability and density depend almost entirely on grading. Strength, durability, permeability, and stability of the aggregate in the compacted mass also depend to some extent on grading.

In the case of railway ballast, stability and drainage are both greatly affected by grading.

In the manufacture of lime, size gradation of kiln feed is important in ensuring proper and uniform burning. Shaft kilns generally use feed over 3 inches in size, whereas rotary kilns use feed down to ½ inch in size.

Petrographic Examination

Petrographic examination of commercial stone samples by a petrographer or competent geologist is often of primary importance in assessing the presence and effect of deleterious materials, textures, or structures in the stone that may cause serious difficulties in the commercial application

intended. Among deleterious materials in concrete aggregate are clay, shale, shaly limestone or dolomite, ochre-producing minerals or iron oxides, chert and opaline silica, schists, secondary micaceous minerals, coated particles, sulphides, sulphates and water-soluble minerals, zeolites, and organic matter. Reactive materials such as montmorillonite clay, present even in small quantities in a limestone or dolomite, may cause serious swelling and failure of the concrete. Where minor adverse mineralogical or textural defects are present, a microscopic examination of thin sections of the stone may be required to assist in identification and detection of the offending element.

In assessing commercial aggregates for concrete, crushed stone, and asphalt construction, the Ontario Department of Highways makes a preliminary petrographic examination, which assigns a petrographic number to the aggregate. The petrographic number is an attempt to assign an empirical value representing the quality of the aggregate, so that certain numerical limits can be defined for aggregate specifications. For example, Ontario Department of Highways specifications for concrete aggregate specify a petrographic number of less than 125, whereas for hot-laid, asphalt surface course (HL 3) the petrographic number should not exceed 135. This petrographic number is arrived at as follows: a weighed sample of the aggregate is examined. The fragments are classified petrographically into one of nine major petrographic subdivisions: limestone, dolomite, shale, sandstone, chert, clay, metamorphic rocks, igneous rocks, and miscellaneous. Within these major subdivisions the fragments are classified into one of 47 minor petrographic divisions each of which has a characteristic evaluation factor, between 0.9 (for trap rock) and 6.0 (for clay, shale, etc.). The classification for limestone is as follows:

Limestone	Factor
Angular, hard	1.0
Pebble sound	1.0
Pitted hard or arenaceous	1.3
Soft, slightly weathered	1.5
Shaly	2.5
Clayey	4.0
Ochre-producing	4.0

The weight of sample in each category is expressed as a percentage of the whole and multiplied by its evaluation factor. The total gives the petrographic number, which ranges from 90 for trap, and 100 for hard limestone, upwards. For example, if the aggregate was 100 percent angular hard limestone (factor 1.0), the petrographic number is 100. If the aggregate contained 90 percent hard, angular limestone and 10 percent shaly limestone the petrographic number would be $90 \times 1.0 + 10 \times 2.5 = 115$. Chert has a factor of 5, so that for concrete aggregate the maximum allowable percentage of chert in an angular hard limestone would be 6 percent ($94 \times 1.0 + 6 \times 5.0 = 124$). This petrographic number is intended to be a guide in evaluating average aggregates. Revisions are made at intervals depending on research and performance data.

A.S.T.M. specifications suggest that chert that will readily disintegrate under the $MgSO_4$ soundness test should not exceed 1 percent of the total weight of aggregate. Some chert, however, may prove to be quite sound.

Soundness Tests

The soundness of a stone is its ability to resist the action of weathering agents, particularly freezing and thawing, without disintegration. There are two common tests of soundness in use: the magnesium or sodium sulphate soundness test, and the accelerated freezing and thawing tests.

In the sodium or magnesium sulphate soundness tests (A.S.T.M. C88-56T), a weighed, washed, and dried sample of aggregate is totally immersed in a saturated solution of magnesium or sodium sulphate at 70°F. for 16–18 hours, followed by 4 hours in a drying oven at 105°C (dried to constant weight). The sample is cooled, and the cycle is repeated. After 5 cycles, the sample is weighed, and the percentage weight loss is measured. For coarse concrete aggregate the maximum allowable weight loss is 12 percent (Ont. Dept. Highways specifications). The weight loss depends upon the amount of disintegration of the rock under hydration and expansion of the salt absorbed in the pores of the rock.

A procedure for conducting accelerated freezing and thawing tests is given in A.S.S.H.O. T103-42, but these tests are difficult to standardize. Accelerated freezing and thawing tests are frequently carried out on concrete test cylinders or concrete test beams by subjecting them to alternate freezing and thawing cycles of 2–24 hours duration over 100–300 or more cycles. Deterioration is measured during the tests by sonic apparatus, which measures the velocity of ultrasonic wave impulses through the test cylinders.

Abrasion Tests

The two standard abrasion tests, depending on hardness, toughness, and durability of stone, are the Deval and Los Angeles abrasion tests; the latter is now more widely used.

In the Deval abrasion test a sample of stone consisting of 50 pieces, broken to cubical shape and weighing 5 kilograms, is placed in a cast-iron cylinder, 20 centimetres in diameter and 34 centimetres long inclined at 30 degrees to the horizontal, and rotating at 30–33 revolutions per minute. At the end of 10,000 revolutions the loss in weight is determined by sieving through a U.S. Standard No. 12 sieve. The maximum allowable loss is generally 8–24 percent depending on specifications. (A.S.T.M., D289-55 and D2-33.)

In the Los Angeles abrasion test (A.S.T.M· C131-55) the 5-kilogram sample of the graded aggregate to be tested is placed in a steel cylindrical drum measuring 28 inches in diameter and 20 inches long, rotating at 30–33 revolutions per minute about the cylindrical axis. A radial shelf 4 inches wide extends from end to end inside the drum. A 5-kilogram charge of steel balls is placed in the drum, and it is revolved for 500 revolutions. The percent loss in weight is determined by sieving as before and expressed as a percentage. Maximum allowable loss is 15–35 percent depending on specifications.

Absorption and Porosity

The water absorption properties of stone depend on porosity. Absorption tests are important in building stone but may also be important in the case of concrete aggregate for designing concrete mixes and controlling their water content. Porosity may be determined by comparison of the bulk density with the specific gravity of the stone. Percent absorption is calculated by weighing the test sample of aggregate before and after boiling for 3 hours in water. Maximum allowable absorption is about 2 percent. (See also A.S.T.M., C127-42 —Specific Gravity and Absorption of Coarse Aggregate.)

Reactivity Tests

Failure of concrete due to abnormal expansion, cracking, and "pop-outs" may be due to reaction between certain reactive minerals in the aggregate and the alkalis (potash and soda) in the portland cement. The amorphous varieties of silica, chalcedonic chert, and opal or opaline chert, are particularly reactive. A silicate gel forms by reaction of alkalis with the amorphous silica; on hydration this swells, and if sufficiently abundant in the concrete, failure may occur. Prevention or minimization of this type of alkali reactivity in concrete may be achieved by using a low-alkali cement. Cement containing less than 0.6 percent alkalis (percentage $Na_2O + 0.658 \times$ percentage K_2O) is recommended.

Failure may also occur due to swelling of bentonite or montmorillonite-type clay minerals present in shaly limestone or dolomite.

Reactivity of aggregates may be tested either by chemical methods or by mortar bar expansion tests. In the chemical tests (A.S.T.M., C289-57T) a crushed aggregate sample is placed in a 10-percent solution of NaOH for a certain period, and the amount of silica soluble in NaOH is determined.

In the mortar bar tests (A.S.T.M., C227-52T and C342-55T) test bars are made up with the aggregate, a standard sand, and cements of known alkali content, including both low- and high-alkali cements. Pozzolans may be added to attempt to reduce alkali reactivity. Periodic length measurements are made over periods up to 12 months; these tests normally require 6 months to a year to complete. Bars showing expansion of over 0.1 percent are definitely reactive.

Difficulty with reactive limestone aggregate has been experienced in eastern Ontario, and the A.S.T.M. tests do not always detect alkali reactivity, as indicated by research on the problem by E. G. Swenson.[1]

Incompatibility Tests

Measurement and comparison of the thermal coefficient of expansion of the coarse and fine aggregate and the hydrated cement paste in concrete may be of importance. If there are wide differences in thermal coefficients of expansion between the aggregate and cement paste, serious stresses may be set up in climates where severe temperature differences exist, which lead to expansion and contraction of various ingredients of the concrete at different rates. The optical interferometer or the SR-4 strain gauge are used to measure incompatibility.[2]

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[1]E. G. Swenson, *A Canadian Reactive Aggregate Undetected by A.S.T.M. Tests*, A.S T.M. Bulletin No. 226, Dec. 1957, pp. 48–51.

[2]E. P. Rexford, "Some Factors in the Selection and Testing of Concrete Aggregates for Large Structures," *Transactions*, Amer. Inst. Min. and Met. Eng., Vol. 187, 1950, pp. 395–402.

Loss on Washing

The maximum percentage of fines allowable (percentage passing a 200-mesh sieve) may be specified in a graded aggregate used for concrete, asphalt construction, or other uses. Washing may be necessary to reduce the percentage fines in the graded aggregate below the tolerance figures. In soft rocks, such as the Guelph-Lockport dolomite, a washed and sized aggregate may exceed tolerance for percentage of fines due to attrition on loading and delivery to the user. It should be remembered that any free fall or cascading in stockpiling, or bulldozing on stockpiles and the like, will result in increased fines in the already graded aggregate, particularly when dealing with a soft stone.

Density

Measurements of bulk density and specific gravity are frequently made, particularly in the case of building stone where it is necessary to calculate loads on stressed members in buildings.

Strength

Measurements of compressive strength and transverse strength may be made and are of particular interest in the case of building stone. The abrasion tests are indicative of the toughness of the stone:

A.S.T.M. Test No. C170-50—Test for Compressive Strength of Building Stones.

A.S.T.M. Test No. C99-52—Test for Modulus of Rupture.

Stripping Tests

The surface texture and porosity of an aggregate are of importance in bituminous construction since they affect the adhesion of the bituminous coating and the amount of asphalt required. The term "stripping" refers to the removing or peeling of the bituminous coating from the aggregate particles, generally in the presence of water. Cryptocrystalline Black River limestone, for example, frequently shows up poorly in stripping tests. It may often be difficult to get bituminous patches to adhere to wet pavement.

Several stripping tests are used. In one, the aggregate and bituminous material are mixed, cured for 24 hours, and covered with distilled water to soak, followed by a vigorous shaking. The amount of stripping is judged visually. Immersion-compression tests involve unconfined compression tests on asphalt aggregate mixtures tested in the unsoaked and soaked states. A numerical assessment of stripping is difficult, but the tests give indication of relative resistance to film stripping by various aggregates.

Chemical Analysis

Chemical analyses of stone are required where the stone is to be used for chemical uses such as fluxstone, lime, portland cement, sulphite pulp production, etc.

SPECIFICATIONS FOR LIMESTONE

The main uses for limestone and dolomite in order of importance in Ontario are described in the following pages. (See also (2), p. 2.)

1. Crushed Stone
    a) Road Construction
        i) Traffic-bound Roads
        ii) Bituminous Macadam Roads
    b) Concrete Aggregate
    c) Railway Ballast
2. Portland Cement Manufacture
3. Lime Manufacture
    a) Chemical Lime
    b) Iron and Steel
    c) Building Trades
3. Lime Manufacture — *Continued*
    d) Uranium Mills
    e) Pulp and Paper
    f) Glass Industry
    g) Gold Milling
    h) Sugar Industry
    i) Smelters
    j) Tanneries
4. Flux Stone
5. Building Stone
6. Riprap
7. Pulverized Stone
    a) Asphalt Filler
    b) Agricultural Limestone
8. Pulp and Paper Industry

1. Crushed Stone Specifications

a) ROAD CONSTRUCTION

Graded limestone aggregate is used in three types of road construction: traffic-bound roads, in which the road surface is compacted by traffic; bituminous macadam roads for base course and surface course; concrete roads.

i) Traffic-bound Roads

For traffic-bound gravel roads, the specifications for selected granular base course (G.B.C.)[1] indicate that crushed limestone for this use should be uniformly mixed and well-graded 7/8-inch or 3/4-inch crusher run (100 percent minus 7/8-inch) containing less than 20 percent minus 48-mesh; not more than 60 percent should pass the No. 4 sieve. Organic material and other deleterious material should be absent. This stone is referred to as granular base course (G.B.C.), traffic-bound (T.B.), or 3/4-inch or 7/8-inch crusher run, and is the common road stone in use today for road construction.

For 5/8-inch crushed-stone surface course (Ont. Dept. Highways Form No. 301), specifications call for the following grading of the coarse and fine aggregate mixture:

Sieve No. or Size	Percentage Passing Sieve by Weight
5/8	100
1/2	75–95
3/8	51–80
No. 4	30–50
No. 8	21–48
No. 14	12–40
No. 28	6–30
No. 48	3–18
No. 100	1–8
No. 200	0–5

The coarse aggregate fraction should meet the following physical requirements:

Deval abrasion test	percent loss maximum	24
Absorption by weight	percent maximum	2.0
Loss on washing	percent maximum	1.5
Ont. Dept. Highways petrographic No.	maximum	175

ii) Bituminous Macadam Roads

MIX-IN-PLACE MULCH SURFACE

The mix-in-place mulch surface (see Ont. Dept. Highways Form No. 305) used as a bituminous surface course on many country roads uses 5/8-inch crushed-stone or gravel surface course as specified above.

[1]Ont. Dept. Highways, Form No. 314.

HOT-MIX, HOT-LAID ASPHALT CONSTRUCTION

The Ontario Department of Highways (Form No. 310) divides hot-laid asphalt surfaces and base courses into six different types as follows:

HL 1—Trap Rock Asphaltic Surface Course
HL 2—Sheet Asphalt Surface Course
HL 3—Asphaltic Concrete Surface Course
HL 4—Surface Course or Base Course
HL 6—Base Course (Commercial Coarse Aggregates)
HL 8—Binder Course

Specifications for crushed stone aggregate for this type of asphalt construction are given in (9) and (10).

The sizing requirements for limestone aggregate used in asphalt construction may be briefly summarized as follows:

Surface course—5/8- by 3/16-inch.
Base course—7/8- by 3/16-inch or 1- by 3/16-inch.

b) CONCRETE AGGREGATE[2]

The maximum size of limestone aggregate used in concrete varies from 6 inches in massive dam construction to 5/8 or 3/8 inch in concrete blocks. In concrete highway construction two sizes of coarse aggregate are used; 1 1/2- by 1/2-inch and 1/2-inch by No. 4 size. In concrete structures the maximum size generally varies from 2 1/2- to 3/4-inch. The nominal maximum size generally used in reinforced concrete is 3/4-inch.

Concrete Pavement

Specifications for concrete aggregate used in concrete pavement (see Ont. Dept. Highways Form No. 502) are briefly summarized as follows: for Ont. Dept. Highways specifications coarse aggregates are separated into two sizes; No. 20 (1 1/2- by 1/2-inch), and No. 21 (1/2-inch by No. 4 size). (See (11).) These sizes are blended to meet the final mix requirements shown below:

Physical Requirements for Coarse Aggregate for Concrete Pavement

$MgSO_4$ soundness (5 cycles)	percent loss max.	12
Absorption (by weight)	percent max.	2.0
Petrographic number	max.	125
Material passing No. 200 sieve	percent max.	1.0
Thin or elongated particles	percent max.	20
Los Angeles abrasion	percent loss max.	30
Clay lumps	percent max.	0.25

[2]See also A.S.T.M. specification No. C33-52T: "Tentative Specifications for Concrete Aggregates."

(9) GRADING REQUIREMENTS FOR AGGREGATE FOR ASPHALT CONSTRUCTION

Sieve No. or Size	Percentage Weight passing Sieve according to Type				
	HL 1	HL 3	HL 4	HL 6 and HL 8 (⅞-in. max.)	HL 6 and HL 8 (1-in. max.)
	percent	percent	percent	percent	percent
1-inch	.....	.....	.....	.....	100
⅞-inch	.....	.....	.....	100	75–90
¾-inch	.....	.....	.....	65–88	58–80
⅝-inch	.....	100	100	50–75	44–68
½-inch	100	83–100	70–85	35–60	31–55
⅜-inch	50–70	50–70	30–47	15–35	14–32
¼-inch	20–35	20–35	10–20	5–20	4–19
3/16-inch (No. 4)	0–10	0–10	0–10	0–10	0–10
No. 200	0–1	0–2	0–2	0–2	0–2

(10) PHYSICAL SPECIFICATIONS FOR AGGREGATE FOR ASPHALT CONSTRUCTION

	HL 1	HL 3	HL 4	HL 6	HL 8
$MgSO_4$ soundness (5 cycles) ..... percent loss max.	5	12	12	12	12
Absorption (by weight) ..... percent max.	1.0	1.75	2.0	1.75	1.75
Petrographic number ..... max.	100	135	160	140	160
Loss on washing ..... percent max.	1	2	2	2	2
Thin and elongate particles ..... percent max.	15	15	15	15	15
Los Angeles abrasion ..... percent loss max.	15	25	35	30	35
Deval abrasion ..... percent loss max.	8	18	24	18	22

(11) GRADING REQUIREMENTS FOR COARSE AGGREGATE FOR CONCRETE PAVEMENT

Ont. Dept. Highways No.	Total Percentage, by Weight, passing Tyler Standard Sieve						
	Sieve Sizes (square openings in inches)						
	1½	1	¾	½	⅜	¼	No. 4
	percent	percent	percent	percent	percent	percent	percent
20	100	48–68	20–35	0–10	.....	.....	.....
21	.....	.....	.....	90–100	30–60	0–30	0–10
Final mix	100	58–82	36–64	18–50	6–27	0–14	0– 4.5

(12) GRADING REQUIREMENTS FOR COARSE AGGREGATES FOR CONCRETE STRUCTURES

Nominal Maximum Size of Aggregate	Total Percentage, by Weight, passing Tyler Standard Sieve								
	Sieve Sizes (square openings in inches)								
	2½	2	1½	1	¾	½	⅜	No. 4	No. 8
	percent	percent	percent	percent	percent	percent	percent	percent	percent
2-in. stone	100	95–100	.....	35–70	.....	10–30	.....	0–5	.....
1½-in. stone	.....	100	95–100	.....	35–70	.....	10–30	0–5	.....
1-in. stone	.....	.....	100	95–100	.....	25–60	.....	0–10	0–5
¾-in. stone	.....	.....	.....	100	90–100	.....	20–55	0–10	0–5
½-in. stone	.....	.....	.....	.....	100	90–100	40–70	0–15	0–5

Concrete Structures

For concrete structures typical specifications are similar to those of the Ontario Department of Highways, which are briefly summarized in (12) and below. (See also Ont. Dept. Highways Form No. 9.)

PHYSICAL REQUIREMENTS FOR COARSE AGGREGATES FOR CONCRETE STRUCTURES

$MgSO_4$ soundness (5 cycles)	percent loss max.	12
Absorption (by weight)	percent max.	2.0
Petrographic No.:		
Bridges	max.	140
Culverts	max.	155
Loss on washing	percent max.	2.0
Thin or elongated particles	percent max.	20
Los Angeles abrasion	percent loss max.	30
Clay lumps	percent max.	0.25

c) RAILWAY BALLAST[1]

The function of crushed-stone railway ballast is to support the ties, distribute the wheel loads, and provide for good roadbed drainage. It is non-rigid and allows some vertical movement under loading. Since railway ballast is continuously exposed to weathering, soundness is important. Ballast is subjected to strong and severe impact loading, and a tough durable, hard ballast is desirable.

The American Railway Engineering Association recommend the following physical specifications:

Los Angeles abrasion	percent loss max.	40
Na_2SO_4 soundness (5 cycles)	percent loss max.	10
Soft and friable pieces	percent max.	5
Material from No. 200 sieve	percent max.	1.0
Clay lumps	percent max.	0.5

The grading specifications for railway ballast vary, the nominal sizes in use are shown below:

	SIZE OF STONE Inches
A.S.T.M. No. 24	2½ to ¾
A.S.T.M. No. 3	2 to 1
A.S.T.M. No. 4	1½ to ¾
A.S.T.M. No. 5	1 to ⅜
A.S.T.M. No. 57	1 to No. 4 sieve

2. Portland Cement Manufacture

For the manufacture of portland cement, the limestone should contain less than 2.5 percent magnesia and preferably less than 2 percent magnesia. Silica should not exceed 13 percent, and alumina should not exceed 3.7 percent.

For the manufacture of portland cement the stone is ground to a finely-powdered state, and the initial grading requirements of stone supplied to the cement plant are not important. High-calcium stone fines are generally acceptable to the cement plants, and this may prove an outlet for excess fines from crushing plants producing larger sizes.

[1]A. T. Goldbeck, "Mineral Aggregates for Railroad Ballast," *A.S.T.M. Symposium on Mineral Aggregates*, 1948, pp. 197–204.

3. Lime Manufacture

Size gradation of kiln feed for lime manufacture depends on the type of kiln used and the type of firing, but specifications would average as follows:

TYPE OF KILN	KILN FEED Inches
Vertical stack kilns, externally fired	10 x 5 to 9 x 3
Vertical stack kilns, gas fired	6 x 3 to 3½ x 1¾
Rotary kilns	1¾ x 1¼ to 1¼ x ¾ or ½

The texture and porosity of the stone used for kiln feed may have a profound effect on the rate and temperature of calcining, and upon the product resulting. Uniformity is essential in kiln feed to ensure an evenly calcined product.

Detailed specifications for lime for various uses may be found in the Book of A.S.T.M. Standards:

C5-26—Quicklime for Structural Purposes.
C6-49—Normal Finishing Hydrated Lime.
C207-49—Hydrated lime for Masonry Purposes.
C45-25—Quicklime and Hydrated Lime for Cooking of Rags in Paper Manufacture.
C46-27—Quicklime for Sulphite Pulp Manufacture.
C47-27—Hydrated Lime for Varnish Manufacture.
C258-52—Quicklime for Calcium Carbide Manufacture.

a) CHEMICAL LIME

High-calcium chemical-grade lime, of the type produced at Beachville, is produced from stone with the following chemical specifications:

$CaCO_3 > 98.00$ percent
$MgO < 1.00$ percent (often < 0.8 percent)
$SiO_2 < 1.00$ percent, $R_2O_3 < 0.50$ percent ($SiO_2 + R_2O_3$ often < 1.0)
$S < 0.1$ percent

Stone of such high purity is difficult to find, and chemical lime of comparable purity is not widely produced.

Specifications for high-calcium limestone for the production of high-calcium lime are normally as follows:

$CaCO_3 > 91$ percent
$MgCO_3 < 6$ percent
$CaCO_3 + MgCO_3 > 97$ percent
$SiO_2 + R_2O_3 < 3$ percent

The Beachville high-calcium lime is used in the manufacture of calcium carbide by Cyanamid of Canada Limited. Specifications for lime (A.S.T.M. C258-52) for calcium carbide manufacture specify a minimum CaO content of 92 percent; maximum MgO, 1.75 percent; maximum silica 2.0 percent; maximum combined iron and alumina oxides, 1.0 percent; maximum sulphur, 0.2 percent; and maximum phosphorus 0.02 percent. The Beachville stone meets these specifications.

High-calcium lime produced from the Detroit River limestone at Amherstburg is used for the manufacture of soda ash; for this requirement

limestone as low as 85 percent $CaCO_3$ can be used; however the stone used in Canada is much higher in $CaCO_3$ content.

b) IRON AND STEEL

Lime as well as limestone is used for flux in open-hearth furnace charges. Chemical specifications are, in general, similar to those for flux stone, but tolerances of impurities are almost 50 percent of those in limestone, owing to the CO_2 loss in the case of limestone. A high-calcium lime with low sulphur and silica impurities is desired. Lime is also used in steel plants for such processes as wire drawing and neutralization of pickling liquors.

c) BUILDING TRADES

Quicklimes for the building trades generally have the following specifications (A.S.T.M. Standard C5-26):

	Calcium Lime percent	Magnesium Lime percent
CaO min.	75	..
MgO min.	..	20
CaO + MgO min.	95	95
$SiO_2 + R_2O_3$ max.	5	5
CO_2 max.	10	10

In Ontario the magnesium lime produced from the Guelph-Lockport dolomite is mainly used in the building trades.

d) URANIUM MILLS

Calcium lime is used at the Blind River and Bancroft uranium mines to neutralize acid leaching solutions from the uranium mills. The rapidity of neutralization depends on the proportion of available CaO or CaO + MgO in the lime, and since the companies are primarily interested in units of available CaO per ton, the higher the CaO content the better. With freight an important factor, high purity is desirable. A high-calcium lime is desired because of its higher rate of reaction compared to dolomitic lime. Specifications require a CaO content of over 90 percent and a low phosphorus content, since the presence of phosphorus adversely affects the precipitation of uranium salts. Lime used is $-\frac{3}{4}$ inch, $+\frac{1}{4}$ inch in size.

Consumption of lime in the Blind River camp is 45–60 pounds per ton of ore milled, and in the Bancroft camp is 25–50 pounds per ton of ore milled.

e) PULP AND PAPER

Pulp and paper companies use a substantial amount of lime each year for cooking rags, sulphite pulp manufacture, and soda and sulphite pulp manufacture. For rag-paper manufacture, calcium lime with over 90 percent CaO is desired. For sulphite pulp manufacture, high-calcium lime running 92.5 percent CaO, less than 2.5 percent MgO, and less than 3 percent silica + iron + alumina, or dolomitic lime running 55.4 percent CaO and 39.6 percent MgO (minimum) with same tolerances for impurities, is specified.[1]

f) GLASS MANUFACTURE

Lime is an important ingredient of the glass batch; for the better grades of glass the CaO + MgO content of lime should exceed 96 percent; iron should be below 0.1 percent; with $SiO_2 + Al_2O_3$ less than 4.0 percent.

g) GOLD MILLING

Lime is used in flotation as a depressant and as a pH control reagent. In the cyanidation process of gold milling, lime and cyanide are added to the grinding circuit. About 1.6 pounds of lime per ton of ore milled is the average consumption, and its function is to control the pH of the circuit.

h) SUGAR INDUSTRY

Lime is used in refining beet sugar. For this use a high-calcium limestone having less than 1 percent MgO, less than 1 percent silica, and a low iron content is desirable. The Beachville limestone is used in sugar refining in Ontario.

i) SMELTERS

Lime may be used as a flux in non-ferrous smelters.

j) TANNERIES

Quicklime or hydrated lime with over 85 percent available CaO is used in tanning leather.

4. Flux Stone[2]

High-purity calcium limestone is used as a flux in open-hearth steel furnaces and in some non-ferrous smelters. High-purity limestone or dolomite may be used in iron blast furnaces. If the blast furnace slag is to be used in cement manufacture the flux should be a high-calcium stone with less than 3 percent MgO. Where the slag is processed for aggregate production, the magnesia content should range from 7 to 10 percent, and a mixture of

[1] A.S.T.M. specification C46-27, *Lime for Sulphite Pulp Manufacture.*
A.S.T.M. specification C45-25, *Lime for Cooking of Rags in Paper Manufacture.*

[2] H. F. Kriege, "Mineral Aggregates in the Chemical and Processing Industries and in Certain Other Uses," *A.S.T.M. Symposium on Mineral Aggregates*, 1948, pp. 206–208.

high-calcium limestone and dolomite may be used.

Chemical purity is most desirable in a flux stone. Since the stone loses nearly half its weight when the carbon dioxide is driven off in the initial furnace reaction, if silica and alumina impurities amounted to 2 percent in the original stone, they would make up nearly 4 percent in the resulting lime. The impurities would react with their own weight of lime to produce calcium aluminium silicates thus removing a further 4 percent (approximate) of the available lime for fluxing. Thus the effective fluxing value of a stone is reduced by about four times the percentage of impurities in the original flux stone.

Generally flux stone should carry less than 3 percent impurities and have low sulphur and phosphorus content. High-calcium limestone flux shipped from the Beachville quarries runs as follows:

$CaCO_3$	> 98 percent
MgO	< 1.0 percent
$Al_2O_3 + SiO_2$	< 1.0 percent
S	< 0.1 percent

This flux stone is, however, of unusually high purity.

Dolomite blast furnace flux being supplied from the Guelph-Lockport dolomite in Ontario runs as follows:

$CaCO_3 + MgCO_3$	> 97 percent
SiO_2	< 0.5 percent
Al_2O_3	< 1.0 percent
S	< 0.1 percent

This flux stone is of higher than average purity.

The adaptability of a stone for flux may depend also on its rate of dissolution under furnace conditions; a rapidly dissolving stone that decreases the time necessary for the reaction to be completed in the charge is preferred. The porosity and crystallinity of the stone is therefore a factor when considering requirements for a flux stone.

GRADING REQUIREMENTS

For open-hearth flux, the stone used is normally 10- by 5-inch, 9- by 5-inch, or 10- by 4-inch stone. For blast furnace flux the sizes used range from 5 by 3 inches to 4 by 1½ inches; 3- by 2-inch stone is sometimes used. For sintering flux stone –¼-inch screenings are used.

5. Building Stone

A building stone may be chosen on the basis of colour, texture, and workability. Specifications vary greatly from job to job and may include soundness, absorption, durability, specific gravity, bulk density, freedom from cracks, flaws, seams, iron staining, etc.

6. Riprap

Riprap consists of large angular blocks of quarry stone from 200 pounds to 12 tons or more in weight, used for breakwaters, piers, dikes, revetments, etc. Soundness, durability, and freedom from fractures and bedding planes are important.

7. Pulverized Stone

a) ASPHALT FILLER

Limestone dust is frequently used for asphalt filler, and specifications generally require 65–100 percent through 200-mesh.

b) AGRICULTURAL LIMESTONE

For agricultural limestone, the pulverized stone must contain a minimum of 85 percent calcium carbonate, or calcium carbonate equivalent. Physical specifications require that 100 percent pass a 10-mesh screen, 50 percent pass a 40-mesh screen, and 30 percent pass a 100-mesh screen.

To encourage its use the Ontario Department of Agriculture gives a subsidy on freight or trucking charges on agricultural limestone.

8. Pulp and Paper Industry
(Jensen Tower System of Sulphite Pulp Production)

In the tower system of sulphite pulp production, dolomite or limestone is used in making the sulphurous acid–bisulphite solution used as a cooking agent in producing sulphite wood pulp. SO_2 gas is passed up towers packed with lump limestone down which water flows.

Physical specifications require man-sized blocks of 8–14 inches diameter. Chemical specifications require either a high-calcium limestone or a high-purity dolomite. If high-calcium limestone is used, the CaO content should exceed 53 percent; the MgO content should be under 1.5 percent; combined SiO_2, Fe_2O_3, and Al_2O_3, under 1.5 percent; and organic matter, under 0.5 percent. If dolomite is used the $CaCO_3$ content should be 54–59 percent; $MgCO_3$, 35–44 percent; iron and alumina should not exceed 1 percent; and total insolubles should not exceed 2 percent.

Specifications for limestone used in the glass and sugar industries are indicated under Lime Manufacture.

IV. Distribution and Characteristics of Major Limestone Formations and Ontario Quarry Operations

(13) GEOLOGICAL COLUMN, SOUTHERN ONTARIO

GENERALIZED SECTION

SYSTEM		GROUP OR FORMATION		LITHOLOGY
MISSISSIPPIAN		Port Lambton		Shale
DEVONIAN	UPPER	Kettle Point		Shale
	MIDDLE	Hamilton		Shale, limestone
		Delaware		Limestone, dolomite
		Columbus		Sandy limestone
		Detroit River		Limestone, dolomite
		Bois Blanc		Cherty limestone
	LOWER	Oriskany		Sandstone
SILURIAN	UPPER	**Bertie-Akron**		Dolomite
		Salina		Shale, salt, gypsum
	MIDDLE	**Guelph**		Dolomite
		Lockport-Amabel		Dolomite
		Clinton Group	Decew	Shaly dolomite
			Rochester	Shale
			Irondequoit	Limestone
			Reynales	Dolomite
			Thorold-Neagha	Sandstone, shale
	LOWER	Cataract	Grimsby	Red sandstone, shale
			Power Glen	Shale
			Whirlpool	Grey sandstone
ORDOVICIAN	UPPER	Queenston		Shale
		Meaford		Shale
		Dundas		Shale
		Blue Mountain		Shale
		Collingwood		Shale
	MIDDLE	**Trenton**		Limestone
		Black River		Limestone
	LOWER	*Great Unconformity*		
CAMBRO-ORDOVICIAN				
PRECAMBRIAN		**Grenville Series** Granitic rocks, gneisses, schists, etc.		Marble

NOTES

The limestone and dolomite formations of commercial interest are shown in bold-face type.

Double lines indicate an unconformity.

The Columbus, Detroit River, and Oriskany formations may be absent due to unconformity.

The Bertie-Akron formation is also known as the Bass Island.

GEORGETOWN–BRUCE PENINSULA AREA

GROUP OR FORMATION		LITHOLOGY
Guelph		Dolomite
Amabel		Dolomite
Clinton Group	Fossil Hill	Dolomite
	Wingfield	Dolomite
	Dyer Bay	Dolomite
Cataract	Cabot Head	Shale
	Manitoulin	Cherty dolomite

OTTAWA–ST. LAWRENCE LOWLAND

GROUP OR FORMATION		LITHOLOGY
Trenton		Limestone
Black River		Limestone
Chazy	St. Martin	Limestone
	Rockcliffe	Shale, sandstone
Beekmantown	**Oxford**	Dolomite
	March	Sandstone, dolomite
Nepean or Potsdam		Sandstone
Great Unconformity		
PRECAMBRIAN		

The geological column for southern Ontario is given in (13). The limestone and dolomite formations of commercial interest are indicated in boldface type, and include the following formations, which are described in this report in six sections:

1. Precambrian Grenville limestone and dolomite.
2. Beekmantown Dolomite.
3. Trenton–Black River Limestones.
4. Guelph-Lockport Dolomite.
5. Bois Blanc Limestone and Bertie-Akron Dolomite.
6. Detroit River and Delaware Limestones.

The last four groups of formations are the most important commercial stone horizons. Their distribution in Ontario, and the locations of operating quarries, and cement and lime plants, are shown on map No. 1960c (in map case).

1. PRECAMBRIAN LIMESTONE AND DOLOMITE

The only Precambrian limestones and dolomites being commercially exploited in Ontario are the Grenville marbles of the Grenville geological province of southeastern Ontario. These rocks are recrystalized white limestone and dolomite ranging in grain size from fine to coarse. They may be quite pure but often contain mica, lime silicates, garnet, serpentine, pyrite, magnetite, and other impurities.

Companies quarrying Grenville marble in Ontario are shown in (14).

Dominion Magnesium Limited, at Haley in Renfrew county, quarries white Grenville dolomite of high purity for the manufacture of dolomitic lime. This lime is used as the raw material for the production of magnesium metal by the Pidgeon process. The average composition of the dolomite used is as follows:[1]

	Percent
CaO	30.85–31.95
MgO	20.48–21.55
Insolubles	0.25– 0.65
R_2O_3	0.25– 0.60
Ignition loss	46.8 –47.1

Carleton Lime Products at Carleton Place operates a small Grenville limestone quarry in lot 8, concession VI, Ramsay township, Lanark county. Lump stone from the quarry is used for the manufacture of lime in a small wood-fired stack kiln at Carleton Place. The kiln has a capacity of 9–12 tons of lime per 24 hours. Goudge (p. 119)[2] gives a chemical analysis of Grenville limestone from the property in (15).

Man-sized blocks of Grenville dolomite, produced by Jamieson Lime Company at a small quarry on the southern outskirts of Renfrew, are used by pulp and paper companies in the production of sulphite pulp (by the Jensen tower system). Some of the other quarries listed in (14) also produce man-sized Grenville limestone or dolomite for pulp and paper companies. Flux stone is also produced by some of the companies listed.

A substantial tonnage of terrazzo chips, chips for artificial stone, stucco dash and poultry grit, and pulverized white marble is produced each year by Bolenders Limited, Bonter Marble Products, W. F. Bonter Limited, Canadian Dolomite Company, and Stoklosar Marble Quarries. None of these quarries, however, produce on a large scale, owing to the small market.

Although Grenville marble was formerly quarried as building stone in the Bancroft area, at the present time there is no production of marble building stone in Ontario from Precambrian deposits.

[1] J. Satterly, *Mineral Occurrences in the Renfrew Area*, Ont. Dept. Mines, Vol. LIII, 1944, pt. 3, p. 66.

[2] See References p. ix.

(14) GRENVILLE MARBLE QUARRIES

Company	Location	Type	Main Uses
Dominion Magnesium Ltd.	Haley	dolomite	magnesium production
Carleton Lime Products Co.	Carleton Place	limestone	lime
Jamieson Lime Co.	Renfrew	dolomite	pulp and paper
Bolenders Ltd.	Eagle Lake	dolomite	chips, grit, pulverized stone
Bonter Marble Products	Marmora	limestone	chips, grit, pulverized stone
W. F. Bonter Ltd.	Malone	limestone	chips, grit, pulverized stone
Canada Talc Industries	Madoc	dolomite	chips, grit, pulverized stone
Canadian Dolomite Co.	Ross tp., Renfrew co.	dolomite	chips, grit, pulverized stone
Stoklosar Marble Quarries	Madoc	dolomite	chips, grit, pulverized stone

(15) CHEMICAL ANALYSIS—CARLETON LIME PRODUCTS

(Analysis from Goudge, p. 119)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
153.....	1.04	0.16	0.12	0.02	92.53	5.63	99.50	trace	51.83	2.69

2. BEEKMANTOWN DOLOMITE

The main area of Beekmantown dolomite in Ontario of commercial interest is on the west flank of the Ottawa–St. Lawrence basin and extends from Ottawa to Brockville, underlying parts of Carleton, Dundas, Grenville, and Leeds counties.

The Beekmantown dolomite of the Ottawa–St. Lawrence basin is divided into a lower March formation, consisting of interbedded grey sandstone, sandy dolomite, and grey dolomite, and an upper Oxford formation, consisting of thick-bedded dolomite and dolomitic limestone.[1] The March formation constitutes transition beds from the underlying Nepean sandstone to the overlying Oxford dolomite and attains a maximum thickness of about 30 feet. The Beekmantown dolomite (Oxford plus March formations) has a thickness of 240–350 feet. The Beekmantown dolomite is overlain by the Rockcliffe formation, consisting of shale and sandstone of Chazyan age.

Beekmantown dolomite is quarried for crushed stone by Brockville Crushed Stone Company in Elizabethtown township, Leeds county; by Iroquois Rock Registered in Matilda township, Dundas county; and by Armstrong Brothers in Gloucester township, Carleton county. During construction of the St. Lawrence Seaway, Canada Dredge and Dock Company Limited operated a small quarry in Edwardsburgh township, Grenville county.

[1]Alice E. Wilson, *Geology of the Ottawa–St. Lawrence Lowland, Ontario and Quebec*, Geol. Surv. Can., Memoir No. 241, 1946, pp. 12-14.

Quarries

BROCKVILLE CRUSHED STONE LIMITED (BROCKVILLE QUARRY), BROCKVILLE

The quarry of Brockville Crushed Stone, now operated by Permanent Transit-Mix Concrete Limited, is located in lot 4, concession I, Elizabethtown township, Leeds county, on the north side of highway No. 2 on the eastern outskirts of the city of Brockville.

Geology

The quarry face of 15–20 feet in height is brownish Beekmantown dolomite of the March formation.[2] The rock quarried is fine crystalline to aphanitic, medium- to thin-bedded, even-bedded, dark brownish grey dolomite with shaly partings. A geological section measured by the author at the west quarry face is shown in (16). A pronounced 2-inch black shale parting forms the quarry floor.

Chemical analyses, made of chip samples taken down the west face, are given below in (17).

Quarry Operation

The 20-foot quarry face is drilled on a 6- by 6-foot pattern by two truck-mounted Worthington wagon drills drilling 2-inch holes. Air is supplied by two

[2]Map No. 852A *Ottawa-Cornwall Sheet*, Geol. Surv. Can., 1946 (Alice E. Wilson).

(16) QUARRY SECTION—BROCKVILLE CRUSHED STONE LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
3	Dolomite, dark brownish grey, medium brownish grey weathering; medium to fine crystalline; medium bedded; hard, dense, mottled; black shale partings; calcite crystals; upper beds rusty weathering, thin bedded.....	9.0
2	Dolomite, dark brownish grey to light brownish grey, weathers medium to medium light grey; colour lamination in finer grained beds; medium crystalline grading upward to aphanitic; medium-bedded; some graded bedding; shaly partings; calcite crystals.....	6.9
1	Dolomite, sandy; light brown, weathers light buff; aphanitic; medium bedded; colour lamination light to dark brown; black, shaly partings.....	2.3
	Total Thickness	18.2

(17) CHEMICAL ANALYSES—BROCKVILLE CRUSHED STONE LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	0 – 2.3	12.44	3.85	0.87	17.24	26.84	36.71	0.20	98.15
2	2.3–10	9.66	2.24	0.76	16.24	28.70	40.58	0.23	98.41
3	10 –17	7.08	1.61	0.63	16.88	31.85	41.51	0.04	99.60

315 cubic-foot-per-minute Worthington compressors. Dynamite and prilled ammonium nitrate are the blasting agents. The stone breaks readily, and there is little secondary blasting. A 2-cubic-yard Lorain diesel shovel loads two 22-ton Euclid trucks, which dump on a grizzly feeding a Cedarapids 36- by 18-inch twin jaw-crusher. The product from the jaw-crusher is carried by a 24-inch conveyor to screen tower No. 1 equipped with two Dillon double-deck 4- by 12-foot vibrating screens. The screened products go to bins, and the oversize goes to a Cedarapids impact breaker for secondary crushing. The product from the impact breaker is conveyed to screen tower No. 2 housing a double-deck 5- by 12-foot vibrating screen. The screened products go to bins, while the oversize goes to a Cedarapids 40- by 24-inch set of rolls. The product from the rolls goes to screen tower No. 3 equipped with a double-deck 5- by 12-foot screen and bins. Maximum capacity is attained by single-pass, three-stage reduction with no circulating load.

The three screen towers allow flexibility in product sizing: 1¼- by ⅜-inch, 1⅛- by ⅜-inch, 1- by ¼-inch, 1-inch crusher run; ⅝-inch by 0, and ¼-inch by 0 are among the main sizes produced. Plant capacity is about 100 tons per hour. Stockpiling is done by 5-ton trucks. Stone haulage is by trucks, which are loaded by overhead loader from stockpiles.

IROQUOIS ROCK COMPANY REGISTERED (IROQUOIS QUARRY)

The quarry of Iroquois Rock Company Registered, an associated company of Harvey Construction Limited, is located in lots 30 and 31, concession I, Matilda township, Dundas county, on the north side of highway No. 2, west of Iroquois.

Geology

The 80-foot quarry face is dense, brownish, even-bedded, medium- to thick-bedded, Beekmantown dolomite of the Oxford formation.[1] A section measured on the north face of the quarry is given in (18). Chemical analyses were made of composite chip samples from the quarry face and are shown in (19).

Quarry Operation

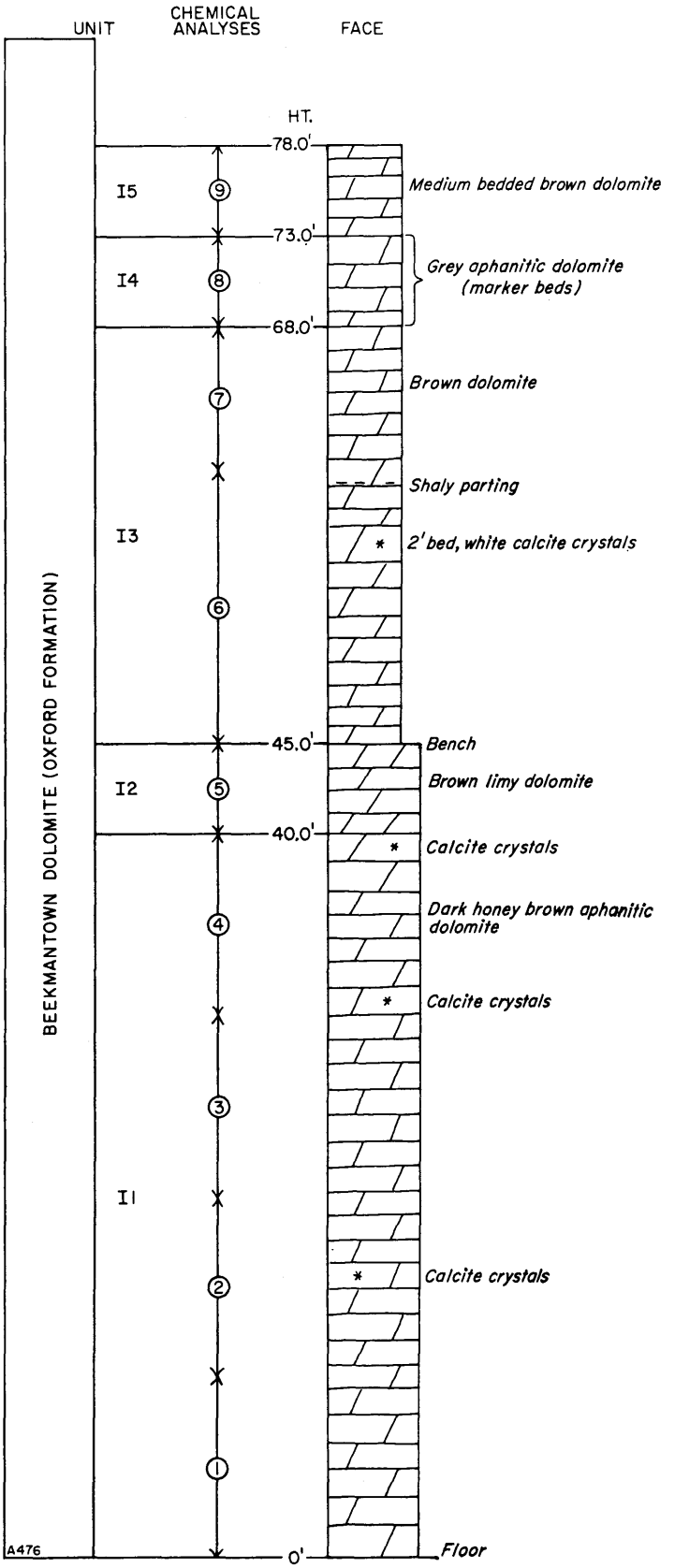
The 80-foot quarry face is operated on two lifts, a lower one of 45 feet, and an upper lift of 35 feet. Overburden is 5–10 feet thick. Drilling is carried out by two Gardner Denver Air Trac drills served by two 600-cubic-feet-per-minute Jaeger compressors. Three-inch holes are drilled on a 7- by 10-foot pattern. Forcite and prilled ammonium nitrate are

[1]Map No. 852A, *Ottawa-Cornwall Sheet*, Geol. Surv. Can., 1946 (Alice E. Wilson).

(18) QUARRY SECTION—IROQUOIS ROCK COMPANY

UNIT	DESCRIPTION	THICKNESS Feet
I5	Dolomite: dark brown; dense, aphanitic, hard; medium to thick bedded; white calcite crystals; slightly shaly with shaly partings	5.0
I4	Dolomite: light grey; aphanitic; medium bedded; colour lamination; black shaly partings	5.0
I3	Dolomite: same as I5 unit	23.0
I2	Dolomite: dark brown; aphanitic; hard; medium to thick bedded; slightly shaly; effervesces weakly with acid	5.0
I1	Dolomite: same as I3 and I5 units	40.0
	Total	78.0

(18) QUARRY SECTION—
IROQUOIS ROCK
COMPANY



Scale: 1 inch to 10 feet

Two Air-Trac drills operate on the 45-foot lift of Beekmantown dolomite at Iroquois Rock Company.

used for blasting. A 1½-cubic-yard Northwest diesel shovel, and a 1¾-cubic-yard Lima diesel shovel, load five 15-ton Euclid trucks hauling to the primary crusher. Some secondary breaking is done in the quarry by 5,500-pound drop-balls fitted on the shovel buckets.

The primary crusher, preceded by a feeder, is a 42- by 48-inch Lippmann jaw-crusher, located on a bench at the south end of the quarry. The 6-inch stone from the jaw-crusher is elevated by a 36-inch conveyor to the 6-inch rock surge pile south of the quarry opening. A reclaiming tunnel and conveyor carries 6-inch stone to chutes loading railway cars on the siding. A second reclaiming tunnel and a 36-inch conveyor carries 6-inch stone to the crushing and screening tower. The screen tower has two 3-deck 5- by 12-foot vibrating screens in parallel, and bins are provided for plus 3-inch, 3-inch, 1½-inch, No. 1 SP, ¾-inch, and ⅝-inch stone. The secondary crusher, a 4¼-foot Symons cone, handles plus 3-inch stone, and the tertiary crusher, a 4-foot Symons cone, handles minus 3-inch stone. Both cones are fed from bins by Syntron feeders after initial sizing of the 6-inch stone in the screen tower. Products from these crushers are returned to the screen tower by a 2-stage, 30-inch conveyor.

The 1½-inch stone is also stockpiled to the east of the screen tower by conveyor, and a reclaiming tunnel and conveyor carries 1½-inch stone from this stockpile to the railway loading chutes as indicated in (20).

SAND LINE

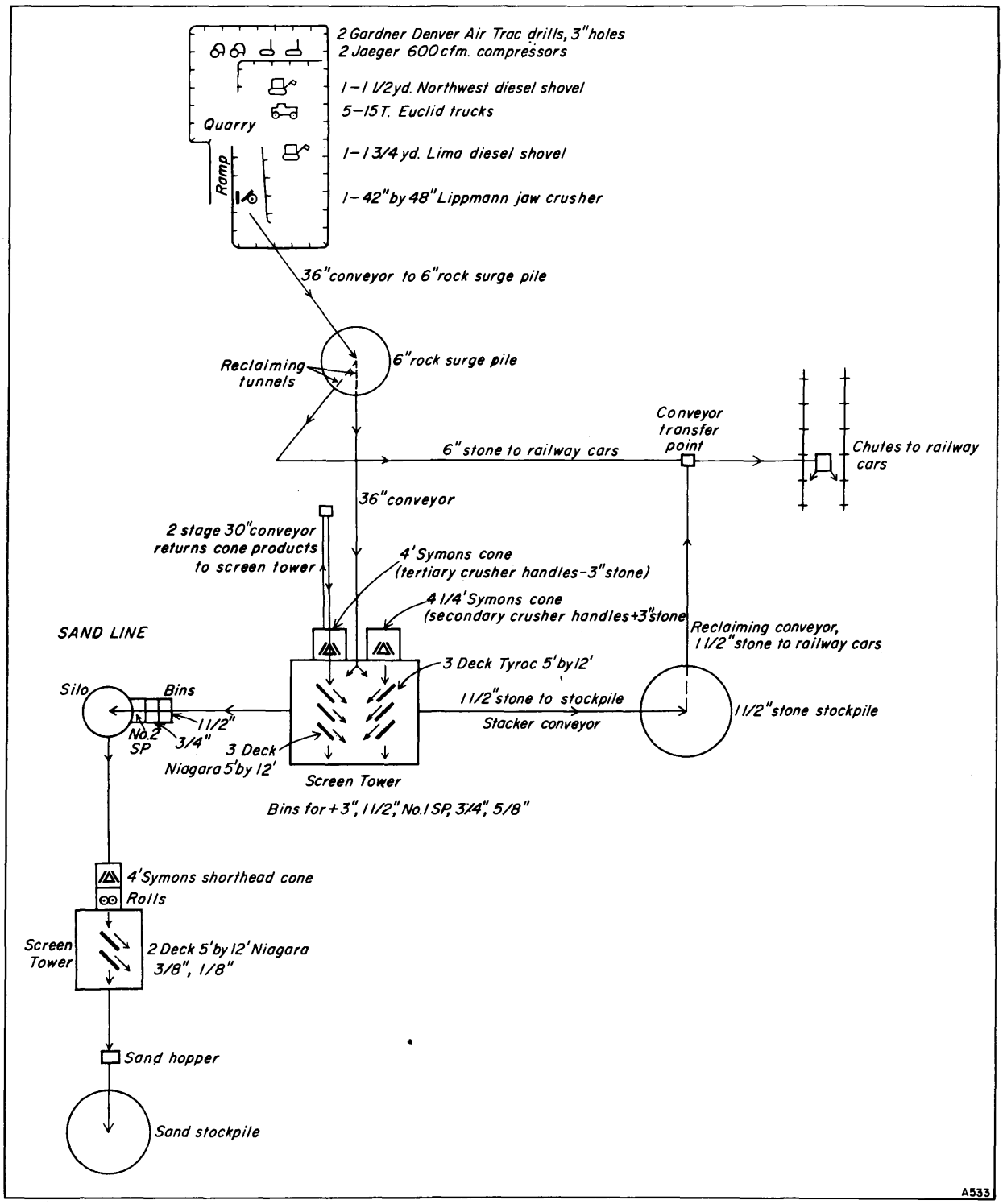
To the west of the crushing and screening building there is a sand line for the manufacture of rock sand. Storage for the sand line consists of a large silo and bins for 1½-inch, ¾-inch, and No. 2 SP (American) stone. The sand line consists of a 4-foot Symons shorthead cone, a set of rolls, and a screen tower with a 2-deck Niagara 5- by 12-foot vibrating screen. The sand is stockpiled by conveyor.

Transportation is by railway or by truck. Railway cars are loaded by a conveyor from the stockpile; trucks are loaded by overhead loaders. The quarry is a large supplier of railway ballast, con-

(19) CHEMICAL ANALYSES—IROQUOIS ROCK COMPANY

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	0–10	9.18	4.20	1.10	17.13	26.33	39.87	0.17	97.98
2	10–20	7.23	3.91	0.98	18.78	27.00	41.46	nil	99.36
3	20–30	7.06	4.14	0.89	18.09	27.10	41.02	0.17	98.47
4	30–40	7.84	3.96	0.98	17.83	26.60	40.31	0.55	98.07
5	40–45	9.26	5.81	1.14	16.89	27.10	39.46	0.68	99.66
6	45–60	8.94	4.98	0.88	17.31	27.10	40.68	0.46	100.35
7	60–68	8.18	3.98	0.83	17.81	28.10	41.68	0.34	100.58
8	68–73	15.14	9.57	1.23	13.85	23.90	34.62	0.63	98.96
9	73–78	18.74	7.98	1.31	14.84	21.70	32.59	0.93	98.09


2 Gardner Denver Air Trac drills, 3" holes
2 Jaeger 600 cfm. compressors
1-1 1/2yd. Northwest diesel shovel
5-15T. Euclid trucks
Quarry
Ramp
1-1 3/4 yd. Lima diesel shovel
1-42" by 48" Lippmann jaw crusher
36" conveyor to 6" rock surge pile
Reclaiming tunnels
6" rock surge pile
Conveyor transfer point
6" stone to railway cars
Chutes to railway cars
36" conveyor
2 stage 30" conveyor returns cone products to screen tower
4' Symons cone (tertiary crusher handles-3" stone)
4 1/4' Symons cone (secondary crusher handles+3" stone
Reclaiming conveyor, 1 1/2" stone to railway cars
SAND LINE
3 Deck Tyroc 5' by 12'
Silo
Bins
1 1/2" stone to stockpile
Stacker conveyor
1 1/2" stone stockpile
1 1/2"
No.2 SP
3/4"
3 Deck Niagara 5' by 12'
Screen Tower
Bins for +3", 1 1/2", No.1 SP, 3/4", 5/8"
4' Symons shorthead cone
Rolls
Screen Tower
2 Deck 5' by 12' Niagara 3/8", 1/8"
Sand hopper
Sand stockpile
A533

crete aggregate, road stone, and sand. The plant has a capacity of about 300 tons per hour and averages 3,000 tons per day on a 10-hour shift. The production is mainly crushed stone and concrete aggregate.

ARMSTRONG BROTHERS COMPANY LIMITED (SOUTH GLOUCESTER QUARRY), OTTAWA

The South Gloucester quarry of Armstrong Brothers Company Limited is located in lot 25, concession V, Gloucester township, Carleton county on highway No. 31 south of Ottawa, near Greely.

The quarry was operated in 1957 for road stone but was not in operation when visited by the author on May 28, 1958. At this time the quarry was filled with water, and only the upper nine feet of the quarry face could be examined. The quarry face appeared to be about 20 feet high.

Geology

The quarry face is medium-grey, medium-crystalline, medium-bedded Beekmantown dolomite of the Oxford formation and is described as follows:

Dolomite; medium light grey to medium grey, buff tones on weathered surface especially in the upper part; medium- to fine-crystalline; medium-bedded; calcite vugs; rare shaly partings with rusty weathering along shaly partings; fossils rare. Thickness examined, 9 feet.

A chemical analysis was made of a composite chip sample representing the 9 feet of exposed dolomite (21).

(21) CHEMICAL ANALYSIS—ARMSTRONG BROTHERS COMPANY LIMITED

(Analysis by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample Interval	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
feet	percent	percent	percent	percent	percent	percent	percent	percent
0–9	10.23	3.77	1.70	17.60	26.60	39.08	0.43	99.41

3. TRENTON–BLACK RIVER LIMESTONES

The Trenton–Black River limestones of Ordovician age occur in two main areas in southern Ontario, the Georgian Bay–Lake Ontario area and the Ottawa–St. Lawrence basin.

Georgian Bay–Lake Ontario Area

The Trenton–Black River limestones outcrop in a wide belt south of a line extending from Midland, on Georgian Bay, eastward across the north end of Lake Simcoe, through Bobcaygeon and Madoc, to Kingston on Lake Ontario. The Trenton–Black River limestones have a thickness of 600–750 feet, divided into seven formations, as follows, from base to top: Basal Clastics; Lower, Middle, and Upper Black River; Lower, Middle, and Upper Trenton.

The lowermost Black River beds or Basal Clastics rest directly on the Precambrian peneplane surface. The limestones dip to the southwest off the Laurentian Shield area. Relief on the Precambrian peneplane surface was low, but occasional Precambrian hills rose up as high as 350 feet above the general peneplane, forming islands in the Black River Sea. These Precambrian monadnocks, when partially resurrected, form inliers such as the Shannonville and Ameliasburg inliers in the Belleville area about 20 miles south of the Precambrian-Paleozoic contact. At the Ameliasburg inlier, middle Trenton beds (Sherman Fall) lap on to the Precambrian, indicating a relief here of at least 350 feet (Kay 1942, p. 632).[1] These Precambrian hills when buried under a Paleozoic cover may cause local doming of the structure in the beds overlying and flanking them; initial dips of 10–20 degrees have been observed on the flanks of such inliers. A Precambrian buried hill of this type is probably responsible for the dome structure in the Black River limestone floor of the Canada Cement Company Limited quarry at Point Anne.

Trenton–Black River Rock Classification

The classification of rock units in the Black River and Trenton groups is given in the accompanying table (22). The rock units and formations used by the author in this report generally follow those of B. A. Liberty of the Geological Survey of Canada; however, to simplify the nomenclature for the commercial quarry operator, only the terms Black River and Trenton are used. The lithological units here used are distinct and mappable on a lithological or chemical basis, largely without recourse to fossils.

[1]See References p. ix.

	TIME-ROCK UNITS	JOHNSTON AND ULRICH AND RAYMOND (1912)	G. M. KAY (1937)	OKULITCH (1938)	LIBERTY (1953)	LIBERTY (1958)	HEWITT (Present Report)	
		From B. A. Liberty, "Stratigraphic Studies of the Ordovician System in Central Ontario," Proceedings, Geol. Assoc. Can., Vol. 7, pt. 1, 1955.				Personal Communication	GEORGIAN BAY–LAKE ONTARIO Description	OTTAWA–ST. LAWRENCE BASIN Description
TRENTON GROUP	COBOURG	*Hormotoma* and *Fusispira* beds *Rafinesquina deltoidea* beds	COBOURG: HILLIER / UPPER HALLOWELL / LOWER HALLOWELL		COBOURG	LINDSAY	UPPER TRENTON: HILLIER Shaly limestone beds; UPPER HALLOWELL Massive limestone beds	UPPER AND MIDDLE TRENTON: Shaly limestone
	SHERMAN FALL	KIRKFIELD GROUP: *Prasopora* beds	SHERMAN FALL		STURGEON LAKE	VERULAM	MIDDLE TRENTON: LOWER HALLOWELL Shaly limestone beds; SHERMAN FALL *Prasopora* beds (shaly limestone)	
	HULL	Crinoid beds	HULL (KIRKFIELD)		KIRKFIELD	BOBCAYGEON: UPPER	LOWER TRENTON: Crinoid beds (shaly limestone) *Dalmanella* beds	HULL BEDS (UPPER LOWER TRENTON): Grey crystalline calcarenite
	ROCKLAND	*Dalmanella* beds	ROCKLAND			MIDDLE		LOWER TRENTON, UPPER AND MIDDLE BLACK RIVER: Limestone, in part shaly
BLACK RIVER GROUP	LERAY	COBOCONK *Columnaria* beds		COBOCONK	COBOCONK	LOWER	UPPER BLACK RIVER: Coquinoid calcarenite beds	
	LOWVILLE	UPPER LOWVILLE "Birdseye" and *Tetradium* beds	CHAUMONT	MOORE HILL	GULL RIVER: UPPER	GULL RIVER: UPPER	MIDDLE BLACK RIVER: Lithographic beds *Tetradium* beds	
			LOWVILLE	GULL RIVER	MIDDLE	MIDDLE		
	PAMELIA	LOWER LOWVILLE *Beatricea* beds	PAMELIA		LOWER	LOWER	LOWER BLACK RIVER: Magnesian beds (Sandy dolomite and limestone)	LOWER BLACK RIVER: Magnesian limestone, dolomite
		BASAL SERIES		SHADOW LAKE	SHADOW LAKE	SHADOW LAKE	BASAL CLASTICS: Arkose, grit, shale	BASAL CLASTICS (includes limestone and dolomite): Impure limestone, sandy dolomite, shale, sandstone

The formational subdivisions used in this report are as follows:

TRENTON GROUP:	Upper Trenton
	Middle Trenton
	Lower Trenton
BLACK RIVER GROUP:	Upper Black River
	Middle Black River
	Lower Black River
	Basal Clastics

Black River Group

BASAL CLASTICS (Shadow Lake Formation, Rideau Beds)

At the base of the Black River group where the sediments rest directly on the Precambrian basement, there is commonly from a few inches to several feet of basal clastics composed of conglomerate, grit, arkose, sandstone, and red and green shale. Thicknesses up to 40 feet were reported by J. F. Caley and B. A. Liberty.[1] In southern Ontario the basal clastics have been called the Shadow Lake formation or Rideau beds.

In the Marmoraton pit at Marmora the basal clastics are well exposed at the Paleozoic-Precambrian contact. They consist of red and buff shale, shaly sandstone, and grit.

The basal clastics are not exposed in any operating commercial stone quarries in Ontario.

The upper limit of the basal clastic beds is generally placed at the first appearance of aphanitic or microcrystalline grey or reddish limestone.

LOWER BLACK RIVER FORMATION (Pamelia, Lower Gull River Formation)

The Lower Black River formation consists of buff dolomite, often sandy and silty, interbedded with grey lithographic limestone and mottled grey and buff dolomitic limestone. Occasionally there are greenish-grey interbeds of shale. This formation is characteristically dolomitic and impure, with a considerable fraction of clayey and silty material often present. Some of the grey lithographic limestone interbeds are of high purity.

The upper limit of the Lower Black River formation is marked by a thick-bedded, buff, sandy dolomite member 4–12 feet thick. This member may be seen at the Port McNicoll, Coldwater, Uhthoff, Longford, Marmoraton, Frontenac, and McGinnis and O'Connor quarries, where it marks the top of the formation. Except in the Kingston area, this upper buff member of the Lower Black River marks a chemical unconformity between the magnesian beds of the Lower Black River and the calcium limestone of the Middle Black River formations. In the Kingston area shaly and silty magnesian beds occur well up into the Middle Black River formation, perhaps owing to the nearness of the land masses associated with the Frontenac axis.

The lower beds of the formation may be buff sandy dolomite or occasionally, as at the Marmoraton pit and in the Madoc area, a maroon lithographic or aphanitic limestone.

The entire Lower Black River section is exposed at the Marmoraton pit at Marmora, where it has a thickness of 60 feet. In other quarries only the upper part of the formation is exposed, but 35 feet of the Lower Black River can be seen in the highway No. 401 roadcut at Montreal Street in Kingston.

The Lower Black River formation is the Lower Gull River formation of B. A. Liberty, and approximates the Pamelia time-rock unit.

MIDDLE BLACK RIVER FORMATION (Lowville, Middle and Upper Gull River Formations)

The Middle Black River formation consists mainly of light grey weathering lithographic limestones, including the *Tetradium* and "birdseye" beds. This unit is usually, in part, high-purity calcium limestone, but shaly interbeds sometimes occur, and chert may be found in the upper part of the unit. Although predominantly calcilutite, the beds grade upward into the fossiliferous calcarenite of the Upper Black River formation. In places the upper contact with the overlying coquinoid calcarenite of the Upper Black River is difficult to place, and there may be several feet of transition or passage beds from calcilutite to fossiliferous calcarenite. At Uhthoff, Longford, and Marmora there is a distinct contact between the underlying light-grey to white calcilutite of the Middle Black River and the overlying brownish- to medium-grey coquinoid calcarenite of the Upper Black River. At Coldwater, Hampshire Mills, Coboconk, Point Anne, and Roblindale the contact is transitional from calcilutite to calcarenite.

The Middle Black River formation has a thickness of 67 feet where it is completely exposed at the Marmoraton pit; it is 66 feet thick in the Montreal Street roadcut on highway No. 401 at Kingston. In the Coldwater-Longford area it is 20–35 feet thick. The Middle Black River formation is the Middle and Upper Gull River formations of B. A. Liberty, and approximates the Lowville time-rock unit.

[1] J. F. Caley and B. A. Liberty, *Geology and Economic Minerals of Canada*, Geol. Surv. Can., Econ. Geol. Series No. 1 (fourth edition), 1957, p. 219.

UPPER BLACK RIVER FORMATION
(Leray, Coboconk, or Lower Bobcaygeon Formations)

The Upper Black River formation is characterized by medium- to thick-bedded, medium-grey calcium limestones. They are frequently calcarenite and may contain abundant fossil debris. The lowermost beds may be coquinoid calcarenite. *Stromatocerium* and the coral *Lyopora halli* are characteristic.

The upper contact of the Upper Black River formation is placed at the change from thick-bedded, medium-grey limestone to thin-bedded, fossiliferous, shaly limestone of the Lower Trenton. The only quarry where this contact is exposed is the Canada Cement quarry at Point Anne, where about 8 feet of thin shaly Lower Trenton beds can be recognized on the north-central quarry wall. A complete section of Upper Black River is exposed in the quarry, but the contact between the Middle and Upper Black River appears to be transitional. The thickness of the Upper Black River at this quarry is 40–72 feet, depending on where the contact is placed. In the quarries to the west of Belleville the maximum thickness of Upper Black River strata is at Cobo Minerals Limited's Coboconk East quarry, where 22 feet are exposed. The lower part of the Upper Black River is exposed at Longford, Hampshire Mills, Uhthoff, and Coldwater.

The Upper Black River formation is the equivalent of the Coboconk or Lower Bobcaygeon formations of B. A. Liberty and approximates the Leray time-rock unit.

Trenton Group

LOWER TRENTON FORMATION
(Rockland and Hull; Kirkfield Formation; Middle and Upper Bobcaygeon Formation)

The Lower Trenton (Kirkfield) formation is composed of thin- to medium-bedded, medium-brownish grey, fine to medium crystalline limestone, with prominent blue-grey shale partings. It is generally fossiliferous and includes the *Dalmanella* beds of the Rockland and the crinoid beds of the Hull time-rock units. The lower contact with the Upper Black River formation is placed at the transition from thick-bedded Black River limestone to thin-bedded, fossiliferous, shaly Trenton beds. The upper part of the Lower Trenton is medium bedded and has occasional shaly partings. The upper contact with the overlying Middle Trenton formation is marked by a change to the thin-bedded, medium-crystalline limestone with abundant shaly partings of the Middle Trenton. The Middle Trenton (Sherman Fall) is notably more shaly than the Lower Trenton.

The thickness of the Lower Trenton (Rockland and Hull) formation given by Kay (1942, p. 588) is 130 feet. The only quarry section examined is that of Kirkfield Crushed Stone at Kirkfield, where 36 feet of the Lower Trenton, overlain by 5 feet of Middle Trenton beds, are exposed.

The Lower Trenton formation is the equivalent of the Kirkfield formation or the Middle and Upper Bobcaygeon formations of B. A. Liberty.

MIDDLE TRENTON FORMATION
(Sherman Fall and Lower Hallowell: Sturgeon Lake or Verulam Formation)

The Middle Trenton (Sherman Fall and Lower Hallowell) beds consist of thin- to medium-bedded, medium-grey, aphanitic to medium-crystalline limestone and interbedded grey shale. These beds are generally highly fossiliferous and include the *Prasopora* beds of Johnston, Ulrich, and Raymond.[1]

The Middle Trenton has a thickness of about 260 feet, including 200 feet of Sherman Fall beds and 60 feet of Lower Hallowell beds. The only quarries examined in this formation are the abandoned quarry of Canada Cement Company Limited at Lakefield, and a small abandoned quarry just east of highway No. 28, north of Peterborough in concession V, Smith Township.

UPPER TRENTON FORMATION
(Upper Hallowell and Hillier Members of the Cobourg Unit, Prince Edward Formation)

The Upper Trenton formation is composed of a lower unit of medium-bedded, medium-grey, fine-crystalline limestone with shaly partings but lacking interbeds of shale, and an upper unit of thin-bedded shaly limestone with interbeds of shale. These two units correspond to the Upper Hallowell and Hillier members of the Cobourg formation described by Kay (1937, p. 278).[2]

The lower unit (Upper Hallowell) of the Upper Trenton has a thickness of 40 feet and can be distinguished lithologically and chemically from the overlying shaly unit (Hillier member), which has a thickness of over 100 feet.

The lower contact of the Upper Trenton is marked by a change from the shaly limestone and interbedded shale of the thin-bedded Middle Trenton to the medium-bedded higher-purity limestone

[1]B. A. Liberty, "Stratigraphic Studies of the Ordovician System in Central Ontario," *Proceedings*, Geol. Assoc. Can., Vol. 7, pt. 1, 1955, p. 143.

[2]See References, p. ix.

of the Upper Hallowell member of the Upper Trenton. The upper contact of the Trenton is placed at the base of the Collingwood shale.

The stratigraphic divisions used in this report are based on rock-units or formations distinguished from one another by lithology dependent on physical and chemical features. Kay (1937, p. 263) points out that:

> The differentiation of the Sherman Fall from the Lower Cobourg is arbitrary and difficult, for, although the lower Sherman Fall and higher Lower Cobourg have persistent guide fossils, none that are both distinctive and abundant have been discerned in the intermediate beds. *Pasceolus globosus* Billings ("*Ischadites* sp.") is locally abundant in the base of the Cobourg in northwestern New York and in Prince Edward County, Ontario, and has been considered to mark the top of the Sherman Fall.

Kay states further (p. 278) that the Hallowel[1] member of the Cobourg is the zone of *Rafinesquina deltoidea.*

> The lower boundary of the member is arbitrarily drawn at the base of a zone containing *Pasceolus globulus* . . . The top of the member is distinguished from the overlying Hillier member in that it is composed of heavy-ledged, coarse-textured limestones in which *Rafinesquina deltoidea* is normally abundant; the overlying [Hillier] beds are argillaceous, and buff, nodular-weathering.

Since this subdivision is based on faunal zones, the author has discarded it and divided the Sherman Fall and Cobourg into two formations, the Middle Trenton and Upper Trenton, on the basis of lithology and chemical unconformities. The Middle Trenton includes the Sherman Fall and Lower Hallowell members, and the Upper Trenton includes the Upper Hallowell and Hillier members of the Cobourg formation. These units are easily recognizable lithologically and chemically in diamond-drilling carried out in the Cobourg-Picton area.

The Picton quarry of Lake Ontario Portland Cement Company is in the Upper Hallowell member of the Upper Trenton. The Ogden Point quarry of St. Lawrence Cement Company is in the Hillier member of the Upper Trenton.

Quarry Centres

The chief quarry centres in the Trenton–Black River strata of the Georgian Bay–Lake Ontario area are at Uhthoff, Kirkfield, Ogden Point, Belleville, Picton, Roblindale, and Kingston.

The operating quarries and other quarries or sections giving important regional stratigraphic information on the Trenton–Black River strata are described below.

PORT McNICOLL QUARRY, PORT McNICOLL

The Port McNicoll quarry, located on Midland Bay, lots 19 and 20, concession V, Tay township, Simcoe county, was formerly operated by the Canada Iron Furnace Company of Midland. The 32-foot quarry section is illustrated and described in (23). The buff beds, 4.6 feet thick, mark the top of the Lower Black River formation, which is impure dolomite and dolomitic limestone, in part cherty. Although the Middle Black River beds are generally rather pure calcium limestone, in this area there appears to be a substantial shaly facies in the lower part of the Middle Black River, attaining here a thickness of 7.6 feet.

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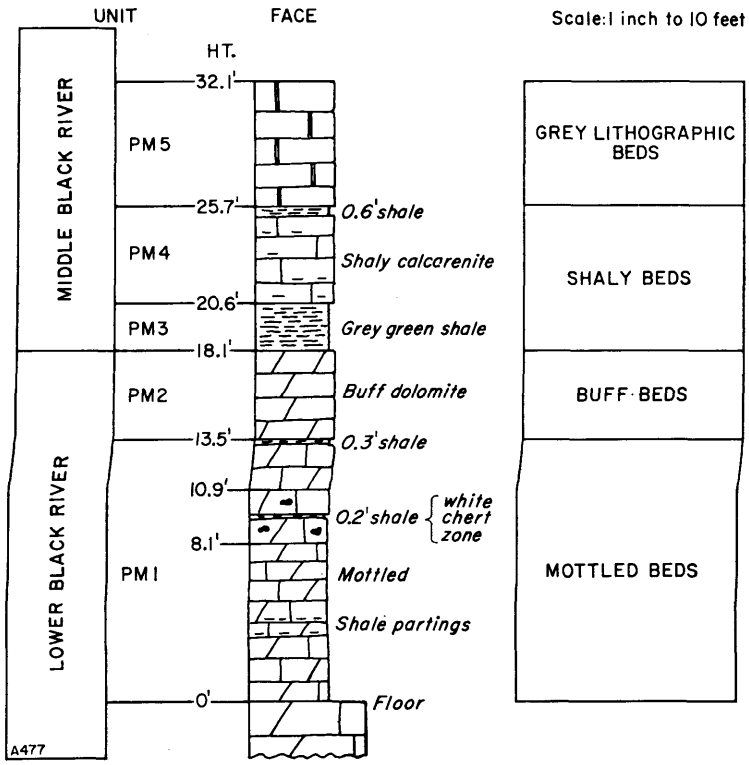
(23) QUARRY SECTION—PORT McNICOLL QUARRY

UNIT	DESCRIPTION	THICKNESS Feet
PM5	Limestone: calcilutite; light brown, light grey to white weathering; weathers in thin plates or laminae; medium to thick bedded; microcrystalline to aphanitic; calcite crystals.....	6.4+
PM4	Limestone: shaly calcarenite; light greenish grey, grey-buff weathering; fine crystalline to microcrystalline; medium to thin bedded; lesser silty dolomitic layers; fine fossil debris; 0.6 feet buff, platy shale at top overlying grey calcilutite bed.....	5.1
PM3	Shale: grey-green; calcareous, dolomitic; silty; platy.....	2.5
PM2	Dolomite: silty; light buff grey, greenish buff weathering; medium bedded; aphanitic; more limy in upper part.....	4.6
PM1	Dolomitic Limestone: grey to buff mottled, light brownish grey; aphanitic; medium to thick bedded; minor white chert nodules 8.1–10.9 feet; top 0.3 feet shale, shale partings especially at 3.7, 4.2, and 9.7 feet, rare glauconite.....	13.5+
	Total	32.1

(23) QUARRY SECTION—PORT McNICOLL QUARRY



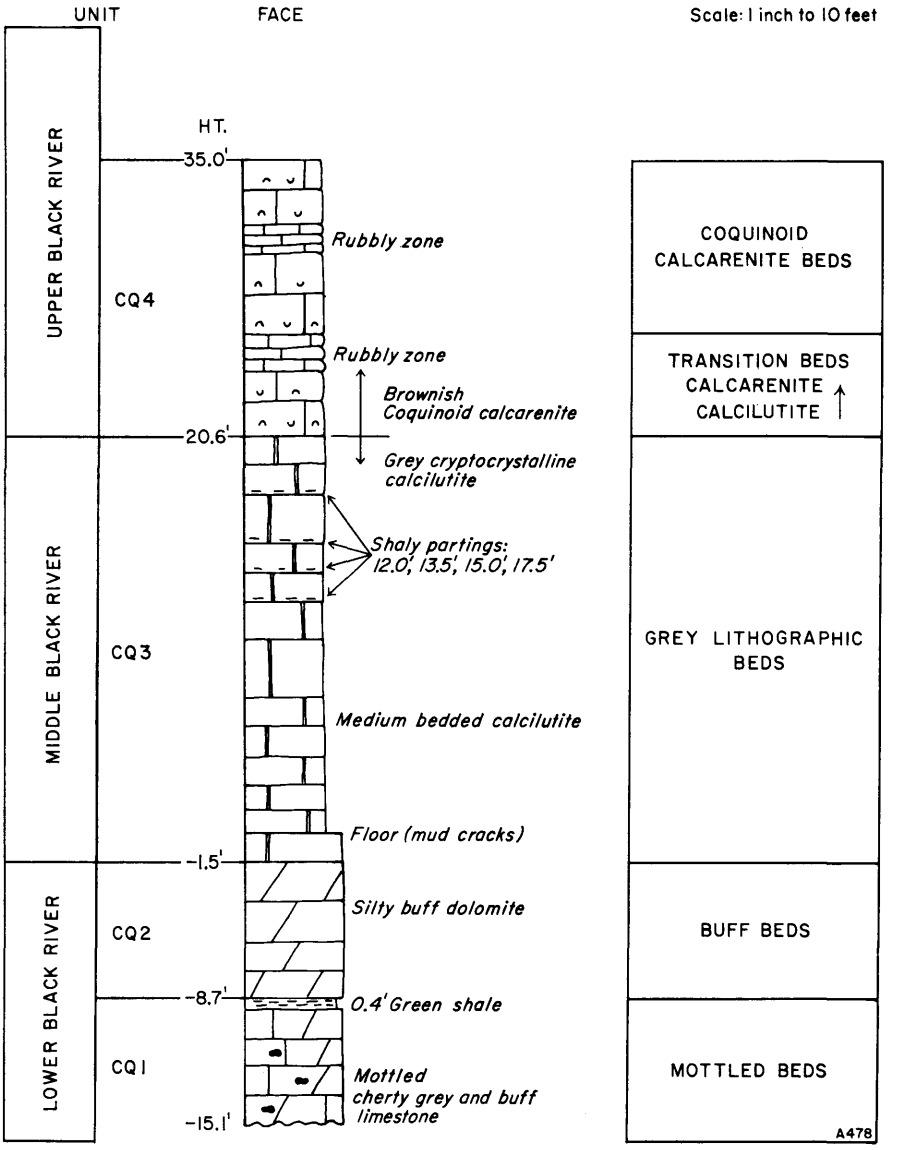
COLDWATER QUARRY, MEDONTE

The Coldwater quarry is located in lots 19 and 20, concession XIII, Medonte township, Simcoe county, south of Medonte station on the Canadian Pacific railway. The quarry was formerly operated by Coldwater Crushed Stone Limited but is now inactive. The property is now owned by Limestone Products Limited.

The section exposed in the Coldwater quarry is illustrated and described in (24). The 35-foot quarry face consists of 20.6 feet of grey, thick- to medium-bedded, lithographic limestone of the Middle Black River formation, overlain by 14.4 feet of calcarenitic fossiliferous, medium-bedded to rubbly limestone of the Upper Black River formation. The lower 5 feet of the Upper Black River beds mark a transition from calcilutite of the Lower Black River to coquinoid calcarenite of the Upper Black River. This quarry face, as indicated by the accompanying analyses (25) quoted from Goudge (p. 190) is a high-purity calcium limestone.

Below the quarry floor a further section, 15 feet thick, can be seen in ditches. The upper 1.5 feet is lithographic limestone of the Middle Black River formation. The buff dolomite beds marking the top of the Lower Black River (Pamelia beds) are 7.2 feet thick. These are underlain by 6.4 feet of mottled grey and buff dolomitic limestone and dolomite containing rare, grey chert nodules. The buff and mottled units correlate with the same units to the west in the Port McNicoll quarry; to the east the buff beds are exposed in the floor of the Uhthoff quarry.

(24) QUARRY SECTION—COLDWATER QUARRY



UNIT	DESCRIPTION	THICKNESS Feet
CQ4	Limestone: coquinoid calcarenite to calcilutite; grey to brownish grey, mottled; grey weathering; medium crystalline to microcrystalline; thick bedded; very fossiliferous, worm borings; in part cross-laminated; surface pitting; lower 5 feet transitional from calcilutite upwards to calcarenite, microcrystalline matrix common	14.4
CQ3	Limestone: calcilutite; light grey to brownish grey, light grey to white weathering; microcrystalline to cryptocrystalline; thick to medium bedded; calcite crystals; shaly partings, worm borings, *Tetradium* near top	22.1
CQ2	Dolomite: silty; brownish grey to light brownish green, greenish-buff weathering; aphanitic; medium to thick bedded; includes 0.6-foot bed of mottled buff dolomite and grey calcilutite	7.2
CQ1	Dolomitic Limestone: mottled grey and buff, grey limestone with silty buff, dolomite patches; light brownish grey; microcrystalline and aphanitic; thick bedded; streaked and mottled grey and buff layers commonly following current bedding; minor nodular grey chert; pronounced colour lamination. Upper 0.4 feet, green shale	6.4
	Total	50.1

(25) CHEMICAL ANALYSES—COLDWATER QUARRY

(Analyses from Goudge, p. 190)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
5A	1.56	0.38	0.54	0.02	96.98	1.07	100.55	trace	54.32	0.51
5B	6.04	0.96	2.42	0.04	59.46	30.02	98.94	0.18	33.32	14.35
5C	3.88	0.50	1.72	0.07	65.73	27.59	99.49	0.06	36.85	13.19
5D	1.58	0.19	0.33	0.02	92.20	5.00	99.32	trace	51.64	2.39

Sample 5A—Coldwater quarry, 35-foot face worked in 1934.
Sample 5B—Coldwater quarry, upper 32 inches of unit CQ2. (See section.)
Sample 5C—Coldwater quarry, lower 49 inches of unit CQ2.
Sample 5D—Coldwater quarry, unit CQ1, 7 feet of mottled beds, exclusive of chert.

LIMESTONE PRODUCTS LIMITED (UHTHOFF QUARRY)

The quarry of Limestone Products Limited is located at Uhthoff, 7 miles northwest of Orillia, in lot 10, concession IV, Orillia township, Simcoe county. It is served by Canadian Pacific and Canadian National railways as well as by truck haulage.

Geology

The 38-foot quarry face consists of 2 feet of coquinoid, brownish-grey calcarenite limestone belonging to the Upper Black River formation, underlain by 36 feet of grey-weathering, dense, medium-bedded lithographic limestone of the Middle Black River formation of Lowville age. These latter include the *Tetradium* and "birdseye" beds. The contact between the Middle and Upper Black River formations is marked by a colour and texture change from light-grey cryptocrystalline limestone below to brownish-grey coquinoid calcarenite above. Within the 36 feet of Middle Black River grey lithographic beds there are two prominent white- or silver-grey-weathering massive limestone marker beds, the upper one 3 feet thick, and the lower one 3.3 feet thick. These white marker beds are easily distinguished on outcrop sections and can be traced at least as far as Hampshire Mills. There is some mottling and colour lamination in the cryptocrystalline limestone. At 7.5 feet above the quarry floor, greenish-grey beds are overlain by brownish-grey beds. This lower 7.5 feet of the quarry face is greenish in tone and slightly argillaceous. Although this increase in shale content is small in this lower unit of the Middle Black River formation atUhthoff, it is marked at Port McNicoll to the west, and at Marmora and Kingston to the east.

The quarry floor is the top of the sandy buff dolomite beds that mark the upper contact of the Lower Black River (Pamelia) beds, and these beds are exposed in ditches. This buff unit marks the lower limit of calcium limestone in this area.

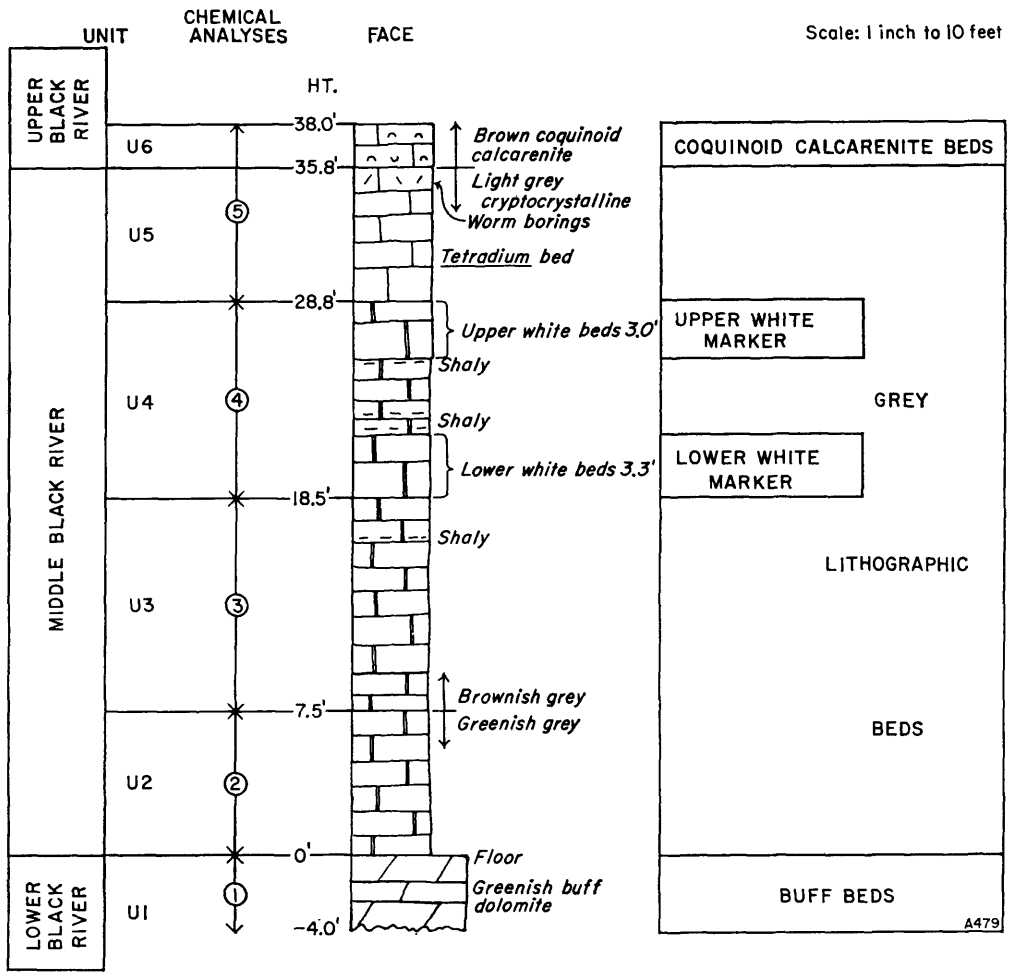
The complete quarry section is described in (26). Chemical analyses were made of five composite chip samples from the quarry face (27).

Quarry Operation

The 38-foot quarry face is operated on one lift at the west side of the quarry and on two lifts of 18 and 20 feet respectively on the east side of the quarry. Overburden is 4–10 feet thick. Drilling is carried out by one Bucyrus-Erie 40R Rotary diesel drill using a 6¾-inch bit on a 20- by 18-foot pattern on the 38-foot face, and a 15- by 16-foot pattern on the 20-foot faces. A Bucyrus-Erie 22T gasoline churn-drill may also be used. In heavy-bedded sections, 4-foot helper holes may be drilled by wagon drill to obviate secondary breaking. Blasting agents are 70-percent Dynamex, 50-percent Forcite and prilled ammonium nitrate fused with Primacord and millisecond electric blasting caps. A 3-cubic yard Bucyrus-Erie 71B diesel shovel loads five 15-ton Euclid rear-dump trucks for haulage to the primary crusher. Two 22-ton Euclid trucks are on standby duty. A clean and level floor and excellent road system are maintained by two motor graders, and a bulldozer on clean-up.

The primary crusher is a 30-inch Nordberg gyratory, set at 5 inches. A 40- by 48-inch Buchanan jaw-crusher is used as a primary standby. The 5-inch stone is carried by a 36-inch conveyor to a surge pile. A reclaiming tunnel and conveyor carries the stone to the secondary crushing building where it discharges over a 2-deck Tyroc scalping screen with 3-inch and 1-inch openings. The plus 3-inch stone goes to the secondary crusher, a 4-foot Symons standard cone. The plus 1-inch stone may go to two 3-foot tertiary crushers, Symons short-head cones, in parallel. The crusher products go,

(26) QUARRY SECTION—LIMESTONE PRODUCTS LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
U6	Limestone: coquinoid calcarenite; medium brownish grey, medium grey weathering; medium crystalline; thin bedded; fossiliferous	2.2
U5	Limestone: calcilutite, lesser coquinoid calcarenite; grey to buff mottled; cryptocrystalline matrix, medium crystalline fragments; thin to medium bedded; calcite crystals, shaly partings; *Tetradium*	7.0
U4	Limestone: calcilutite; light grey to light buff brown, light grey weathering; cryptocrystalline; thick bedded; calcite crystals; shaly partings, in part shaly laminated; includes upper and lower white weathering marker beds	10.3
U3	Limestone: calcilutite; light brown to grey, mottled brownish with dark grey argillaceous streaks; cryptocrystalline; medium bedded; calcite crystals	11.0
U2	Limestone: calcilutite, grey to light brownish grey; cryptocrystalline; thin to medium bedded. Upper beds have greenish tone, which contrasts with brownish overlying beds of U3	7.5
U1	Dolomite: brownish to light olive grey, greenish buff weathering; fine crystalline to aphanitic; medium bedded	4.0
	Total	42.0

The 38-foot face of Black River limestone, at the Uhthoff quarry of Limestone Products Limited, shows the two prominent white marker horizons, which can be traced throughout the area.

via a two-stage 24-inch return conveyor, to two 4- by 12-foot triple-deck Dillon screens, with 2½-inch, 1¾-inch, and ⅝- by 4-inch openings. The oversize products may be recrushed if desired.

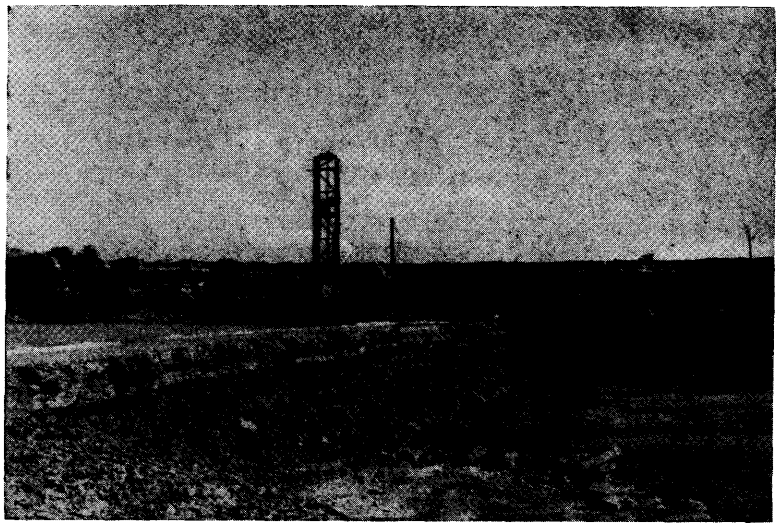
The products from the secondary crushing stage are conveyed to the screen house and storage building by a 30-inch conveyor. In the screen house there are two lines, each consisting of three sets of 4- by 12-foot Dillon screens. The top set is triple-deck, the middle set double-deck, and the lower set triple-deck. The main sizes made are 2-inch, 1-inch, ¾-inch, ⅜-inch special, and bins are provided for these sizes. The larger sizes, 6-inch and 3½-inch stone, are stockpiled from the secondary-crusher building. There is a 4-foot Symons shorthead cone in the screen and bin building, for recrushing.

Transportation is by Canadian National or Canadian Pacific railways, loading directly from bins or from stockpiles by locomotive cranes or Pemco Speedall overhead loaders. There are two diesel yard locomotives. This quarry is one of the three largest in Ontario, with a production of over 1,000,000 tons of stone per year. The plant has a capacity of about 300 tons per hour, and operates on two shifts. The stone is a calcium limestone. The quarry is a large supplier of crushed stone for roads, concrete aggregate, railway ballast, metallurgical flux, and stone for portland cement plants.

(27) CHEMICAL ANALYSES—LIMESTONE PRODUCTS LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent	percent
1	−4 − 0	30.92	7.30	1.44	8.26	23.60	26.82	.....	0.12	98.46
2	0 − 7.5	5.20	3.76	0.62	1.78	49.70	40.31	.....	0.19	101.56
3	7.5–18.5	2.48	0.49	0.35	0.87	52.80	42.24	0.09	0.25	99.57
4	18.5–28.8	2.04	1.65	0.35	0.74	53.80	42.90	0.08	0.15	101.71
5	28.8–37.8	2.06	2.54	0.44	0.72	53.30	42.70	0.12	0.23	102.11



A Bucyrus-Erie 40R rotary drill operates on the first bench at the Uhthoff quarry of Limestone Products Limited.

UHTHOFF DRILLING[1]

In 1955 and 1956, St. Lawrence Cement Company Limited carried out a program of diamond-drilling in the Uhthoff area. Contact logs for diamond-drill holes Nos. 6 and 7 in lot 8, concession IV, and No. 10 in lot 10, concession II, Orillia township, are given in (28).

Chemical analyses of core from holes Nos. 6 and 10 are given in (29).

The weighted averages for the chemical analyses of holes Nos. 6 and 10 are given in (30).

The base of the Lower Trenton in hole No. 10 is placed at the base of a shaly fossiliferous calcarenite unit; as noted in (29) and (30), there appears to be a chemical unconformity at the base of the Lower Trenton, marked by an influx of silt and shale in the Lower Trenton beds. This is indicated by the much higher silica content, averaging 7.49 percent and ranging from 4.90 to 11.44 percent, in the Lower Trenton beds as compared with the underlying Middle and Upper Black River beds, which average 3.25 percent silica. Some 22 feet of Lower Trenton were cored in hole No. 10.

The Upper Black River (Coboconk) formation in hole No. 10 has a thickness of 19.4 feet. The Middle Black River formation has thicknesses of 33.7, 35.0, and 31.2 feet respectively in holes Nos. 6, 7, and 10. The Upper Black River is composed of medium-crystalline, medium-brownish grey, fossiliferous calcarenite. The lower contact is placed at the change to the light-grey to tan cryptocrystalline limestone of the Middle Black River. Although they differ in lithology, the Middle and Upper Black River beds are very similar in chemical composition and can be grouped together chemically. As mentioned in a previous section, the lower 7 feet of the Middle Black River is somewhat higher in silica than the bulk of the formation. The average silica content of the 50.6 feet of Middle and Upper Black River beds in hole No. 10 is 3.25 percent; for the 38.3 feet in hole No. 6 the average silica content is 3.58 percent. The stone cannot therefore be classed as a high-calcium limestone since total impurities (silica + iron + alumina) exceed 3 percent.

[1]Company data, published by permission of St. Lawrence Cement Company, Limited, Clarkson.

(28) CONTACT LOGS FOR DIAMOND-DRILLING—UHTHOFF AREA

	Hole No. 6 Lot 8, Con. IV Orillia tp.		Hole No. 7 Lot 8, Con. IV Orillia tp.		Hole No. 10 Lot 10, Con. II Orillia tp.	
	Depth	Thickness	Depth	Thickness	Depth	Thickness
	feet	feet	feet	feet	feet	feet
Overburden	0 – 6	6	0 –13.2	13.2	0 – 22.8	22.8
Lower Trenton					22.8– 44.8	22
Upper Black River	6 –10.6	4.6+	13.2–14.1	0.9+	44.8– 64.2	19.4
Middle Black River	10.6–44.3	33.7	14.1–49.1	35.0	64.2– 95.4	31.2
Lower Black River	44.3–61.7	17.4+	49.1–67.5	18.4+	95.4–106.2	10.8+

(29) ANALYSES OF TWO DRILL HOLES—UHTHOFF AREA

(Chemical Analyses by Thomas Heys and Sons, Toronto)

Geological Formation		Depth	L. O. I.	CaO	MgO	SiO_2	Fe_2O_3	Al_2O_3
		feet	percent	percent	percent	percent	percent	percent
Drill Hole No. 6 (Lot 8, Con. iv, Orillia Tp.)	Upper Black River	6.0 –10.6	42.14	53.02	0.70	2.58	1.30	0.08
	Middle Black River	10.6 –16.6	42.34	53.39	0.91	3.04	0.21	0.60
		16.6 –22.5	42.15	53.04	0.92	2.86	0.14	0.69
		22.5 –31.1	41.96	52.24	0.81	2.22	0.12	1.72
		31.1 –37.8	41.77	52.15	0.73	3.92	0.14	1.19
		37.8 –44.3	39.84	50.54	1.78	6.90	0.40	0.78
	Lower Black River	44.3 –48.6	34.92	29.22	10.78	22.34	0.91	1.25
		48.6 –52.9	42.92	37.55	12.36	5.40	0.69	0.74
		52.9 –55.2	42.72	48.36	4.42	3.58	0.21	1.04
		55.2 –61.7	43.14	43.41	7.31	4.54	0.36	0.61
Drill Hole No. 10 (Lot 10, Con. ii, Orillia Tp.)	Lower Trenton	22.8 –25.1	39.78	48.80	1.20	8.78	0.30	1.53
		25.1 –33.8	41.02	50.46	0.44	6.00	0.15	0.97
		33.8 –38.9	41.91	52.05	0.16	4.90	0.09	0.99
		38.9 –44.8	38.64	47.86	0.51	11.44	0.21	0.98
	Upper Black River	44.8 –52.2	41.23	52.21	0.26	4.96	0.11	0.81
		52.2 –58.45	42.78	54.67	0.22	2.22	0.09	0.23
	Middle Black River	58.45–67.5	42.43	54.28	0.12	2.70	0.07	0.53
		67.5 –81.2	42.33	54.14	0.14	2.42	0.08	0.54
		81.2 –87.1	42.34	53.24	0.13	2.98	0.10	0.40
		87.1 –92.2	41.98	52.86	0.80	3.30	0.22	0.86
		92.2 –93.9	41.42	51.06	0.41	5.62	0.20	0.92
		93.9 –95.4	40.97	47.25	1.74	8.22	0.61	0.85
	Lower Black River	95.4 –98	31.03	27.83	4.39	26.76	0.89	5.61

(30) WEIGHTED AVERAGES FOR DRILL HOLES NOS. 6 AND 10—UHTHOFF AREA

	Thickness	L. O. I.	CaO	MgO	SiO_2	Fe_2O_3	Al_2O_3
	feet	percent	percent	percent	percent	percent	percent
Drill Hole No. 10							
Lower Trenton	22.0	40.45	49.96	0.47	7.49	0.17	1.04
Middle and Upper Black River	50.6	42.14	53.40	0.29	3.25	0.12	0.58
Drill Hole No. 6							
Middle and Upper Black River	38.3	41.67	52.33	0.98	3.58	0.33	0.94

HAMPSHIRE MILLS QUARRY, HAMPSHIRE MILLS

The inactive Hampshire Mills quarry, located in lot 11, concession VII, Orillia township, Simcoe county, has a face 36 feet high. The section exposed is illustrated and described in (31). The face consists of 6.5 feet of brownish-grey, coquinoid calcarenitic limestone belonging to the Upper Black River formation, underlain by 29.3 feet of grey lithographic limestone belonging to the Middle Black River formation. The upper and lower white marker beds noted in the Uhthoff quarry are seen in this quarry section, and the various units can be correlated lithologically with those in the Uhthoff section.

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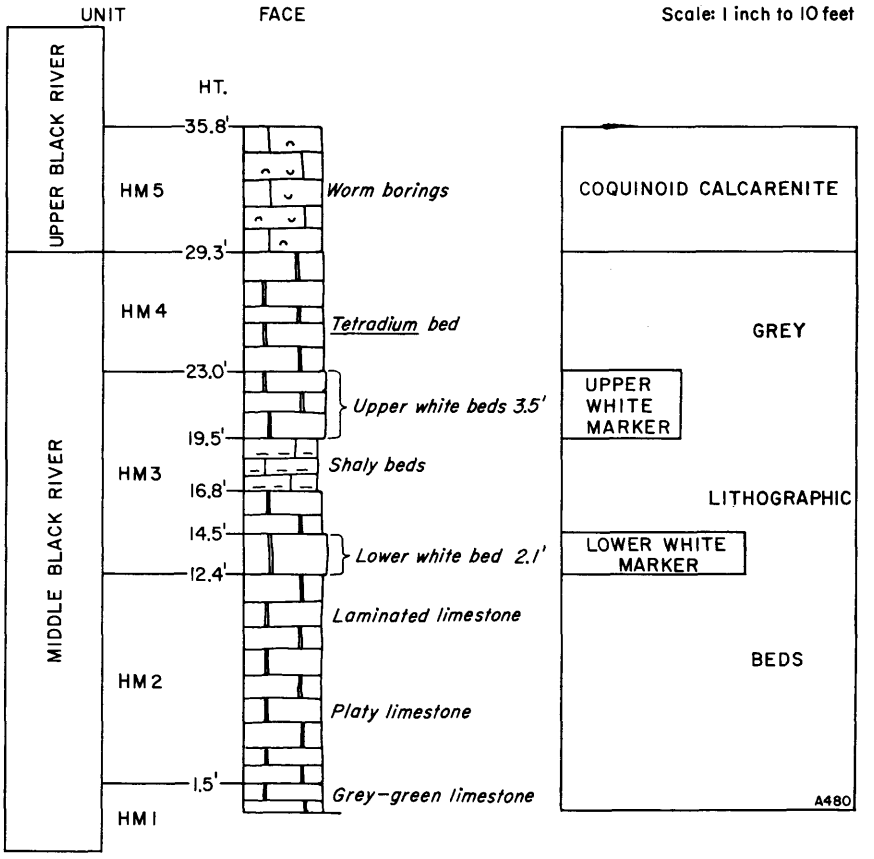
(31) QUARRY SECTION—HAMPSHIRE MILLS QUARRY



UNIT	DESCRIPTION	THICKNESS Feet
HM5	Limestone: coquinoid calcarenite; medium light brownish grey, medium grey weathering; medium bedded; medium crystalline; fossiliferous; rubbly weathering; slight erosional break at base with marked change in lithology from medium-crystalline to underlying microcrystalline.	6.5
HM4	Limestone: calcilutite; light brownish grey, light grey to white weathering; medium to thick bedded; microcrystalline; *Tetradium* beds. (Equals U5 of Uhthoff quarry.)	6.3
HM3	Limestone: calcilutite; light grey to light brownish grey, white-weathering; cryptocrystalline; thick-bedded; calcite crystals; shaly in part. Includes upper and lower white marker beds of Uhthoff quarry. (Equals U4 of Uhthoff.)	10.6
HM2	Limestone: calcilutite; grey to light brownish grey, light grey weathering; microcrystalline; medium to thick bedded; upper 5.3 feet thin laminated, lower 5.6 feet platy weathering; fine stylolites. (Equals U3 of Uhthoff.)	10.9
HM1	Limestone: calcilutite; light brownish grey, greenish grey weathering; microcrystalline; medium bedded. (Equals U2 of Uhthoff.)	1.5
	Total	35.8

HAMPSHIRE MILLS DRILLING[1]

In 1955 and 1956, St. Lawrence Cement Company Limited acquired and diamond-drilled a limestone property at Hampshire Mills, 2 miles east of Uhthoff. The property comprises part of lot 9, concession VI; lots 9, 10, 11, 12, and part of lot 8, concession VII; and parts of lots 9, 10, and 11, concession VIII, Orillia township, Simcoe county.

Extensive diamond-drilling indicated that 40–48 feet of good quality Middle and Upper Black River limestone underlie the whole property, with 0–30 feet of Lower Trenton limestone present on the southeast side of the property overlying the Black River beds. Overburden is shallow, averaging about 5 feet.

The accompanying table (33) gives weighted average chemical analyses and stratigraphic data for 10 diamond-drill holes on the Hampshire Mills property. Holes Nos. 14, 1, 6, 3, 2, and 12, located in concessions VI and VII, intersected Black River beds only; holes Nos. 9, 10, 7, and 8 located on the east side of the property, disclose sections of the Lower Trenton as well as a complete section of the Middle and Upper Black River beds.

As at Uhthoff, the Middle and Upper Black River beds are very similar chemically and are therefore grouped together. The upper contact of the Lower Black River is marked by the greenish siliceous dolomite beds already described in the Uhthoff area. The Middle and Upper Black River beds have a total thickness ranging from 46.2 feet in hole No. 9, to 49.7 feet in hole No. 8. The Middle Black River grey lithographic limestone beds have a thickness of 31–35 feet. They are overlain by 15–17.8 feet of brownish-grey coquinoid calcarenite assigned to the Upper Black River (Coboconk) formation.

The base of the Lower Trenton beds here again is placed at the base of a shaly fossiliferous calcarenite unit, and a marked increase in silica content can be noted at the Black River–Trenton contact. The average silica content of the underlying Middle and Upper Black River beds is 2.48 percent, whereas the Lower Trenton beds average 4.16 percent silica.

The average chemical composition for the Black River and Trenton beds cored in diamond-drilling on the Hampshire Mills property is given in (32).

Quarry-run stone from a 40- to 50-foot face of Middle and Upper Black River limestone could be expected to average as indicated in the tabulation shown. Since much of the silica and alumina is present in thin shaly partings, a washed and screened product could be expected to run somewhat lower than the average in silica and alumina shown.

[1]Company data, published by permission of St. Lawrence Cement Company Limited, Clarkson.

(32) AVERAGE CHEMICAL COMPOSITION OF BLACK RIVER AND TRENTON BEDS —HAMPSHIRE MILLS PROPERTY

	Thickness	L. O. I.	CaO	MgO	SiO_2	Fe_2O_3	Al_2O_3
	feet	percent	percent	percent	percent	percent	percent
Lower Trenton	0–29	40.84	50.99	1.36	4.16	0.63	0.51
Middle and Upper Black River	40–50	42.02	52.39	1.14	2.48	0.56	0.53

LONGFORD QUARRY, LONGFORD

The Longford quarry is located on the west shore of Lake St. John, just north of the village of Longford, between the lakeshore and the Canadian National railway. The quarry was formerly operated for the "Rama" building stone by Longford Quarries Limited, but is now inactive. The "Rama" stone consists of 11.5 feet of thick-bedded buff dolomite, which forms the uppermost "buff beds" of the Lower Black River formation. The dolomite takes a good polish and was used for interior marble as well as exterior building stone. The Imperial Bank Building at King and Yonge Streets, Toronto, is faced with this stone.

The section exposed at the quarry is illustrated and described in (34). The lowermost unit, the 11.5 feet of "Rama" stone, is the buff silty dolomite unit that marks the top of the Lower Black River formation throughout the area and correlates with the buff beds at Coldwater, Uhthoff, and Hampshire Mills. The "Rama" stone unit consists of six beds, which have thicknesses from the top down of 32, 21, 10, 9, 7, and 28 inches (Goudge, p. 137).

Above the "Rama" stone there is 20.4 feet of grey lithographic *Tetradium*-bearing limestone assigned to the Middle Black River. As indicated in (35) the lower 7.1 feet of this formation is somewhat higher in silica than the upper 13.3 feet. The uppermost 6 feet of the quarry is medium light-grey

(33)

HAMPSHIRE MILLS DRILLING, CHEMICAL ANALYSES AND STRATIGRAPHIC DATA*

DRILL HOLE NO.	14	1	6	3	2	12	9	10	7	8
Location	Lot 9 Con. VI	Lot 9 Con. VI	Lot 12 Con. VII	Lot 10 Con. VII	Lot 8 Con. VII	Lot 11 Con. VIII	Lot 11 Con. VIII	Lot 11 Con. VIII	Lot 10 Con. VIII	Lot 10 Con. IX
Overburden....feet	8	nil	0.6	2.0	9.2	2.0	nil	nil	1.0	39.0
LOWER TRENTON†										
Footage	nil	nil	nil	nil	nil	nil	0 –12.0(?)	1 –17.1	2.0–31.0	39.8– 60.3
Thickness							12.0 +	16.1 +	29.0 +	20.5 +
Chemical Analyses (weighted average):										
L. O. I....percent							40.91	40.80	40.62	41.02
SiO_2....percent							3.62	4.32	4.63	4.05
Fe_2O_3....percent							0.62	0.89	0.65	0.35
Al_2O_3....percent							0.16	0.29	0.41	1.18
CaO....percent							51.22	50.19	51.13	51.40
MgO....percent							1.27	1.85	1.37	0.96
Total....percent							97.80	98.34	98.81	98.96
UPPER BLACK RIVER‡										
Footage	8 –17.2	0.7–14.0	1.2– 8.2	3.0–15.8	9.2–25.0	2.8– 9.8	12.0–27.2	17.1–32.6	31.0–48.0	60.3– 78.1
Thickness....feet	9.2 +	13.3 +	7.0 +	12.8 +	15.8 +	7.0 +	15.2	15.5	17.0	17.8
MIDDLE BLACK RIVER•										
Footage	17.2–48.5	14.0–48.5	8.2–43.9	15.8–50.0	25.0–57.1	9.8–44.5	27.2–58.2	32.6–65.3	48.0–80.5	78.1–110.0
Thickness....feet	31.3	33.5	35.7	34.2	32.1	34.7	31.0	32.7	32.5	31.9
Total Middle and Upper Black River♦....feet	40.5	46.8	42.7	47.0	47.9	41.7	46.2	48.2	49.5	49.7
Chemical Analyses (weighted average):										
Footage analyzed	8 –47.6	0.7–48.0	1.2–43.4	3.0–49.2	9.2–57.0	2.8–44.2	12.0–57.2	16.9–65.1	31.0–80.1	60.0–109.4
Thickness....feet	39.6	47.3	42.2	46.2	47.8	41.4	45.2	48.2	49.1	49.4
L. O. I....percent	42.35	42.38	41.96	41.70	42.03	41.88	41.90	42.00	42.02	41.94
SiO_2....percent	2.30	2.14	2.57	2.26	2.67	2.74	2.57	2.38	2.62	2.52
Fe_2O_3....percent	0.45	0.36	0.69	0.49	0.45	0.60	0.72	0.67	0.67	0.50
Al_2O_3....percent	0.87	0.55	0.88	0.67	0.64	0.26	0.41	0.27	0.43	0.34
CaO....percent	52.81	53.27	52.79	53.61	53.10	51.40	51.69	51.37	51.63	52.22
MgO....percent	1.05	0.93	0.80	0.99	0.97	1.34	1.40	1.62	1.09	1.23
Total....percent	99.83	99.63	99.69	99.72	99.86	98.22	98.69	98.51	98.46	98.75
LOWER BLACK RIVER‡										
Footage	48.5–60.0	48.5–66.4	43.9–48.8	50.0–52.8	57.1–61.1	44.5–54.4	58.2–61.6	65.3–66.1	80.5–81.8	110.0–112.7
Thickness....feet	12.5 +	17.9 +	4.9 +	2.8 +	4.0 +	9.9 +	3.4 +	0.8 +	1.3 +	2.7 +

*Company data published with the permission of St. Lawrence Cement Co. Ltd.

†Lower Trenton equals the shaly "Kirkfield beds."

‡Upper Black River equals the Coboconk beds, fossiliferous calcarenite.

•Middle Black River equals Lithographic limestone beds.

♦The Middle and Upper Black River are chemically similar and can be quarried together as a single face.

‡The top of the Lower Black River is marked by the "green dolomite beds", these are impure and high in magnesia and make the potential floor of commercial calcium limestone.

fossiliferous calcarenite carrying *Stromatocerium* and abundant corals, and is assigned to the Upper Black River (Coboconk) formation. There appears to be a minor erosion surface between the Middle and Upper Black River strata.

Chemical analyses, of this quarry face (35) are quoted from Goudge's report (p. 141).

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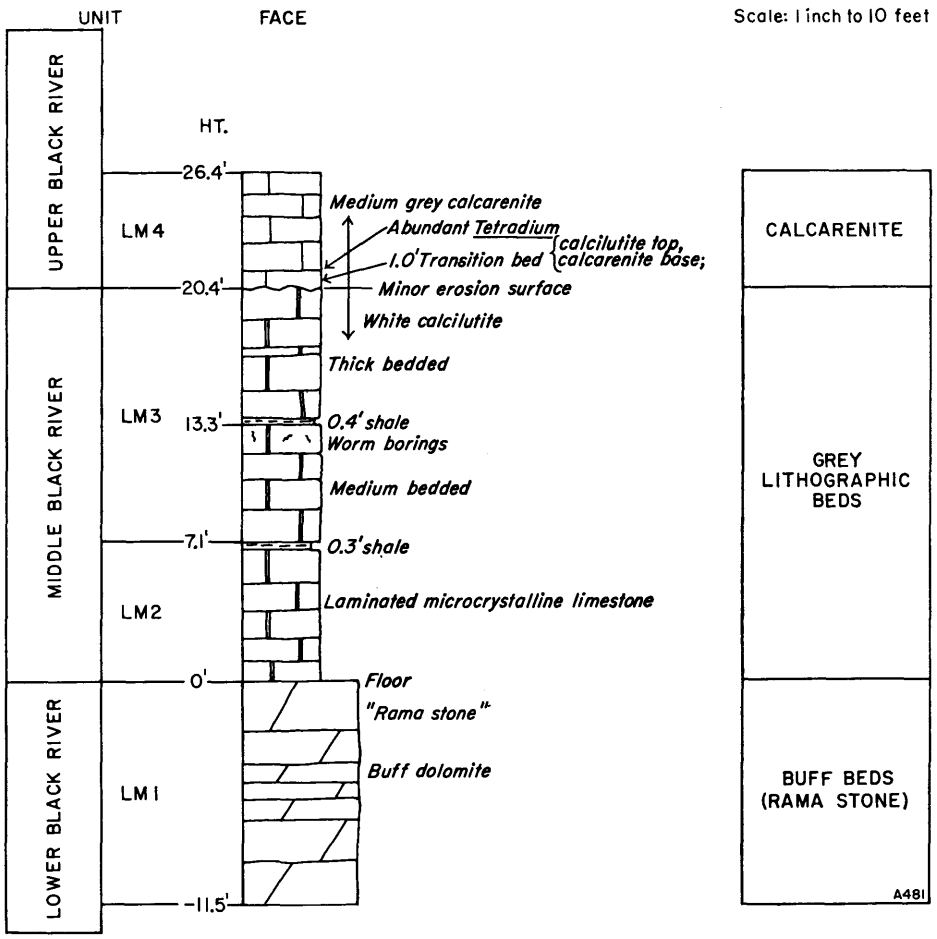
(34) QUARRY SECTION—LONGFORD QUARRY



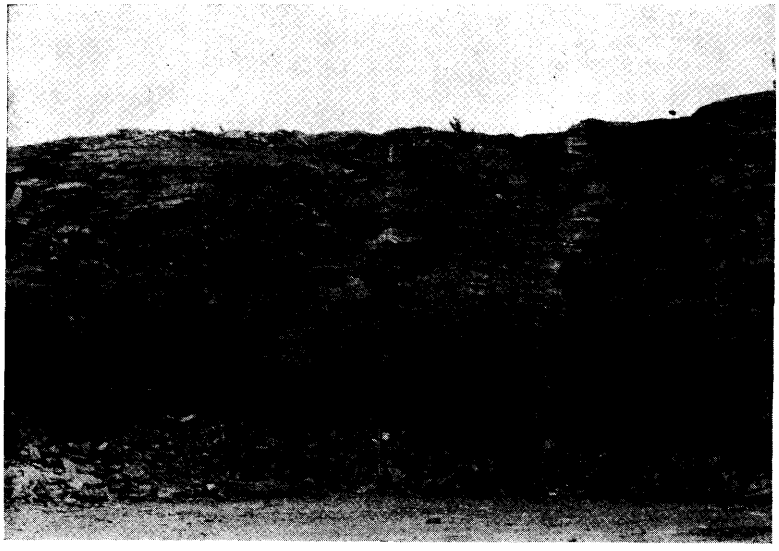
UNIT	DESCRIPTION	THICKNESS Feet
LM4	Limestone: fine calcarenite; medium light grey, medium grey weathering; fine crystalline; thick bedded, upper part medium bedded; scattered fossil debris: *Stromatocerium*, corals, *Tetradium*, coarse crystalline worm tubes. Lower 1.0-foot bed transitional: calcilutite top, calcarenite base	6.0
LM3	Limestone: calcilutite; light grey, white or light grey weathering; microcrystalline to cryptocrystalline; medium to thick bedded; grey shaly partings; calcite crystals; *Tetradium*; rare pyrite	13.3
LM2	Limestone: calcilutite; laminated; light brownish grey, white weathering, cryptocrystalline; medium bedded; calcite eyes; shaly partings; microlaminations	7.1
LM1	Dolomite: silty; light grey, buff weathering; aphanitic; thick bedded. "Rama" building stone beds, largely under water	11.5
	Total	37.9

(35) CHEMICAL ANALYSES—LONGFORD QUARRY

(Analyses from Goudge, p. 141)

Sample No.	Stratigraphic Unit (See (34))	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
		percent	percent	percent	percent	percent
8	LM3, LM4	1.42	0.40	0.96	54.13	0.15
8A	LM2	2.62	1.03	0.30	51.59	1.16
8B–8G	LM1	4.13	1.13	1.52	34.30	15.28

Sample 8—top 20 feet of high-calcium limestone (LM3 and LM4).
Sample 8A—bottom 6 feet of calcium limestone (LM2).
Samples 8B–8G—11.5 feet of "Rama" stone (LM1).



The 41-foot face at the Kirkfield Crushed Stone quarry is mainly composed of thin to medium bedded Lower Trenton limestone with many shaly partings. The upper 3 feet in this photo is thin bedded Middle Trenton limestone.

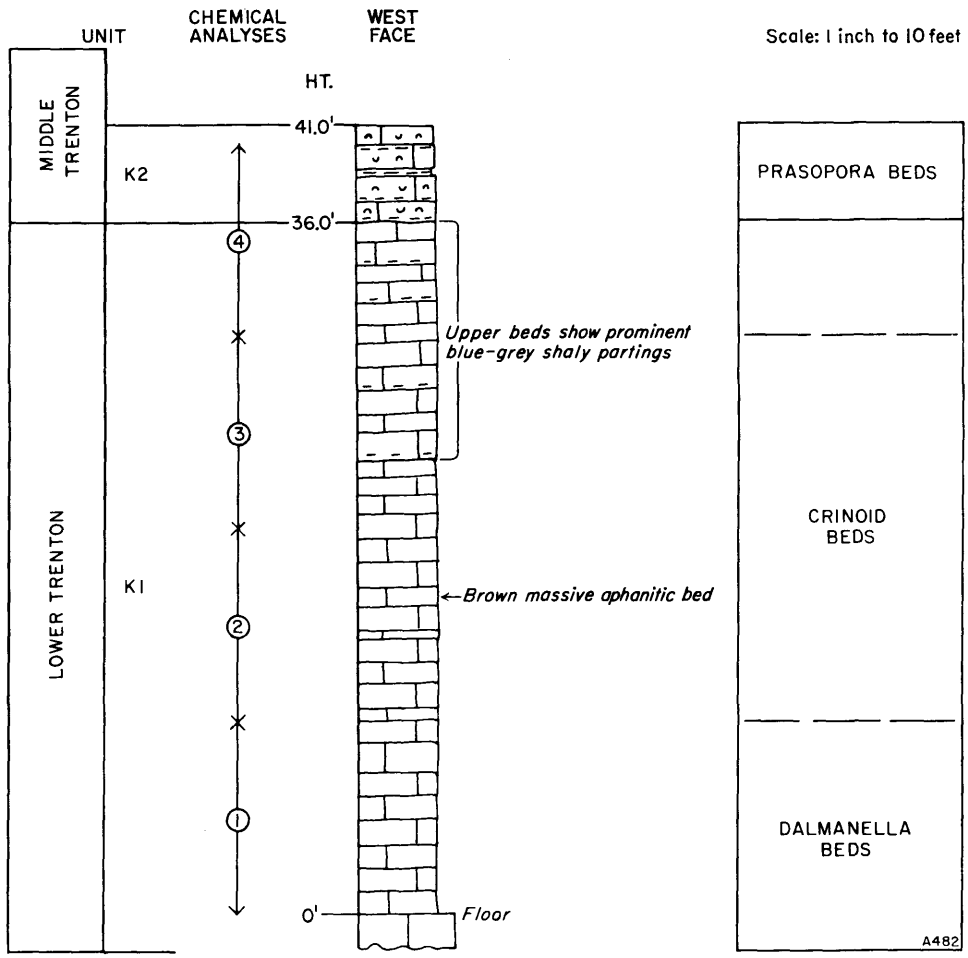
KIRKFIELD CRUSHED STONE LIMITED, KIRKFIELD

The quarry of Kirkfield Crushed Stone Limited is located in the northeast corner of Eldon township, Victoria county, just north of the Canadian National railway line, east of the Trent Canal. It is about 1½ miles northeast of Kirkfield village.

Geology

The 41-foot quarry face consists of fossiliferous medium-brownish grey, medium-crystalline, thin- to medium-bedded, calcium limestone with prominent shaly partings. The quarry section is illustrated and described in (36). The upper 5 feet of rusty-weathering, thin-bedded, fossiliferous calcarenite with shaly partings is referred to the Middle Trenton (Sherman Fall) formation. These beds are distinguished by an abundance of small hat-like *Prasopora* bryozoa, and are referred to as the *Prasopora* beds. The lower 36 feet of the quarry face is Lower Trenton (Kirkfield) formation. These beds consist of medium-grey to brownish-grey, thin- to medium-bedded limestone ranging from fossiliferous calcarenite to calcilutite. There are prominent blue-grey shaly partings especially in the upper 12 feet. The Middle Trenton beds are highly fossiliferous: the lower 10 feet are characterized by the brachiopod *Dalmanella* and are called the *Dalmanella* beds; the next 20 feet above these beds are characterized by an abundance of echinoderms, and are called the crinoid beds. Graded-bedding and cross-lamination were noted in some of the beds. The quarry section, except for the upper 5 feet of rusty-weathering Middle Trenton beds, is rather uniform in lithology. Chemical analyses of composite chip samples taken in 10-foot sections up the quarry face are given in (37). The silica content, ranging from 3 to 5.5 percent, is higher than that of the underlying Black River group. Chemically the Lower Trenton beds of the Kirkfield quarry are similar to the Lower Trenton at Hampshire Mills.

(36) QUARRY SECTION—KIRKFIELD CRUSHED STONE LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
K2	Limestone: coquinoid calcarenite; medium grey to medium brownish grey; weathers buff to rusty brown; rubbly; medium to fine crystalline; thin bedded; shaly partings to 0.2 feet; very fossiliferous: *Prasopora* beds	5.0
K1	Limestone: calcarenite to calcilutite; some coquinoid calcarenite; medium grey to medium brownish grey, rarely medium brown; blue-grey shale partings especially in upper beds; weathers medium grey; medium and fine crystalline to aphanitic; thin bedded, occasionally medium bedded; prominent shale partings; graded bedding from brown crystalline coquinoid calcarenite to aphanitic calcilutite with shaly partings. Some cross-lamination in upper coquinoid beds. Fossiliferous: crinoids, *Dalmanella* common; fucoids	36.0
	Total	41.0

(37) CHEMICAL ANALYSES—KIRKFIELD CRUSHED STONE LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959.)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	0–10	5.54	2.10	0.46	1.37	50.75	41.65	0.12	101.99
2	10–20	5.18	1.68	0.42	1.35	50.80	41.55	0.04	101.02
3	20–30	3.94	1.51	0.57	1.10	52.20	41.30	0.05	100.67
4	30–40	3.18	1.48	0.44	0.88	52.50	41.97	0.10	100.55

Quarry Operation

The 41-foot quarry face is quarried in a single lift. Overburden is light, ranging from 2–5 feet in thickness. Three electric churn-drills drill 6-inch by 45-foot holes on a 20- by 22-foot pattern. Some secondary blasting is required. The blasting agents are dynamite and prilled ammonium nitrate.

The main crushing plant located south of the quarry has a capacity of 120 tons per hour. A semi-portable crushing plant installed in the quarry has a capacity of about 75 tons per hour. In one 10-hour shift the rated production is 2,000 tons. Haulage to the main crushing plant is by rail. A 2-cubic-yard, Bucyrus-Erie diesel shovel loads two 10-car trains hauled by two steam dinky engines. The 10-car load is about 25 tons. Two steam dinky engines are on standby duty. A Koehring 402 diesel shovel of 1-cubic-yard capacity loads three 12-ton tandem Mack trucks for haulage to the semi-portable crushing plant in the quarry.

At the main crushing plant the primary crusher is a 28-inch Superior McCully gyratory, set at 5 inches. This is followed by a scalping screen. Secondary crushing is done by a 3-foot Symons cone in parallel with a 10-inch McCully gyratory. Screening is carried out by a 2-deck, 5- by 12-foot Wetlaufer screen; a Worthington triple-screen trommel producing ½-inch, 1-inch, and 3-inch stone; and a 4- by 8-foot, single-deck, ⅜-inch screen and a 2- by 6-foot, single-deck, ¼-inch screen. Trucks and railway cars are loaded from bins or from stockpiles by a travelling railway crane with a 1½-yard clam bucket.

The semi-portable Cedarapids plant in the quarry consists of a 25- by 40-inch jaw-crusher, screens, bins, and a secondary jaw-crusher and rolls for secondary crushing.

The main sizes produced are 2-, 1½-, ¾-, ⅜-inch, screenings, and ⅝-inch crusher run. The main production is road stone, concrete aggregate, and railway ballast, but some asphalt filler and flux stone are also produced.

COBOCONK EAST QUARRY (COBO MINERALS LIMITED), COBOCONK

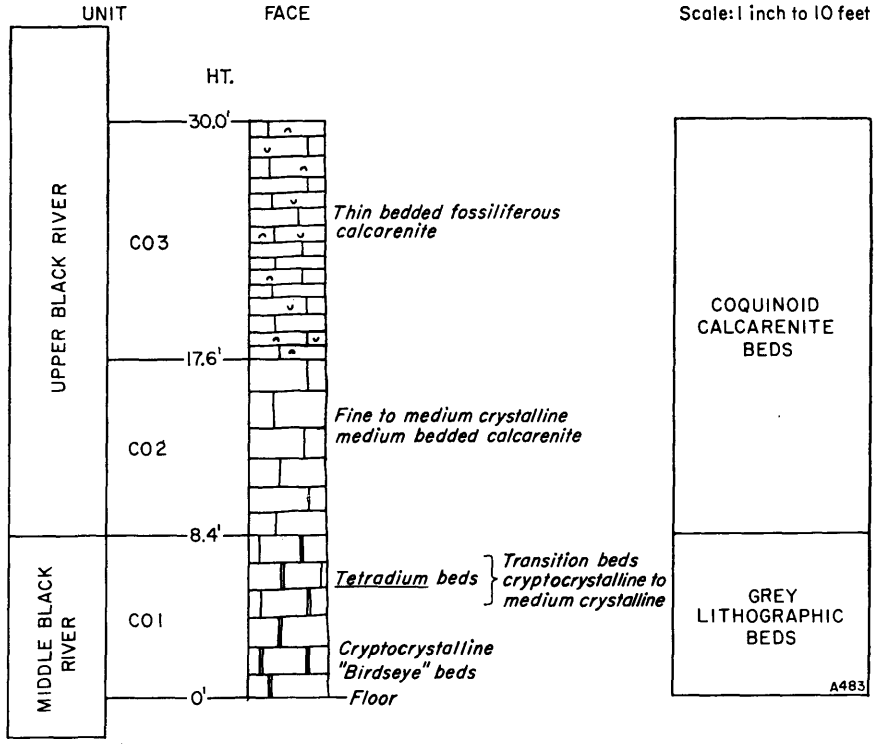
The Coboconk East quarry, operated in 1958 by Cobo Minerals Limited, is located in Somerville township, Victoria county, on the eastern outskirts of Coboconk village, southeast of the Gull River and immediately northeast of highway No. 35. The abandoned quarry of Toronto Lime Company is on the west side of highway No. 35, south of the Coboconk East quarry. The Coboconk East quarry was formerly operated by Canada Lime Company Limited.

Geology

The 30-foot face exposed in the quarry is illustrated and described in (38). The section consists of 21.6 feet of medium-brownish grey, medium- to fine-crystalline, high-calcium limestone, mainly coquinoid calcarenite, which are referred to the Upper Black River (Coboconk) formation, underlain by 8.4 feet of grey, high-calcium, lithographic limestone of the Middle Black River (Gull River) formation. The uppermost 12.4 feet of Upper Black River is thin-bedded and fossiliferous, and is characterized by *Stromatocerium* and *Lyopora halli.* The lower 9.2 feet of the Upper Black River is similar to the overlying strata, but is medium to thick bedded. The contact between the Middle and Upper Black River beds is difficult to place since there is a transition from the cryptocrystalline limestone of the lower unit to the fine-crystalline, coquinoid calcarenite of the upper unit, with interbedding of these two lithological types. The lowermost 8.4 feet of the section, which has been assigned to the Middle Black River, is mainly cryptocrystalline grey limestone characterized by *Tetradium* and calcite eyes ("birdseye beds").

Chemical analyses (39) of this quarry face, quoted from Goudge's report (p. 203), indicate that the section is high-calcium limestone.

(38) QUARRY SECTION—COBOCONK EAST QUARRY



UNIT	DESCRIPTION	THICKNESS Feet
CO3	Limestone: coquinoid calcarenite; medium brownish grey, light grey weathering; medium to fine crystalline; thin bedded; minor black shaly to bituminous partings; fossiliferous: crinoids, brachiopods	12.4
CO2	Limestone: same as C03 above, medium to thick bedded	9.2
CO1	Limestone: calcilutite transitional upwards to coquinoid calcarenite; medium brownish grey, weathers medium light grey; cryptocrystalline to fine crystalline; medium to thick bedded; minor shaly partings; fossiliferous: *Tetradium*; calcite eyes; "birdseye" beds	8.4
	Total	30.0

(39) CHEMICAL ANALYSES—COBOCONK EAST QUARRY

(Analyses from Goudge, p. 203)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
13	1.38	0.31	0.51	0.02	96.55	0.76	99.53	0.03	54.08	0.36
13A	1.20	0.29	0.57	0.07	96.70	0.69	99.52	0.08	54.19	0.33

Sample No. 13—upper 8 feet of quarry section.
Sample No. 13A—lower 21 feet of quarry section.

The 21.6 feet of Upper Black River beds exposed at this quarry may represent a fairly complete section of the Upper Black River (Leray, Coboconk) beds in this area. To the west at Hampshire Mills, the Upper Black River had a complete thickness of 15–18 feet. However, the Lower Trenton beds are not exposed at Coboconk, and the 21.6 feet represents a minimum thickness. The Upper Black River formation thickens to the east.

Quarry and Lime Plant

The quarrying operation, drilling and blasting, is under contract. The quarry stone is trucked from the quarry to a grizzly and bin, situated at the top of the quarry face on the east side of the property. Stone passing the 18- by 18-inch grizzly feeds into a rock storage bin, which is discharged by a feeder to the primary crusher, a 20- by 20-inch Cedarapids impact breaker, situated on the quarry floor. The product from the impact breaker is conveyed to a set of 2-deck, 3- by 8-foot screens having 1¼-inch and ⅝-inch openings. The plus 1¼-inch stone is returned to the impact breaker. The minus ⅝-inch fines are stockpiled by conveyor for disposal or sale. The minus 1¼-inch plus ⅝-inch stone, which serves as kiln feed, is elevated via conveyor to a surge pile on the quarry surface to the east of the crushing plant. This stone is reclaimed from the surge pile by a conveyor, which extends underground below the surge pile in a crosscut into the quarry face. The stone feeds on to the conveyor through a raise to surface under the surge pile.

The lime kiln, a Vulcan rotary kiln measuring 7 by 125 feet, is fired with pulverized coal and is said to have a capacity of 100 tons per 24 hours. Bins are provided for the storage of 500 tons of lime. Approximately 35 percent of production is bagged in the bagging plant. The lime is used in the building trade and in the mining, leather-tanning, water-treatment, and chemical industries.

CANADA CEMENT COMPANY LIMITED (LAKEFIELD QUARRY), LAKEFIELD

The abandoned quarry of Canada Cement Company Limited at Lakefield, is of considerable interest since it is one of the best sections of Middle Trenton (Sherman Fall) beds exposed in this part of Ontario. The quarry is located ½ mile east of the cement plant in lot 16, concession VII, Douro township, Peterborough county.

The 40-foot quarry face is limestone, interbedded with shale, and is very fossiliferous. The section is described in (40).

Chemical analyses supplied by Canada Cement Company Limited as "representative of successive 10-foot sections of the deposit from the surface to a depth of 50 feet" are quoted from Goudge's report (p. 148) in (41).

Winder[1] states that the top of the 40-foot quarry face at the Lakefield quarry is about 100 feet above the base of the Sherman Fall (Middle Trenton), and that the Sherman Fall has a thickness of 200–250 feet in this area.

[1]C. G. Winder, *Burleigh Falls and Peterborough Map-Areas, Ontario*, Geol. Surv. Can., Paper 53-27, 1954, p. 7.

(40) QUARRY SECTION—CANADA CEMENT COMPANY LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
MIDDLE TRENTON	Limestone: shaly; coquinoid calcarenite to calcirudite with grey-blue calcareous shale interbeds; light brownish grey to medium dark grey, blue-grey weathering; medium crystalline to aphanitic; thin bedded; some thin nodular 1-inch limestone beds in shale; very fossiliferous, abundant *Prasopora, Dalmanella, Sowerbyella*	40

(41) CHEMICAL ANALYSES—CANADA CEMENT COMPANY LIMITED

(Analyses from Goudge, p. 148)

Depth	SiO_2	Fe_2O_3 + Al_2O_3	CaO	MgO	L.O.I.	Total
feet	percent	percent	percent	percent	percent	percent
0–10	10.30	4.50	46.02	1.41	37.20	99.43
10–20	11.90	3.82	44.50	1.66	36.80	98.68
20–30	12.58	4.70	43.53	1.99	36.34	99.14
30–40	13.74	5.94	42.42	1.90	35.12	99.12
40–50	12.20	5.00	44.29	1.72	35.56	98.77
Average Composition	12.14	4.79	45.15	1.74	36.20	.....

The Middle Trenton beds may also be examined in a small quarry 4 miles north of Peterborough on the east side of highway No. 28 in lot 25, concession V, Smith township.

The section exposed is limestone, mainly coquinoid calcarenite with shaly interbeds. Limestone conglomerate is also present. The section is very fossiliferous. This quarry is estimated to be 60 feet above the top of the Lakefield quarry.[1] The base of the Sherman Fall (Middle Trenton) is reported to be in contact with the underlying Hull (Lower Trenton) below the road bridge at Lakefield.[1]

MARMORATON MINING COMPANY (MARMORA PIT), MARMORA

At Marmoraton Mining Company's Marmora pit a continuous 144-foot section of the Black River Group from the Precambrian contact upwards is exposed. This reference section for the Black River in this area is illustrated and described in (43). The section, measured on the northwest face of the quarry, consists of 7.4 feet of buff and red basal clastics overlain by 59.6 feet of Lower Black River, 67 feet of Middle Black River, and 10 feet of Upper Black River beds. The basal clastics rest directly on the irregular Precambrian surface and are of varied thickness. They consist of basal conglomerate and red and buff sandstone, shale, and grit. The contact with the Lower Black River is marked by the appearance of limestone. The Lower Black River formation is here divided into four units: the lowermost 12.3 feet is maroon and red lithographic limestone, silty dolomite, and shale; above this is a massive 10-foot unit consisting mainly of sandy dolomite, the "lower buff beds"; above this is 30.3 feet of interbedded grey and buff lithographic limestone and dolomite; the upper contact of the Lower Black River is marked by 7 feet of silty buff dolomite and is separated from the overlying Middle Black River by a minor disconformity.

[1]C. G. Winder, *ibid.*

The Middle Black River formation is divided here into two lithologic units, which are also distinguishable on a chemical basis. The lower unit consists of 21 feet of thin-bedded grey lithographic and clastic limestone with shaly partings. As indicated in (42) samples Nos. 1 and 2 of this unit have a substantial silica and alumina content (silica, 12.72 percent, 7.50 percent; alumina, 3.58 percent and 3.15 percent). This indicates an appreciable content of silt and shale in this lowermost unit of the Middle Black River, and although the magnesia content is low, this unit cannot be classed as high-calcium limestone. The contribution of shaly clastic material in the lowermost Middle Black River beds to the west in the vicinity of Port McNicol and Uhthoff has already been mentioned, and it appears that a similar influx of shaly material in the lower Middle Black River beds also took place from Marmora eastward; this condition is emphasized in the Kingston area, where the thickness of high-calcium stone in the Middle and Upper Black River is very small.

The upper unit of the Middle Black River formation consists of 46 feet of thick-to-massive grey lithographic limestone. As indicated in (42) this unit is a high-calcium limestone (samples Nos. 3, 4, 5, and 6), except for the uppermost 4 feet, where the presence of black chert nodules raises the silica content to 3.48 percent. The contact between the Middle and Upper Black River formations is marked by a change in colour and lithology from light-grey, microcrystalline Middle Black River limestone to medium-grey, medium-crystalline fossiliferous calcarenite of the Upper Black River. The 10 feet of Upper Black River limestone is high-calcium limestone.

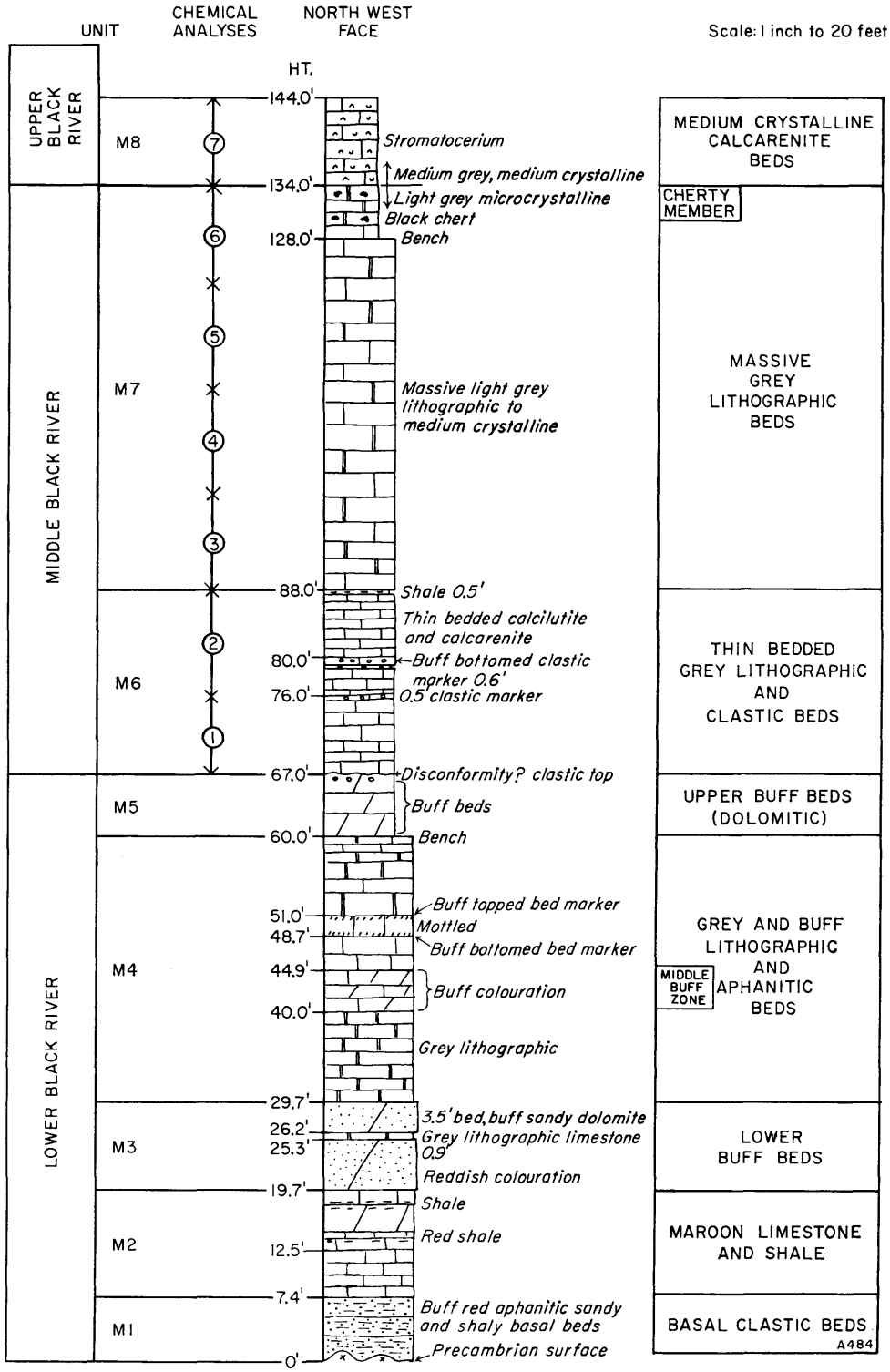
Chemical analyses of composite chip samples taken of the Middle and Upper Black River beds on the southeast side of the quarry are given in (42). The approximate stratigraphic position of the samples taken is indicated on the stratigraphic section; however the actual footages do not exactly correspond as the samples were taken on the opposite side of the quarry from the measured section.

(42) CHEMICAL ANALYSES—MARMORATON MINING COMPANY LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Footage Above Floor	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	CO_2	S	P_2O_5	Total
		percent	percent	percent	percent	percent	percent	percent	percent	percent
1	71.5- 81.5	12.72	3.58	0.91	42.90	1.66	35.20	1.03	.....	98.00
2	81.5- 93.2	7.50	3.15	0.82	47.90	1.46	38.27	0.41	.....	99.51
3	93.2-104.2	1.78	0.64	0.52	54.20	0.87	42.35	0.24	0.10	100.60
4	104.2-115.9	1.68	0.57	0.42	53.60	1.26	43.17	0.12	0.10	100.82
5	115.9-126.6	1.82	0.63	0.35	54.20	0.65	43.18	0.17	0.10	101.00
6	126.6-136.7	3.48	0.62	0.44	53.80	0.73	40.38	0.15	0.12	99.60
7	136.7-145.0	1.66	0.37	0.43	55.30	0.25	42.80	0.05	0.09	100.86

(43) QUARRY SECTION—MARMORATON MINING COMPANY LIMITED



(43) QUARRY SECTION—MARMORATON MINING COMPANY LIMITED

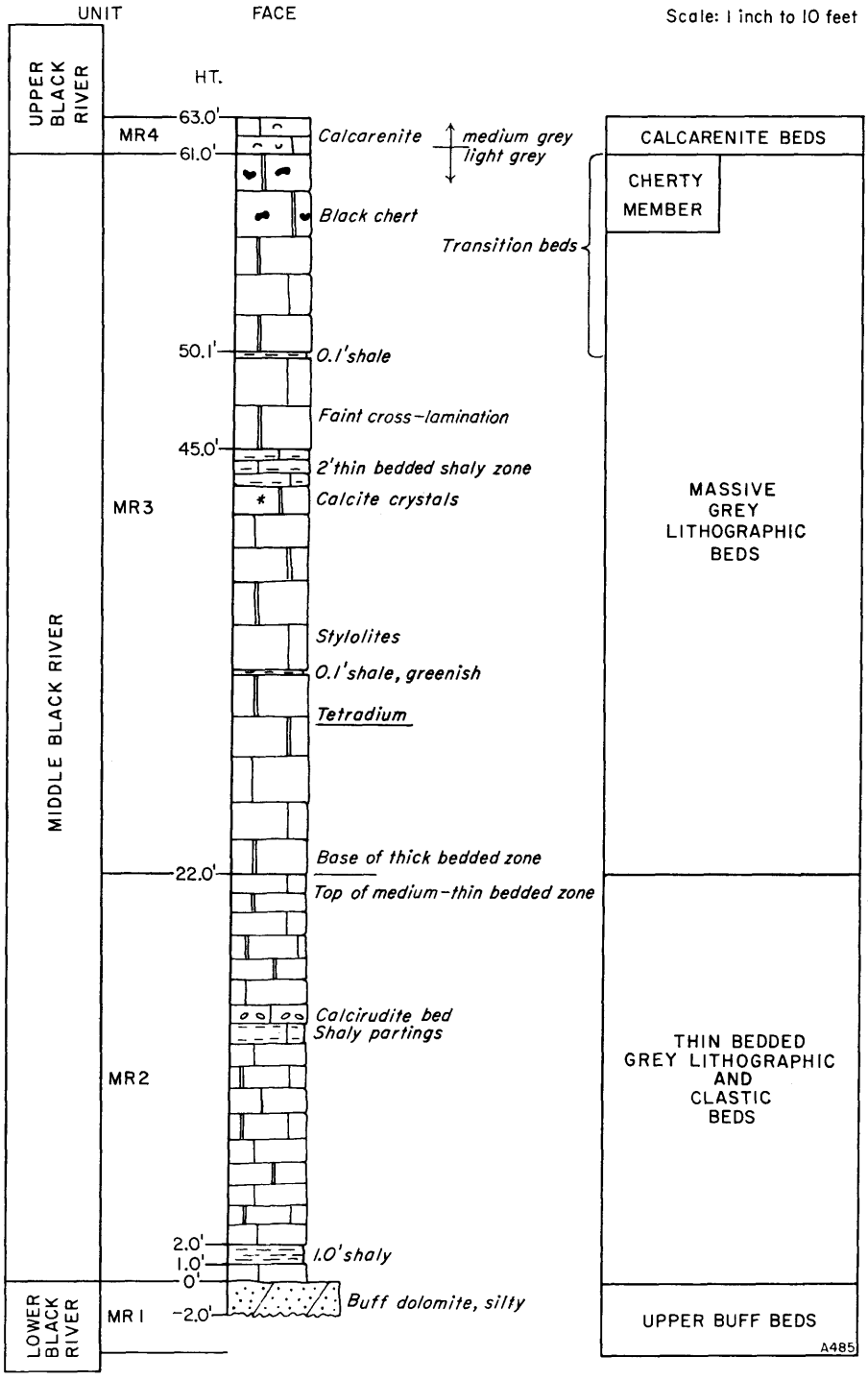
UNIT	DESCRIPTION	THICKNESS Feet
M8	Limestone: calcarenite; medium grey, medium grey weathering; medium crystalline; medium to thick bedded; fossiliferous; *Stromatocerium*	10.0
M7	Limestone: calcilutite to calcarenite; medium brownish grey, light grey weathering; microcrystalline to medium crystalline; massive bedded; common, shaly partings; thin clastic calcarenite beds common; black chert in upper beds; calcite crystals; fossiliferous, *Tetradium*.	46.0
M6	Limestone: calcilutite to calcarenite; medium light grey to dark brownish grey, light-grey weathering; medium-crystalline to microcrystalline; thick to medium bedded; in part thin laminated; shaly partings; graded bedding, calcarenite to calcilutite; clastic horizons common with minor intraformational conglomerate	21.0
M5	Dolomite: silty; light green-grey to brownish, buff weathering; aphanitic; thick bedded; clastic top	7.0
M4	Limestone and Dolomitic Limestone: calcilutite, minor calcarenite; Limestone: medium brownish grey, medium to light grey weathering; microcrystalline; medium to thin bedded; shaly partings; fine bedding lamination; inconspicuous buff mottling in some layers. Dolomitic Limestone: medium dark grey; buff weathering; aphanitic	30.3
M3	Dolomite: sandy; buff grey, buff weathering; aphanitic; massive bedded; reddish colouration in lower part; reddish shaly interbeds	10.0
M2	Limestone and Shale: red to maroon; microcrystalline to aphanitic; medium bedded; in part silty; some dolomitic beds	12.3
M1	Basal Clastic Beds: interbedded buff and red sandstone, shale, and grit; occasional basal conglomerate	7.4
	Total	144.0

MARMORA ROADCUT (HIGHWAY NO. 7), MARMORA

A 65-foot section of Middle and Upper Black River beds may be seen in the roadcut on highway No. 7 on the western outskirts of the village of Marmora. The section, illustrated in (44), is similar to that at the Marmoraton pit. The base of the Middle Black River is placed at the top of the "Upper Buff" silty dolomite beds. The upper contact of the Middle Black River formation is placed at the change from typical light-grey lithographic beds to the medium-grey fossiliferous calcarenite of the Upper Black River. The upper 4 feet of the Middle Black River contains black chert nodules. There are only 2 feet of Upper Black River present at the top of the roadcut. Winder[1] places the contact of Middle and Upper Black River (Lowville-Leray) 18 feet below the top of the cut on the basis of the presence of the coral *Lyopora*. However, he notes that most of this 18 feet is typical Lowville sublithographic limestone and remarks on the difficulty of establishing the Lowville-Leray boundary. Throughout this report the author has based his subdivisions on recognizable lithologic rock units (formations) rather than on time-rock units based on faunal zones. As far as possible the formational subdivisions are based on chemical and physical properties, which are of economic importance to the commercial limestone quarry operator.

[1]C. G. Winder, *Campbellford Map-Area, Ontario*, Geol. Surv. Can., Paper 54-17, 1955, pp. 4, 5.

(44) COLUMNAR SECTION—MARMORA ROADCUT



(44) COLUMNAR SECTION—MARMORA ROADCUT

UNIT	DESCRIPTION	THICKNESS Feet
MR4	Limestone: calcarenite; medium brownish grey, medium light grey weathering; aphanitic to fine crystalline; medium bedded; fossiliferous	2.0
MR3	Limestone: calcilutite to calcarenite; medium brownish grey to medium olive grey, light grey weathering; microcrystalline to fine crystalline; massive to thick bedded; black chert nodules in upper beds; colour banding on weathered surfaces; calcite crystals; faint cross-lamination in places; minor black shaly partings; fossiliferous, *Tetradium*, *Lyopora* in upper beds. Transition beds coquinoid calcarenite in microcrystalline matrix	39.0
MR2	Limestone: calcilutite; medium brownish grey, grey weathering; aphanitic to microcrystalline; medium to thin bedded; abundant shaly partings; silty in part. Calcirudite beds	22.0
MR1	Dolomite: sandy, silty; grey green, buff weathering; aphanitic	2.0
	Total	65.0

ST. LAWRENCE CEMENT COMPANY LIMITED (OGDEN POINT QUARRY), COLBORNE

In 1958 a quarry was opened up at Ogden Point in Cramahe township, Northumberland county, by St. Lawrence Cement Company Limited to supply their cement plant at Clarkson. The quarry site is on the shore of Lake Ontario, south of Colborne. A dock has been built, and the stone will be shipped by water. The Canadian National and Canadian Pacific railways pass to the north of the property.

Geology

In 1956, 1957, and 1958, St. Lawrence Cement Company Limited carried out diamond-drilling on the Ogden Point property and proved up a large tonnage of limestone reserves, suitable for the manufacture of portland cement. Overburden is 0-30 feet, and averages about 5 feet. Drilling indicates that the bedrock formation underlying the Ogden Point area is the Hillier member of the Upper Trenton formation, with a thickness of 57–94 feet. Underlying the Hillier member is the Upper Hallowell member of the Upper Trenton with a thickness of 34–42 feet. Below this unit, drill hole No. 16 cuts 81.7 feet of Middle Trenton beds (Lower Hallowell and Sherman Fall). The quarry is expected to be entirely in the Hillier member of the Upper Trenton formation.

The Upper and Middle Trenton beds cut by diamond-drill hole No. 16 drilled to a depth of 197 feet on the Ogden Point property (lot 32, con. I, Cramahe tp.), just north of the quarry site are described in (45).

The accompanying table (46) gives chemical analyses of the core from diamond-drill hole No. 16 at Ogden Point, and it is considered to be typical of the chemical composition of the Upper and Middle Trenton beds in the immediate quarry area.

The accompanying table (47) gives weighted-average chemical analyses of the Hillier member (Upper Trenton), Upper Hallowell member (Upper Trenton), and Middle Trenton beds intersected in six diamond-drill holes at Ogden Point. Stratigraphic thicknesses of these units are also given. Lithologically the Upper Hallowell member of the Upper Trenton can be distinguished from the Hillier member above and the Middle Trenton formation below by its much lower shale content and medium-bedded rather than thin-bedded character. As will be noted in examination of the chemical analyses in the accompanying tables, (46) and (47), the Upper Hallowell member can be distinguished chemically from the overlying and underlying beds. Average weighted chemical analyses of the overlying Hillier member in 13 diamond-drill holes at Ogden Point and Popham Bay indicate a range of silica content of 11.60–13.52 percent, with a lime content of 42.37–44.51 percent. In contrast, the Upper Hallowell member, which averages about 40 feet in thickness, shows a range of silica content of 6.55–8.52 percent, with a lime content of 45.93–48.25 percent. The underlying Middle Trenton beds are again higher in shale content and show a range of silica content of 10.83–15.67 percent, with a lime content of 40.25–44.61 percent.

Quarry Operation

The quarry was not yet in full operation when visited by the author in August, 1958. Quarrying was being started under contract, and the stone stockpiled for shipment in 1959.

(45) DRILL-HOLE SECTION—HOLE NO. 16, OGDEN POINT PROPERTY

(Abstract from Drill Logs, St. Lawrence Cement Co. Ltd.)

UNIT	DESCRIPTION	FOOTAGE	THICKNESS Feet
Upper Trenton (Hillier Member)	Limestone: argillaceous to slightly argillaceous; light grey to dark grey; medium or fine crystalline to aphanitic; thin, irregularly bedded to medium-bedded, with shaly partings; conspicuous banding due to layers of coarse coquinoid calcarenite; abundant fossil debris in certain beds.....	3 – 75.5	72.5
Upper Trenton (Upper Hallowell Member)	Limestone: slightly argillaceous; grey; medium or fine crystalline to aphanitic; thin to medium bedded with shaly partings	75.5–115.3	39.8
Middle Trenton (Lower Hallowell and Sherman Fall Members)	Limestone: argillaceous; grey to dark grey; medium crystalline to aphanitic; thin bedded with shaly layers; fossil debris, in part coquinoid calcarenite.....	115.3–197	81.7

(46) CHEMICAL ANALYSES—DIAMOND-DRILL HOLE NO. 16

(From Company data published by permission of the St. Lawrence Cement Co. Ltd.)

	Footage	Thickness	L. O. I.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	Total
		feet	percent	percent	percent	percent	percent	percent	percent	percent
Upper Trenton (Hillier Member)	5.2– 15.0	9.8	37.97	9.35	1.13	2.13	46.80	1.43	0.19	99.00
	15.0– 25.0	10.0	36.77	9.80	1.33	3.88	44.52	2.47	0.28	99.25
	25.0– 33.7	8.7	35.70	13.54	1.72	3.87	42.51	1.63	0.11	99.08
	33.7– 45.6	11.9	35.60	12.56	1.64	4.42	42.80	1.89	0.14	99.05
	45.6– 55.0	9.4	35.15	13.20	1.56	3.65	42.56	1.72	0.15	97.99
	55.0– 63.1	8.1	32.38	16.77	2.03	5.11	38.36	3.23	0.38	98.26
	63.1– 75.5	12.4	35.38	13.10	1.60	3.22	42.81	1.90	0.12	98.13
Upper Trenton (Upper Hallowell Member)	75.5– 87.7	12.2	39.12	7.10	1.13	1.99	48.06	1.29	0.12	98.81
	87.7– 99.6	11.9	39.78	5.70	1.17	1.50	49.34	1.26	0.16	98.91
	99.6–115.3	15.7	38.15	8.31	1.29	2.36	47.13	1.56	0.36	99.16
Middle Trenton (Lower Hallowell and Sherman Fall Members)	115.3–126.2	10.9	34.85	13.07	1.83	3.60	42.68	1.52	0.67	98.22
	126.2–140.2	14.0	33.83	13.80	2.36	4.76	41.86	1.16	0.88	98.65
	140.2–150.4	10.2	34.52	13.61	1.94	4.68	42.42	1.21	0.62	98.95
	150.4–161.4	11.0	34.36	13.34	2.03	4.64	41.50	1.75	0.11	97.73
	161.4–171.5	10.1	35.16	13.89	1.56	3.04	43.82	1.29	0.52	99.28
	171.5–184.4	12.9	36.61	10.41	1.48	3.62	44.35	1.69	0.11	98.27
	184.4–197.0	12.6	37.02	9.66	1.40	3.31	45.28	1.45	0.7	98.82

(47) OGDEN POINT DRILLING—CHEMICAL ANALYSES AND STRATIGRAPHIC THICKNESSES

(Company Data published by permission of St. Lawrence Cement Co. Ltd., Clarkson)

Diamond-drill Hole No.	Overburden	Hillier Member (Upper Trenton)						
		Thickness	L. O. I.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
	feet	feet	percent	percent	percent	percent	percent	percent
OP 16	5.15	72.5	35.64	12.50	1.56	3.72	43.02	2.01
OP 1	1.5	93.7	35.33	12.21	1.69	5.10	42.42	2.04
OP 2	33.0	68.2	35.59	13.05	1.37	3.53	43.46	1.73
OP 4	3.3	57.0	35.60	13.04	1.41	3.84	42.99	1.80
OP 5	2.1	58.5	35.50	13.14	1.36	4.00	42.73	1.71
OP 6	6.5	75.9	36.04	13.19	1.32	3.75	43.07	1.68

OGDEN POINT DRILLING—CHEMICAL ANALYSES AND STRATIGRAPHIC THICKNESSES—*Continued*

Diamond-drill Hole No.	Upper Hallowell Member (Upper Trenton)						
	Thickness	L. O. I.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
	feet	percent	percent	percent	percent	percent	percent
OP 16	39.8	38.93	7.16	1.21	1.99	48.07	1.39
OP 1	34.0	37.90	7.70	1.74	2.88	45.93	1.93
OP 2	2.9	38.38	8.52	0.98	2.03	47.32	1.58
OP 4	42.3	38.50	7.58	1.14	2.13	47.84	1.47
OP 5	38.1	39.23	7.52	0.88	2.14	47.68	1.54
OP 6	41.5	38.59	7.48	0.97	2.36	47.18	1.40
	Lower Hallowell and Sherman Fall (Middle Trenton)						
	feet	percent	percent	percent	percent	percent	percent
OP 16	81.7	35.21	12.45	1.80	3.96	43.15	1.44
OP 1	24.2	34.44	13.43	2.53	4.25	41.38	1.87
OP 2	.....	.....	.....	.....	.....	.....	.....
OP 4	14.9	30.51	15.67	1.94	4.79	43.14	1.51
OP 5	8.4	36.16	10.83	1.52	4.32	44.61	1.47
OP 6	.....	.....	.....	.....	.....	.....	.....

ST. LAWRENCE CEMENT COMPANY LIMITED (CEMENT PLANT), CLARKSON

In 1956, St. Lawrence Cement Company Limited opened a new two-kiln wet-process portland cement plant at Clarkson, on Lake Ontario, about 15 miles west of Toronto. The two kilns, each with a capacity of 5,700 barrels per ~~hour~~ day, produce in excess of 4,000,000 barrels of cement annually. Four types of portland cement are made.

The main raw materials used are limestone, shale, gypsum, pyrite, and coal (for firing the kilns). Until the Ogden Point quarry is able to supply the limestone requirements, limestone is being purchased and shipped by rail from Beachville and Uhthoff. The Uhthoff stone is minus 6-inch lump, while the Beachville stone is minus ¾-inch fines. Shale is quarried by contract on the Clarkson property from an open pit in the Dundas shale formation. Gypsum is trucked from the Canadian Gypsum Company's Hagersville mine.

Materials, Handling and Crushing

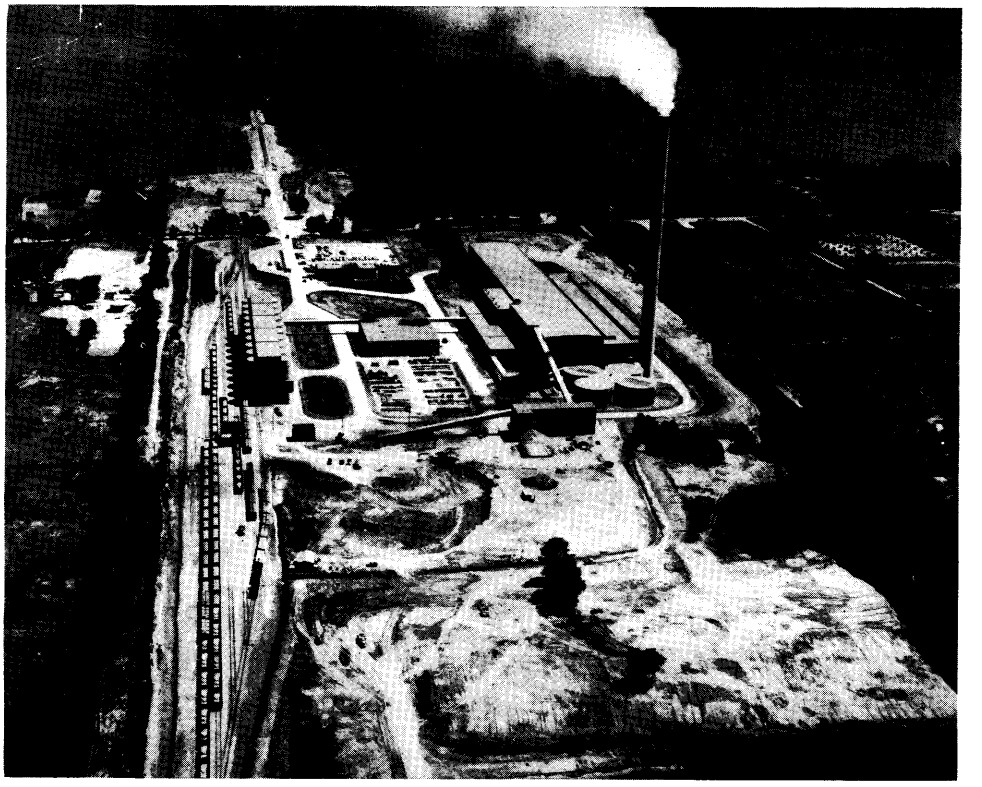
A 30-inch belt conveyor handles raw materials via vibrating feeders from the loading hoppers at the railway siding to the secondary-crushing building. Shale goes to a shale-crushing station on the main conveyor line between the rail unloading point and the secondary-crushing building. The shale is crushed to minus 5 inches by a 30- by 50-inch single-roll crusher, and feeds via a vibrating feeder to the main conveyor belt. A receiving hopper at this station also handles truck deliveries of ½-inch gypsum and pyrite.

The secondary crusher is a Pennsylvania reversible impactor with a capacity of 450 tons per hour. It produces a minus ⅝-inch product and is in closed circuit with two 5- by 12-foot single-deck vibrating screens. The minus ⅝-inch product goes to a series of mill storage-silos in the raw-materials storage building adjacent to the raw-grinding department. At the secondary-crushing building the 60- by 72-inch vibrating feeder handling the discharge from the main conveyor can be swiveled to by-pass the impactor. Gypsum, pyrite, and Beachville limestone fines can go directly to raw-materials storage.

Raw Grinding

The raw-grinding department consists of four, 3-compartment Compeb 8- by 37-foot ball mills. Feed to the grinding mills is automatically blended limestone and shale, fed at constant rate in predetermined proportions by two electronically controlled vibrating feeders, one of 60 tons per hour for limestone and one of 15 tons per hour for shale. A third 3-ton-per-hour feeder handles pyrite and other minor additives to the mix. The ball-mill products are sampled every hour to give close control of the composition of the slurry. The mills use 1¼- to 4-inch steel balls. They each have a capacity of 45 tons per hour, and are powered by 900-horsepower electric motors. The product of the ball mills, 80 percent through 200 mesh, is a slurry containing 33½ percent water.

Courtesy of the St. Lawrence Cement Co. Ltd.



The 4,000,000-barrel per year plant of St. Lawrence Cement Company at Clarkson.

Kilns and Kiln Feed

The slurry is pumped to four 80-foot slurry basins having a capacity of 6,000 tons each. Continuous agitation and compressed air blown from below ensure thorough mixing. The slurry is then pumped from the slurry basins to the two 402-foot kilns fired with powdered coal. Continuous automatic control of kiln feed is ensured by a controlled ferris-wheel feeder. Radioactive isotopes in the slurry feed allows measurement of the density of slurry flow in the kiln by gamma ray counters connected to continuous recording meters at the central kiln panel. The kilns each have a capacity of 1,000 tons or 5,700 barrels of clinker per day. The kilns operate at 1 revolution per minute. The dimensions of the preheat, calcining, and burning zones are 13 feet 2 inches, 11 feet 6 inches, and 13 feet 2 inches. Hot clinker is discharged to an air-quenched clinker cooler. Waste heat is used for coal drying.

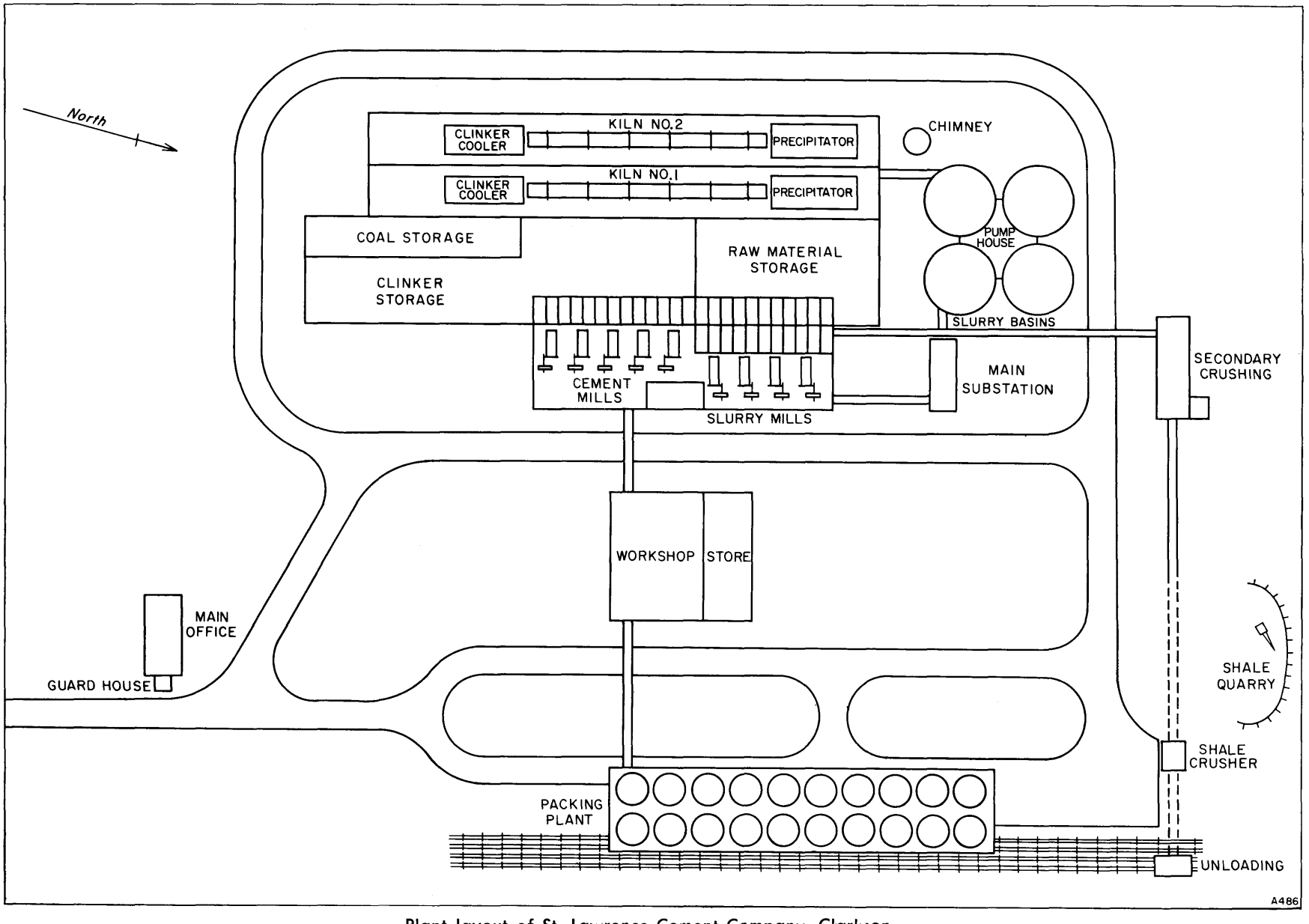
Clinker Grinding

The clinker is conveyed to the clinker storage area adjacent to the finish-grinding department. The cement-grinding mills are five 2-compartment, 10- by 28-foot, Compeb ball mills each having a capacity of 33 tons per hour, rotating at 16.8 revolutions per minute. About 3½ percent gypsum is added to the ball-mill feed. Each ball mill is in closed circuit with a Sturtevant air classifier, which returns the oversize to the ball mills.

Cement Storage and Packing

Cement is pumped to the cement packing plant where there are two rows of ten silos, each with a capacity of 8,000 barrels. Much of the cement is shipped in bulk, but there are five 4-spout bagging machines. Two 850-ton silos are provided for bulk-loading on the wharf.

The whole plant has achieved a high degree of automation. Quarry operation and plant maintenance are by contract.



Plant layout of St. Lawrence Cement Company, Clarkson

LAKE ONTARIO PORTLAND CEMENT COMPANY, PICTON

The limestone quarry and cement plant of Lake Ontario Portland Cement Company are located on a 700-acre property on the west shore of Picton Bay, 2½ miles northeast of Picton, in Sophiasburg township, Prince Edward county. The two-kiln, 5,000-barrel-per-day, dry-process portland cement plant began operation in 1958. Aggregate and cement are shipped by boat, rail, or truck.

Geology

The 30-foot quarry face is uniform, medium-bedded, fine-crystalline grey limestone with shaly partings. The section is described in (48).

The section is correlated as the Upper Hallowell member of the Upper Trenton formation. Chemical analyses of composite chip samples up the quarry face are given in (49).

These analyses agree very well with chemical analyses of the Upper Hallowell member at Ogden Point. To the south of the cement company property, an excellent section of the Middle and Upper Trenton beds is exposed along the bay shore at the Marmoraton Mining Company loading dock. Here the upper beds are the more shaly Hillier member of the Upper Trenton; a complete section of Upper Hallowell and several feet of the Middle Trenton are exposed in the 85-foot cliff.

Quarry and Crushing Plant

The limestone quarry supplies stone for the cement plant as well as for a large-scale aggregate operation. The crushed stone operation has a capacity of 600 tons per hour. Drilling is carried out by an electric Ingersoll-Rand Drillmaster with a 6-inch bit drilling the 31-foot face on a 14- by 15-foot pattern. Two Ingersoll-Rand wagon drills are on standby duty. A 5-cubic-yard P & H electric shovel loads four 22-ton Euclid rear-dump trucks, for haulage to the primary crusher. The primary crusher is a 48-inch Kennedy Van Saun gyratory, set at 6 inches. The crusher product goes via a 42-inch conveyor to the 6-inch stone surge pile. The conveyor is equipped with a continuous weigh-scale.

Secondary Crushing and Screening

The 6-inch surge pile feeds two parallel conveyor systems in the reclaiming tunnel, one a 36-inch line for the cement plant and the other a 42-inch line for the aggregate plant. Both conveyors discharge at the top of the secondary crushing and screening building.

CEMENT LINE

The 36-inch cement-line conveyor discharges to two 5- by 12-foot Tyler double-deck screens in parallel, with 4½-inch and 1-inch openings. The plus 1-inch stone goes to two 36- by 48-inch impact crushers (KVS Senior Cubers). The cuber products are re-cycled to the 5- by 12-foot screens. The minus 1-inch stone goes via conveyor to the cement plant raw storage or may on occasion be directed to the aggregate plant screen towers.

AGGREGATE PRODUCTION LINE

The 42-inch conveyor of the aggregate production line supplies stone from the 6-inch surge pile to two 5- by 12-foot Tyler scalping screens in parallel,

(48) QUARRY SECTION—LAKE ONTARIO PORTLAND CEMENT COMPANY

UNIT	DESCRIPTION	THICKNESS Feet
UPPER TRENTON		
(Upper Hallowell Member)		
	Limestone: medium dark grey to dark grey, brownish weathering; fine crystalline to aphanitic; thin to medium bedded, thin bedded on weathered surfaces; shaly partings; in part fossiliferous calcarenite	31.0

(49) CHEMICAL ANALYSES—LAKE ONTARIO PORTLAND CEMENT COMPANY

(Analyses by Provincial Assay Office, Ont. Dept. Mines 1959)

Sample No.	Footage From Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
		percent	percent	percent	percent	percent	percent	percent	percent
1	0–15	7.62	2.02	1.00	1.50	48.90	39.28	0.39	100.71
2	15–30	7.71	1.91	0.93	1.43	47.50	39.50	0.19	99.17

The Picton quarry of Lake Ontario Portland Cement Company exposes a 30-foot face of Upper Trenton limestone. The 5-cubic yard electric shovel is shown in the foreground.

followed by two 5- by 14-foot Tyler double-deck screens in parallel. These four sets of screens handle the sizing, and the screen openings may be varied as desired. Oversize from the scalping screens are sent to a 20-inch KVS gyratory secondary crushing unit in closed circuit with the scalping screens. Oversize from the second set of screens or sizes requiring recrushing, are sent to two No. 49½ KVS gyratory tertiary crushers. The crushing system is flexible, and throughs from the scalping screens may be sent to one No. 49½. The second No. 49½ gyratory is generally in closed circuit with the 5- by 14-foot screens.

Aggregate Sizing and Storage

The products from the secondary-crushing building are sent to screen tower No. 1 in a series of four 90-foot-high screen towers, which stand in line, each over its own rock-storage pile. Five sizes of stone are produced. Each screen tower has a pair of 5- by 14-foot single-deck Tyler screens to scalp the size of stone to be stored in each storage pile. The stone sizes at each tower are as follows: No. 1, 1½-inch; No. 2, 1-inch; No. 3, ½-inch; No. 4, 3/16-inch. The throughs at No. 4 tower (minus 3/16-inch) are stockpiled in a fifth storage pile or conveyed directly to the raw storage at the cement plant. The scalped stone at each tower is stockpiled below the tower, while the throughs proceed via conveyor to the next screen tower. A reclaiming tunnel below the storage piles allows transportation and blending of aggregates. The reclaiming conveyor discharges either to a 48-inch, retractable-boom, boat-loading conveyor at the wharf or to an inclined-belt conveyor system, which returns the stone to the secondary-crushing building for recrushing.

Cement Plant

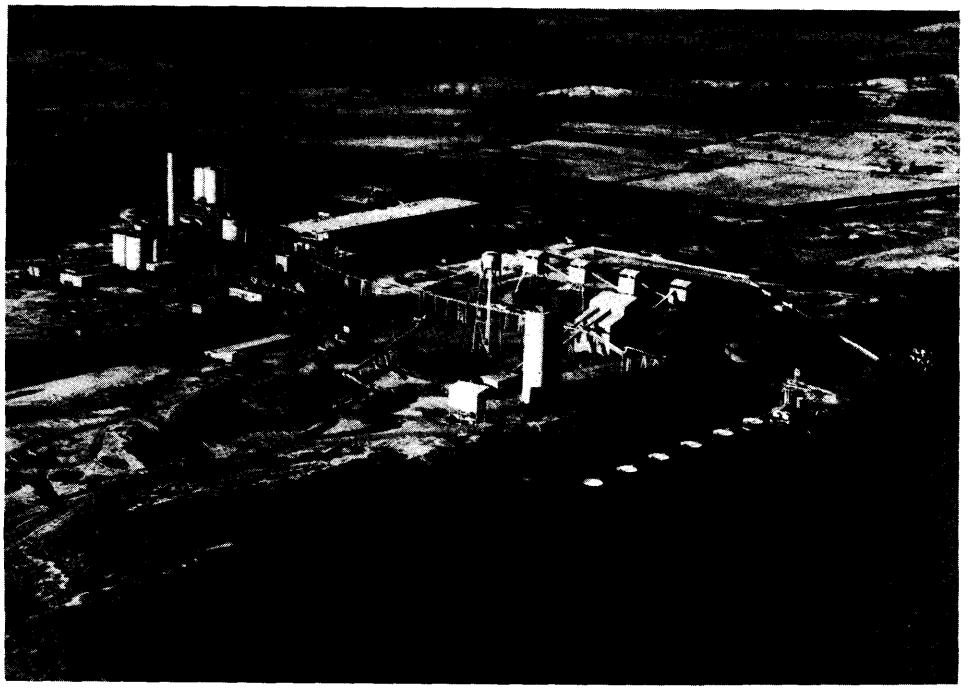
Coal and gypsum are moved from stockpiles on the bay shore via conveyor to the cement plant on the west side of the highway. Clay and sand as required in the mix are quarried at local pits. Picton dune sands are now being used as a source of silica and alumina. Clay is dried in a 10- by 50-foot rotary drier. Raw materials are transferred from storage piles in the plant to mill-feed bins by travelling crane.

The average bulk analysis of limestone used for cement in June, 1958, was as follows: SiO_2, 8.6 percent; Fe_2O_3 and Al_2O_3, 3.4; CaO, 49.5; MgO, 0.9; and ignition loss, 37.9 percent.

Grinding Plant

The raw and finish grinding are carried out by four 11- by 20-foot Kennedy Van Saun two-compartment ball mills. Two of the mills are for raw grinding and two for finish grinding, but if extra capacity is required in either department, a switch can be made. The raw mill feed is automatically controlled and measured by weighing belt feeders from the mill-feed bins. The feed is elevated to two 16-foot Raymond air classifiers where it is sized and at the same time dried by hot air. The rejects from the classifiers go to the two ball mills, which are in closed circuit with the classifiers. The ball

Courtesy of Lake Ontario Portland Cement Co.



Both aggregate and portland cement are produced at the Picton plant of Lake Ontario Portland Cement Company located on a bay of Lake Ontario.

mills are charged with steel balls of 1¼- to 3-inch diameter and rotate at 18 revolutions per minute. The fines from the air classifiers go via Airslide to four raw-blending silos of 4,000-barrel capacity.

Kiln Feed and Kilns

Feed is drawn and blended from the four raw-blending silos as required by chemical analysis, and conveyed by Airslides to the 9,700-barrel kiln-feed silo. Material in the silos is kept in a fluid state by quadrant compressed-air blending systems. The kiln-feed silo feeds via Airslide and de-aerating screw-conveyor to the two kilns. These are Kennedy Van Saun (KVS), 11- by 375-foot rotary kilns running at 1 revolution per minute. They are fired with powdered coal supplied from a coal mill and classifier. A burning temperature of 2,600°F. is maintained. The rated capacity of each kiln is 2,500 barrels per day.

Clinker discharges on a 7- by 40-foot, inclined-grate, cooler to a scalping screen. The oversize clinker is crushed in a KVS gyratory crusher in closed circuit with the scalper. The scalper throughs go to clinker storage.

Finish Grinding

The clinker goes from storage to two of the four 11- by 20-foot KVS two-compartment ball mills in the grinding department. Clinker and gypsum are automatically fed to the two ball mills, which are in closed circuit with two 16-foot Raymond air classifiers. The product of the air classifiers has a Blaine fineness of 3,200.

Storage and Loading

The finished cement is conveyed via Airslide to one of four 15,000-barrel silos at the plant or to two 20,000-barrel storage silos at the wharf. Cement from the plant silos is shipped in bulk or bagged, as required. All cement-storage silos are equipped with quadrant compressed-air agitation systems. The 1,200-foot dock is equipped to load cement in bulk at the rate of 3,000 barrels per hour. Aggregate can be loaded on freighters at the rate of 2,000 tons per hour. Incoming shipments of coal and gypsum can be unloaded at the rate of 2,000 tons per hour.

Bulk cement storage and packing facilities are provided at Rochester, N.Y., and Toronto.

CANADA CEMENT COMPANY LIMITED (BELLEVILLE PLANT), POINT ANNE

The Belleville plant and limestone quarry of Canada Cement Company Limited are located at Point Anne in Thurlow township, Hastings county, on the Bay of Quinte, 4 miles east of Belleville. Rail, road, and water transportation are available. The wet-process cement plant has three kilns, with a total rated capacity of 11,600 barrels per day or about 4,000,000 barrels per year. Two of the kilns were installed after 1947, tripling the plant capacity since World War II.

Geology

The 60- to 65-foot quarry face consists of medium- to thick-bedded, medium-brownish grey aphanitic limestone. A composite section is given in (50). Eight feet of Lower Trenton limestone, consisting of thin-bedded, shaly fossiliferous calcarenite, may be seen along the rim of the north-central quarry face. This is the only part of the quarry where there are Lower Trenton beds. Below this there is 12 feet of brownish-weathering, medium-crystalline calcarenite, which makes up "transition beds" between the Lower Trenton and the underlying Upper Black River. A 0.6-foot seam of black shale occurs at the base of the transition beds. A shale seam, which may correlate with this marker, can be seen on the south quarry face about 5 feet from the top of the face. On the south face there is a section of 60 feet of massive-bedded, grey, aphanitic limestone of the Upper Black River formation exposed to the quarry floor. The contact between the Middle and Upper Black River formations at this quarry is gradational. The characteristic coquinoid calcarenite facies of the Upper Black River to the west is not developed here, and the section appears to be much thicker. In the ditches in the quarry floor typical Middle Black River lithographic limestone with abundant *Tetradium* is exposed, and the author places the Middle–Upper Black River contact at the quarry floor. In October, 1931, a bore hole (No. 1) was drilled in the quarry floor. Chemical analyses of this hole, supplied by the Company are given in (51).

This hole indicates about 55 feet of Middle Black River beds (on the basis of magnesia content) and a further 40 feet of Lower Black River beds, mainly interbedded sandy dolomite and limestone. The Precambrian surface is irregular: one diamond-drill hole, cut in the east-central quarry floor in 1953, indicated the Precambrian surface at a depth of 90 feet, with 50 feet of Middle Black River beds and 40 feet of Lower Black River beds. A second diamond-drill hole, drilled at the same time on the crest of a dome in the quarry floor in the west-central portion of the quarry, indicated the Precambrian surface at a depth of 60 feet, with 40 feet of Middle Black River and 20 feet of Lower Black River (the correlation based on percentage of magnesia). This dome structure apparently reflects the structure of an underlying Precambrian buried hill.

Chemical analyses of the quarry face taken from Goudge (p. 109) are given in (52).

The quarry area appears to be on the north limb of the Salmon River anticline (Kay (1942), plate 7), an anticline whose axis trends northeast from Hungry Bay up the Salmon River. The structure of the area is complex since there are three main factors to be considered: major northeast-trending folding; northeast-trending faulting; and dome structures, due to initial dips over buried Precambrian hills, and quaquaversal dips flanking Precambrian inliers.

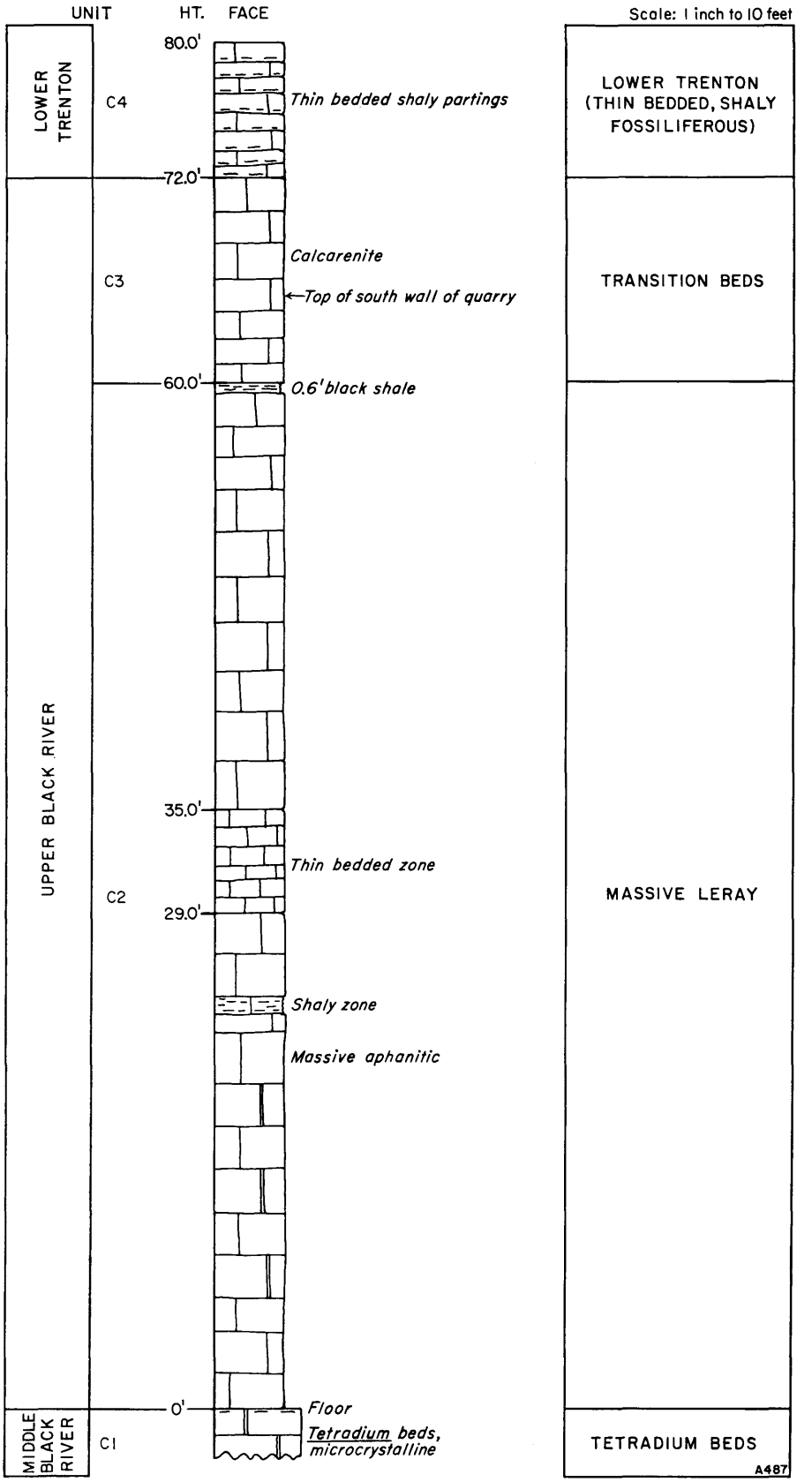
Half a mile to the northwest of the quarry, on Point Anne Lane, there is an old railway cut exposing fossiliferous, thin-bedded Lower Trenton limestone with blue-grey, shaly partings. A diamond-drill hole here indicated 45 feet of Lower Trenton, 11 feet of "transition beds," 40 feet of Upper Black River, and terminated in 5 feet of lithographic limestone tentatively assigned to the Middle Black River. The accompanying sketch (53) shows the formations in the immediate vicinity of the quarry.

The abandoned Point Anne Quarry, to the west of Point Anne Lane, exposes a section similar to that in the Canada Cement Company Limited quarry. However, the section is weathered and more accessible in places. Here the thin-bedded, shaly, fossiliferous Lower Trenton beds are exposed at the south end of the quarry. The underlying beds of massive, light grey weathering, Upper Black River limestone are medium crystalline to aphanitic, rarely microcrystalline. These beds contain abundant *Stromatocerium* and the Leray index coral *Lyopora halli.*

Quarry Operation

Overburden ranges from 5–15 feet in thickness and is stripped by a Bucryus-Erie 38B, 1½-cubic-yard shovel, loading 5-ton dump trucks. The 60- to 65-foot quarry face is drilled on a 20- by 25-foot to 25- by 32-foot pattern by two Bucyrus-Erie 29T electric churn-drills drilling 9-inch holes. Nitrone is used for blasting. Stone is loaded by two 3¼-cubic-yard Bucryus-Erie 85B electric shovels. Haulage to the primary crusher is done by five International tractors with 18-ton side-dump

(50) QUARRY SECTION—CANADA CEMENT COMPANY LIMITED



(50) QUARRY SECTION—CANADA CEMENT COMPANY LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
LOWER TRENTON		
C4	Limestone: shaly calcarenite, rubbly weathering; medium dark brownish grey, brownish grey weathering; thin bedded; medium crystalline to aphanitic; fossiliferous	8.0
UPPER BLACK RIVER		
C3	Limestone: calcarenite; medium brownish grey, brownish weathering; medium crystalline; medium to thick bedded (Transition beds)	12.0
	0.6 feet of black shale	
C2	Limestone: medium dark brownish grey, medium grey weathering; aphanitic, rarely micro-crystalline; massive bedded; shaly partings; thin bedded zone at 29 to 35 feet	60.0
MIDDLE BLACK RIVER (Contact gradational, may be up to 20 feet higher.)		
C1	Limestone: calcilutite; medium brownish grey, light grey weathering; aphanitic to micro-crystalline; medium bedded; shaly partings; *Tetradium* beds	5.0+

(51) CHEMICAL ANALYSES—CANADA CEMENT COMPANY LIMITED

(Analyses supplied by the Company)

	Depth Below Floor	SiO_2	R_2O_3	CaO	MgO	L. O. I.	Total
MIDDLE BLACK RIVER	feet	percent	percent	percent	percent	percent	percent
	0– 5	1.16	0.69	54.47	0.72	42.39	99.43
	5–10	1.77	0.92	53.79	0.86	42.19	99.53
	10–15	5.25	2.17	50.71	1.09	39.95	99.17
	15–20	5.19	2.08	50.72	1.06	40.03	99.08
	20–25	9.18	3.90	46.58	1.28	37.60	98.54
	25–30	5.10	1.76	50.80	1.01	40.61	99.28
	30–35	7.88	2.44	48.58	1.20	38.61	98.71
	35–40	7.79	3.09	48.12	1.38	38.27	98.65
	40–45	7.05	3.13	48.45	1.09	38.65	98.37
	45–50	5.91	2.95	49.27	1.14	39.44	98.71
	50–55	4.00	1.73	51.35	1.04	41.07	99.19
LOWER BLACK RIVER	55–60	13.07	4.79	42.38	2.54	35.45	98.23
	60–65	15.98	4.78	40.16	2.39	34.11	97.42
	65–70	6.94	3.15	47.13	2.32	39.61	99.15
	70–75	6.22	3.62	41.89	6.86	40.31	98.90
	75–80	2.92	1.68	47.74	4.18	42.22	98.74
	80–85	3.96	1.89	44.15	6.62	42.45	99.07
	85–90	4.77	2.05	45.55	5.34	42.55	100.26
	90–93	7.45	3.01	46.46	3.30	N.D.	.....

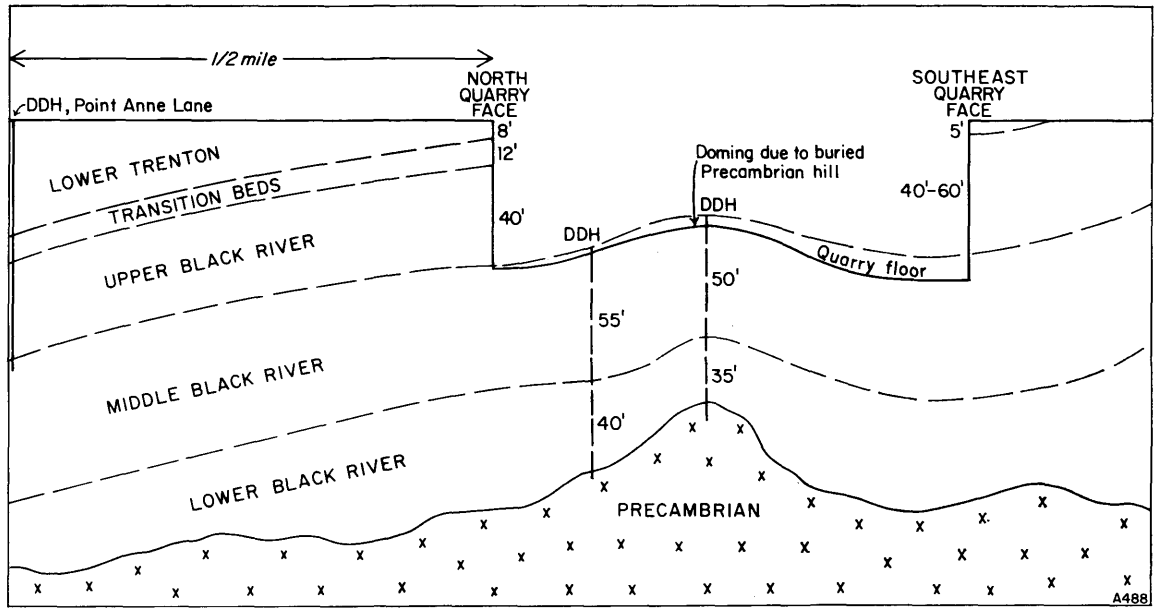
(52) CHEMICAL ANALYSES—CANADA CEMENT COMPANY LIMITED

(Analyses from Goudge, p. 109)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	CaO	MgO	S	$CaCO_3$	$MgCO_3$	Total
	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
42 (upper 45 ft. of face)	3.60	0.37	0.79	0.02	53.02	0.36	0.12	94.66	0.76	100.20
42A (lower 15 ft. of face)	1.96	0.52	0.54	0.08	53.60	0.59	0.08	95.59	1.24	99.93

(53) DIAGRAMMATIC SECTION—CANADA CEMENT COMPANY QUARRY

(Vertical Scale Enlarged)



Easton semi-trailers. Due to the massive-bedded character of the stone a considerable amount of secondary blasting must be done.

Crushing

The primary crusher, located on the quarry floor at the east end, is a 42-inch McCully gyratory, set at 8 inches. The stone is conveyed to the secondary crushing building on surface southeast of the quarry. Secondary crushing is carried out by two Pennsylvania reversible impactors in closed circuit with two Dillon single-deck screens. The impactors reduce the stone to minus ¾-inch. This stone is conveyed to stone storage piles west of the screen house.

Cement Plant

The expansion of the plant from one to three kilns in the post-war period involved installation of new secondary-crushing capacity, new rock-storage facilities, a new raw mill, two additional wash mills, and additional clay and slurry storage basins.

Clay is obtained from clay pits to the north of the plant. It goes to one of four clay wash mills and on to two clay slip storage basins equipped with compressed-air agitation systems. From the clay slip storage basins it is pumped to a silo adjacent to the new raw-grinding mill where the clay slip is fed automatically to the raw mills as required.

Raw Grinding

Minus ¾-inch stone is loaded into the mill-feed bins of the raw-grinding department by a 12½-ton Provincial travelling crane with a 3½-cubic-yard clamshell bucket. In the new raw-grinding mill, stone and clay slip are charged into three 8- by 39-foot, three-compartment, Unidan ball mills. Water content of the slurry is approximately 35 percent. The three mills have a total capacity of 300 barrels per hour with 90 percent of the product minus 200-mesh. The old raw-grinding mill, located east of Nos. 1 and 2 kilns, consists of two 4- by 10-foot Hardinge ball mills in closed circuit with 15-mesh wet-type vibrating screens, followed by four 7- by 26-foot, Vickers tube mills in open circuit. These four mills have a total capacity of 300 barrels per hour.

Kiln Feed and Kilns

The slurry from the old and new raw-grinding mills is pumped to a sump and then to six air-agitated blending tanks each of 3,600-barrel capacity. From the blending tanks the slurry is

pumped to two slurry basins of 10,000- and 12,000-barrel capacity. Nos. 1 and 2 kilns are 455-foot Smidth kilns of 11 feet 3 inches by 10 feet by 11 feet 3 inches dimensions, placed side by side. No. 3 kiln, installed in 1952-53, is a 430-foot, 11-foot 3-inch Smidth kiln, located to the east of the other kilns. The kilns are fired with powdered coal and have a total rated capacity of 11,600 barrels per day.

Clinker Grinding

Clinker from the three kilns goes through two, 4-foot, Symons shorthead cone-crushers, set at ⅜ inch. The crushed clinker is conveyed to clinker storage. From clinker storage a 10-ton mobile overhead crane loads clinker mill-feed bins. Clinker and gypsum are ground in two stages by three 9- by 13-foot, Smidth ball mills followed by four 7- by 30-foot, Unidan ball mills in closed circuit with 5 air classifiers, and one 10- by 18-foot, Smidth ball mill.

The finished cement is pumped to eight cement-storage silos. Cement is shipped by boat, rail, or truck, either in bulk or bagged.

MILLTOWN QUARRY, MILLTOWN

In 1958, H. J. MacFarland Construction Company operated a small quarry in lot 11, concession I, Tyendinaga township, Hastings county, 1 mile north of Milltown, just south of highway No. 401.

The quarry face consists of 17 feet of Lower Trenton limestone described as follows. Limestone: medium-brownish grey, medium-grey weathering; medium-crystalline to aphanitic; thin-bedded; shaly partings. A composite chip sample, representative of the 17-foot quarry face, was analysed by the Provincial Assay Office, Ontario Department of Mines, as follows: SiO_2, 7.00 percent; Al_2O_3, 2.49; Fe_2O_3, 0.57; CaO, 45.00; MgO, 5.33; CO_2, 38.79; S, 0.09 percent; for a total of 99.27 percent.

No permanent quarry plant was set up since the operation was a temporary one supplying stone for the construction of highway No. 401. As is typical of other such operations in the province, a portable plant was used. Drilling was carried out by two Gardner Denver wagon drills, drilling 2-inch holes on a 5- by 5-foot pattern. Air was supplied by a Canadian Ingersoll-Rand 500-cubic-foot-per-minute compressor. A 2½-cubic-yard Northwest diesel shovel loaded two 18-ton Mack trucks hauling to the Cedarapids portable crushing plant. The portable plant consisted of feeder, impact crusher, rolls, and screens. The plant produced 140–160 tons per hour of ⅞-inch crusher run for use as road stone.

ROBLINDALE QUARRIES LIMITED, ROBLINDALE STATION

The quarry of Roblindale Quarries Limited is located in Camden township, Lennox and Addington county, just east of Roblindale Station, on highway No. 41. It is served by the Canadian Pacific Railway line from Belleville to Smiths Falls.

Geology

The 58-foot quarry face, cut in the escarpment on the southeast side of the Salmon River valley, consists of medium- to dark-brownish grey, medium-crystalline to cryptocrystalline limestone of the Middle and Upper Black River formations. The section is illustrated and described in (54). Most of the quarry face is assigned to the Middle Black River formation, since the typical thick grey calcilutite beds carrying an abundance of *Tetradium* are present. However the author was unable to establish the contact between the Middle and Upper Black River formations here, but would tentatively place it as the first notable horizon of coquinoid calcarenite at 53.8 feet above the quarry floor (base of unit RB 6).

The whole quarry section is almost uniform in chemical composition as indicated by the analyses of composite chip samples from the quarry face (55).

The magnesia content of the limestone is low, but the silica and alumina contents are somewhat higher than found in these formations to the west.

Quarry Operation

Roblindale Quarries Limited is an associate company of H. J. McFarland Construction Limited, with head offices at Picton. The quarry normally operates from April to November. The 58.6-foot quarry face is operated in three lifts; the lower lift is 13.3 feet, the second is 15.6 feet, and the third lift is 30 feet. Overburden is light. Drilling is carried on by two Gardner Denver wagon drills drilling 2-inch holes on a 6- by 6-foot pattern. Air is supplied by a Gardner Denver 600-cubic-foot-per-minute compressor. The blasting agent is Forcite. A 1½-cubic-yard Northwest diesel shovel loads two 18-ton Mack rear-dump trucks, which haul to the primary crusher.

The primary crusher is a 25- by 40-inch jaw-crusher. It is followed by a Dillon scalping screen with 1½-inch openings. The oversize goes to a 4-foot Symons cone. The crusher products are sized by a 6- by 8-foot, 3-deck, Simplicity screen. A set of rolls is used to produce ⅝-inch chip stone.

The main production sizes are 2-inch crusher run used mainly for railway ballast, 1-inch stone for concrete aggregate, 1¼-inch crusher run for road metal, and ⅝-inch chips. The stone is stockpiled by truck. Stone is loaded for rail transportation by a travelling crane and for truck by overhead loaders.

The plant capacity is about 180 tons per hour, or 1,800 tons per 10-hour shift; the operation is seasonal.

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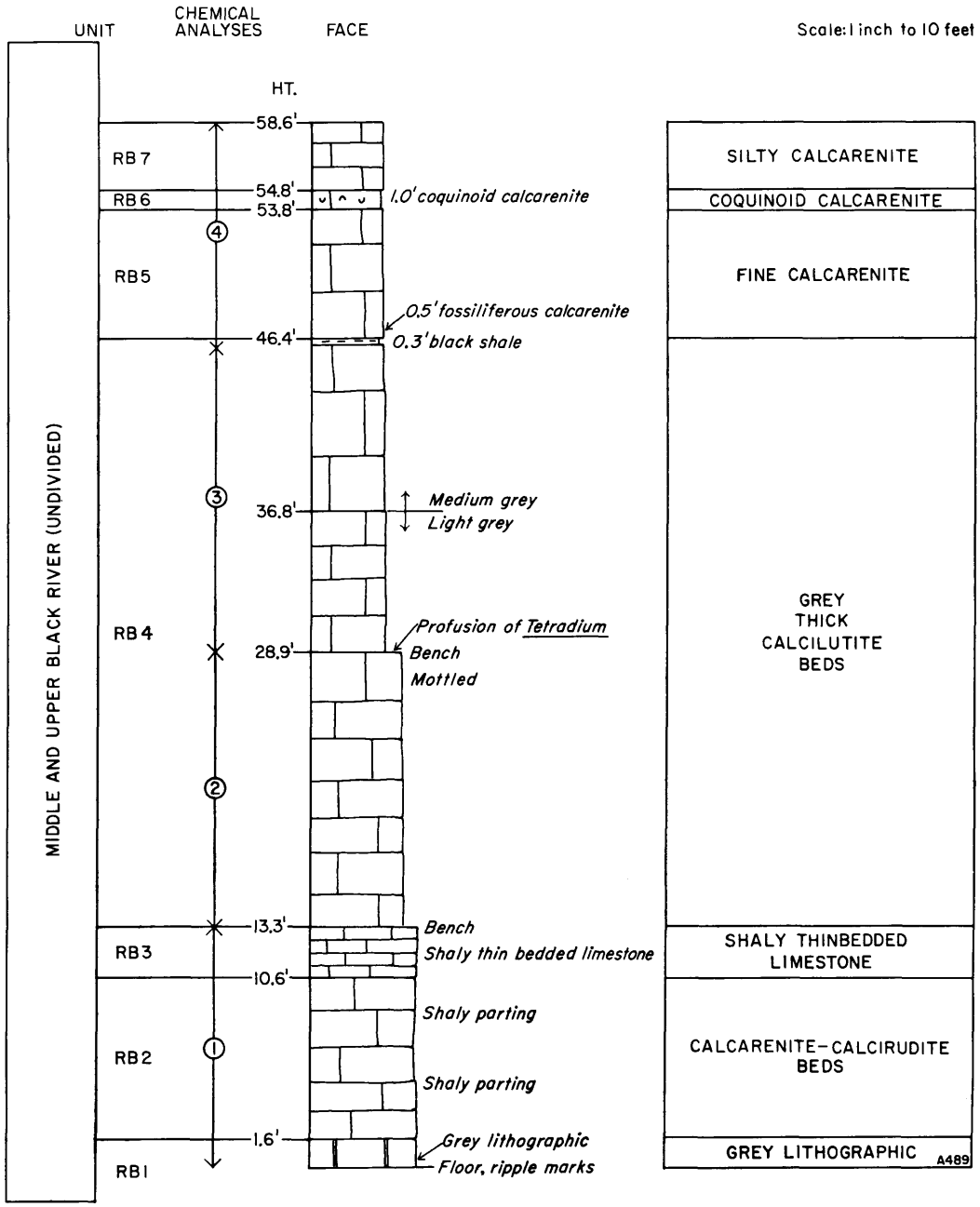
(54) QUARRY SECTION—ROBLINDALE QUARRIES LIMITED



Fifty-eight feet of Black River limestone are exposed in the face at Roblindale Quarries, Roblindale station. Wagon drills may be seen in operation on bench No. 1 in the background.

(54) QUARRY SECTION—ROBLINDALE QUARRIES LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
RB7	Limestone: fine silty calcarenite; medium brownish grey, grey weathering; aphanitic; thin to medium bedded; thin laminated siltstone to fine calcarenite	3.8
RB6	Limestone: coquinoid calcarenite; medium brownish grey; coarsely crystalline; medium bedded; highly fossiliferous: bryozoa, brachs, crinoids	1.0
RB5	Limestone: calcarenite; medium dark grey, grey weathering; microcrystalline to fine crystalline; thick bedded; shaly partings	7.4
RB4	Limestone: medium to dark brownish grey, medium to light grey weathering; cryptocrystalline to medium crystalline; medium to thick bedded; shaly partings; in part clastic with calcilutite fragments; upper beds laminated calcilutite, calcite crystals ("birdseye" beds); fossiliferous: abundant *Tetradium.* (Top 0.3 feet, black shale.)	33.1
RB3	Limestone: calcilutite; dark brownish grey, grey weathering; fine crystalline to microcrystalline; thin bedded; shaly	2.7
RB2	Limestone: calcarenite to calcirudite; dark brownish grey, grey weathering; fine crystalline; medium bedded; shaly partings; in part clastic with calcilutite fragments	9.0
RB1	Limestone: calcilutite; dark brownish grey, grey weathering; microcrystalline; medium bedded	1.6
	Total	58.6

(55) CHEMICAL ANALYSES—ROBLINDALE QUARRIES LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Lift	Sample Interval From Quarry Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
Lower	0 –13.3	7.52	3.85	1.09	0.95	47.30	38.00	0.23	98.94
Second	13.3–28.9	4.65	1.78	1.24	0.62	50.60	40.31	0.20	99.40
Third	28.9–46.1	3.47	0.88	1.20	0.43	51.40	41.10	0.20	98.68
	46.1–58.6	4.33	2.02	0.66	0.79	50.60	40.66	0.19	99.25

NAPANEE AREA

On the eastern outskirts of Napanee, on the east side of the Napanee River, there is a 100-foot scarp of limestone consisting of the Middle and Upper Black River formations. A good section is exposed in the roadcut along highway No. 2 ascending the scarp, where about 65 feet of Middle and Upper Black River beds are present. Kay (1942, p. 593), correlates the lower 49 feet of this section with the Lowville (Middle Black River) and places the upper Lowville contact 13 feet 3 inches below a 3-foot shaly horizon near the top of the cut. The upper beds he correlates as Chaumont (here called Upper Black River). This contact is placed on faunal evidence.

Storey Quarry

The Storey quarry is located on the top of the scarp just north of the Napanee roadcut described above, in lot 19, concession VII, North Fredericksburg township, Lennox and Addington county.

The quarry face consists of 13 feet of medium- to thin-bedded, dark-brownish grey limestone similar to the upper beds exposed in the roadcut. The quarry section of Upper Black River limestone is described in (56).

Drilling at the quarry is carried out by jackhammers run by compressed air from a 125-cubic-foot-per-minute Jaeger compressor. The stone is loaded by a ⅝-cubic-yard Rapier shovel into a 3-ton truck for haulage to the primary crusher, a 12- by 36-inch Dore jaw-crusher. This is followed by a scalping screen. Secondary crushing of the oversize material is carried out by a set of Cedarapids 15- by 30-inch rolls. Screening is done by a 16-foot trommel. The main products are 1½-inch crusher run, ¾-inch crusher run, and ¾-inch stone for aggregate.

Gibson Property

In 1954 diamond-drilling was carried out on this Black River limestone scarp on the south side of the Napanee River a mile north of highway No. 2. The drilling was done on the Gibson farm, northeast quarter of lot 22, concession VII, North Fredericksburg township, Lennox and Addington county, on the Palace road 1 mile northeast of Napanee.

Chemical analyses of diamond-drill hole No. 1, located on the property on the top of the scarp, were supplied by G. B. Langford and are given in (57).

The higher silica content of the Middle and Upper Black River limestones as they are traced eastward is apparent. The low magnesia content indicates that the Lower Black River formation was not penetrated.

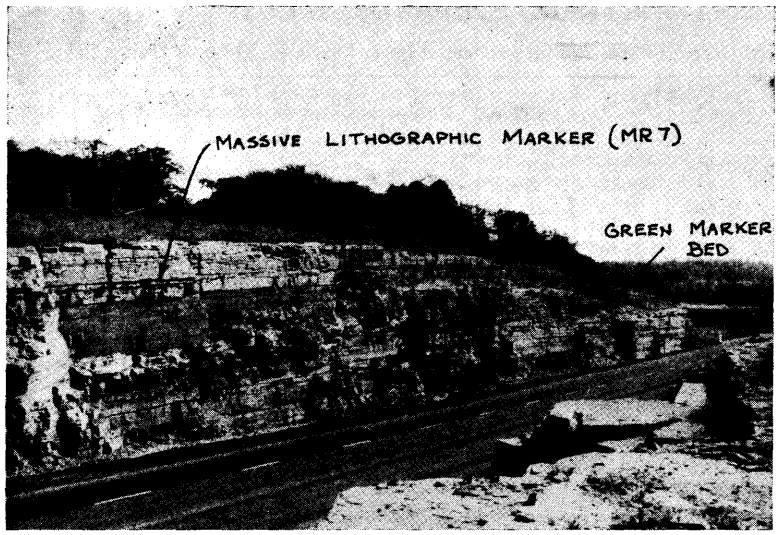
(56) QUARRY SECTION—STOREY QUARRY

UNIT	DESCRIPTION	THICKNESS Feet
4	Limestone: dark brownish grey, medium grey weathering; medium-bedded; aphanitic	3.0
3	Limestone: shaly; fossiliferous calcarenite; dark brownish grey, grey weathering; medium crystalline; thin bedded. (This is the 3-foot shaly horizon of Kay.)	2.6
2	Limestone: dark brownish grey, blue grey weathering; fine crystalline to aphanitic; thin bedded; shaly partings	7.4
	Quarry Floor	
1	Limestone: dark brownish grey, blue grey weathering; fine crystalline to microcrystalline; medium bedded; shaly partings	6.0
	Total	19.0

(57) CHEMICAL ANALYSES—GIBSON PROPERTY

(Analyses by the Provincial Assay Office, Ont. Dept. Mines 1954)

Depth	SiO_2	Fe_2O_3 + Al_2O_3	CaO	MgO
feet	percent	percent	percent	percent
0–16 (overburden)				
16–30	1.94	0.50	50.86	1.62
30–45	4.84	0.96	48.60	1.39
45–60	5.12	1.02	48.82	1.11
60–73	6.50	1.00	45.71	1.65
73–86	9.72	1.30	42.81	1.69
86–98	7.16	1.20	46.01	1.32



An excellent reference section of Black River limestone is exposed in the Montreal Street roadcut on highway No. 401, at Kingston. The photo is taken looking north, just west of the highway bridge. Marker horizons are indicated.

KINGSTON AREA
Montreal Street Roadcut, Highway No. 401

An excellent reference section for the Black River limestones of the Kingston area may be seen in the new highway No. 401 roadcut at Montreal Street in Kingston. Here a continuous 103-foot section from the Upper Black River to Lower Black River formations is exposed.

The section is illustrated and described in (59). The top of the Lower Black River formation is tentatively placed at the 3.5-foot "green marker bed" of silty greenish-buff dolomite, which occurs approximately 23 feet above the deck level of the bridge at the base of the cut. The thickness of Lower Black River beds in this cut is 34.7 feet consisting of interbedded grey lithographic limestone and buff silty dolomite.

The beds here tentatively assigned to the Middle Black River, from footage 34.7 to footage 100.3, consist of interbedded, grey lithographic limestone and buff silty dolomitic limestone. Calcilutite is more common in the lower part, with calcarenite and shaly calcirudite coming in higher in the section. A grey, massive lithograph bed 2.7 feet thick (footage 47.6–50.3) makes another good marker bed in the area. A prominent greyish shaly dolomitic limestone unit occurs in the upper part of the section from footage 80.2 to footage 85.6; this unit also makes a good marker in the area and is called the "upper greenish beds."

The base of the Upper Black River is tentatively placed at the first occurrence of coquinoid calcarenite at footage 100.3. About 10 feet of Upper Black River beds are exposed further west along the highway.

Chemical analyses of composite chip samples of the Middle and Upper Black River beds in this rock-cut are given in (58).

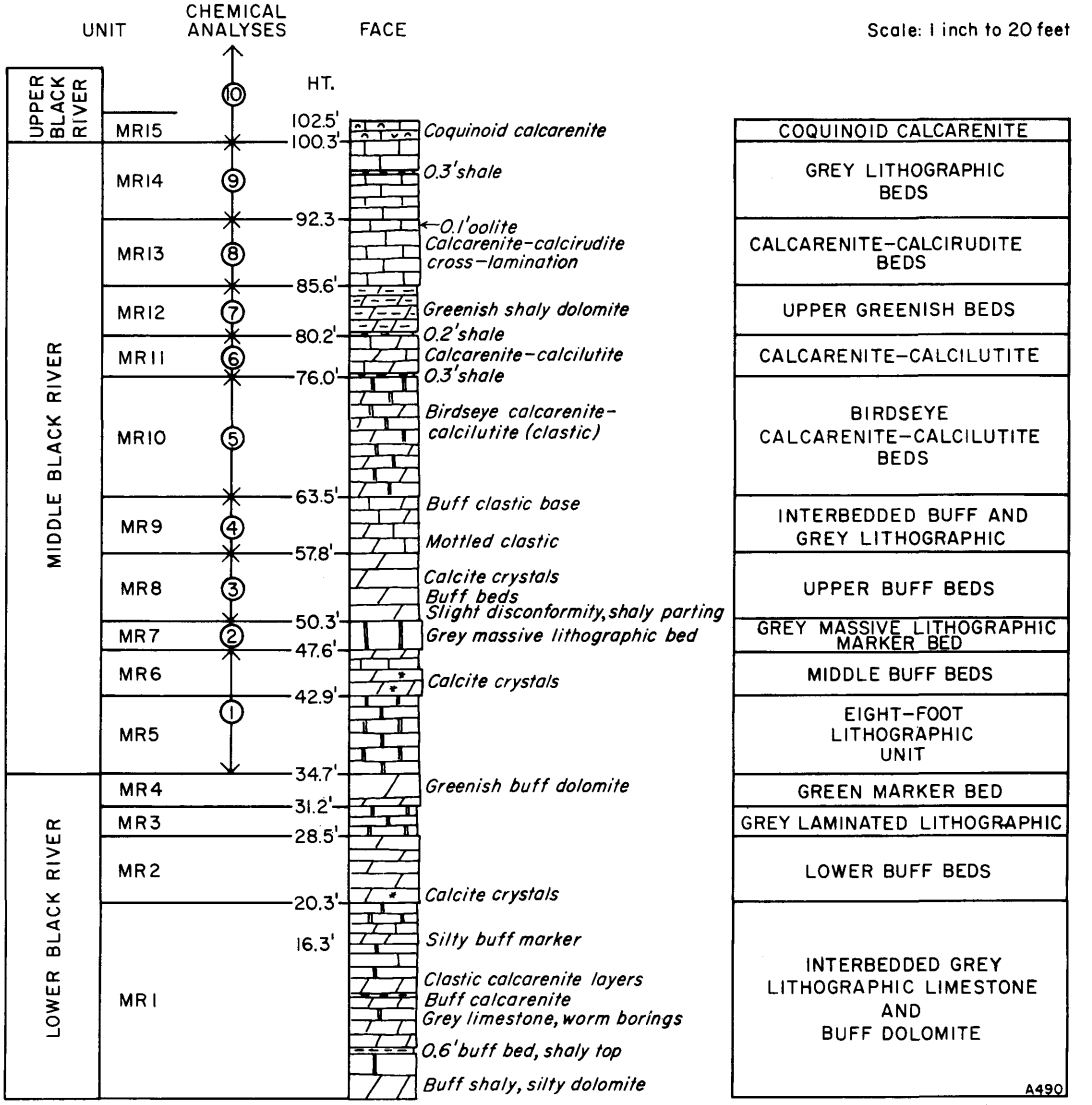
As indicated, the "upper greenish beds", unit MR12, are shaly, silty dolomite. The 45.5 feet of Middle Black River beds below this horizon are also relatively high in silica, alumina, and magnesia, much higher than are the Middle Black River beds to the west of Kingston. This indicates an influx of shaly and silty material in the Middle Black River time in the Kingston area. On a chemical basis, to conform with the magnesia cut-off used for the Middle Black River beds in the area to the west, the beds from unit MR12 down should be assigned to the Lower Black River formation. This, however, would cut the thickness of the Middle Black River to about 15 feet. In the next available sections to the west, at Napanee and Roblindale, substantial thicknesses of Middle Black River (over 50 feet), low in magnesia (less than 2 percent, frequently less than 1 percent), are present. More information is required on the chemical composition and stratigraphy in the area between Napanee and Kingston to resolve this problem.

(58) CHEMICAL ANALYSES—MONTREAL STREET ROADCUT

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959; Samples collected by I. Maycock, Queen's University)

Sample	Stratigraphic Unit	Footage	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	P_2O_5	Total
			percent	percent	percent	percent	percent	percent	percent	percent	percent
1.....	MR5, MR6	34.7– 47.6	8.42	2.63	0.79	4.86	42.64	38.87	0.10	.....	98.31
2.....	MR7	47.6– 50.3	2.70	0.41	0.54	1.31	52.30	42.66	0.07	0.12	99.99
3.....	MR8	50.3– 57.8	3.74	1.16	0.92	11.70	38.30	42.85	0.07	0.11	98.74
4.....	MR9	57.8– 63.5	3.38	1.05	0.46	3.60	48.60	43.62	0.08	0.10	100.79
5.....	MR10	63.5– 76.0	4.74	1.73	0.52	2.98	48.00	41.06	0.07	.....	99.10
6.....	MR11	76.0– 80.2	7.18	2.01	0.76	2.76	46.20	39.21	0.07	.....	98.19
7.....	MR12	80.2– 85.6	32.78	9.94	1.24	6.24	22.65	25.05	0.22	.....	98.12
8.....	MR13	85.6– 92.3	15.52	4.05	0.57	0.80	42.40	34.57	0.20	.....	98.11
9.....	MR14	92.3–100.3	3.56	1.36	0.62	0.72	51.00	41.28	0.03	0.12	98.57
10.....	MR15	100.3–112.3	6.61	2.04	0.66	1.20	48.20	39.31	0.11	.....	98.13

(59) COLUMNAR SECTION—MONTREAL STREET ROADCUT



(59) COLUMNAR SECTION—MONTREAL STREET ROADCUT

UNIT	DESCRIPTION	THICKNESS Feet
MR15	Limestone: coquinoid calcarenite; medium brownish grey, light grey weathering; medium crystalline; medium bedded; fossiliferous	2.2
MR14	Limestone: medium brownish grey, light grey weathering; cryptocrystalline to fine crystalline; medium to thin bedded; shaly partings; interbedded lithographic and fine crystalline; fossiliferous: *Tetradium*	8.0
MR13	Limestone: shaly interbeds, calcarenite to calcirudite; medium brownish grey, buff weathering; medium crystalline to aphanitic; medium bedded; cross lamination	6.7
MR12	Dolomite: shaly, silty; calcarenite to calcirudite; greenish grey, greenish buff weathering; top 1.5 feet very shaly	5.2
MR11	Limestone: dolomitic in part; calcarenite to calcirudite; medium brownish grey, brownish weathering; medium crystalline to microcrystalline; medium bedded	4.2
MR10	Limestone: dolomitic in part; calcarenite to calcilutite; medium brownish grey, light grey weathering; microcrystalline to fine crystalline clastic; medium bedded; calcite eyes ("birdseye" beds); shaly partings	12.5
MR9	Limestone: dolomitic in part; medium grey to medium brownish grey, buff to light grey weathering; interbedded aphanitic and microcrystalline; silty in part; shaly partings; some clastic calcarenite, some "birdseye" beds with calcite eyes; medium bedded	5.7
MR8	Dolomite: silty; medium grey, buff weathering; aphanitic; medium to thick bedded; shaly partings; calcite crystals to 3 inches in size	7.5
MR7	Limestone: calcilutite; medium brownish grey, light grey weathering; microcrystalline; a single massive 2.7-foot bed making a distinctive marker	2.7
MR6	Dolomite: silty; medium buff grey, buff weathering; aphanitic and microcrystalline interbedded; medium bedded; calcite crystals	4.7
MR5	Limestone: calcilutite; medium brownish grey, light grey weathering; microcrystalline; medium bedded	8.2
MR4	Dolomite: silty, sandy; "green marker bed"; medium light grey, greenish to buff weathering; aphanitic; thick bedded; easily breaks down on weathering	3.5
MR3	Limestone: calcilutite; medium brownish grey, grey weathering; microcrystalline; medium bedded; thin colour lamination	2.7
MR2	Dolomite: silty; medium grey, buff weathering; aphanitic; medium bedded; shaly partings	8.2
MR1	Limestone and Dolomite: interbedded. Dolomite: silty; medium grey, buff weathering; aphanitic; medium bedded. Limestone: calcilutite to calcarenite; medium grey, light grey weathering; medium bedded; shaly partings; microcrystalline to fine crystalline	20.3
	Total	102.3

FRONTENAC QUARRIES LIMITED, KINGSTON

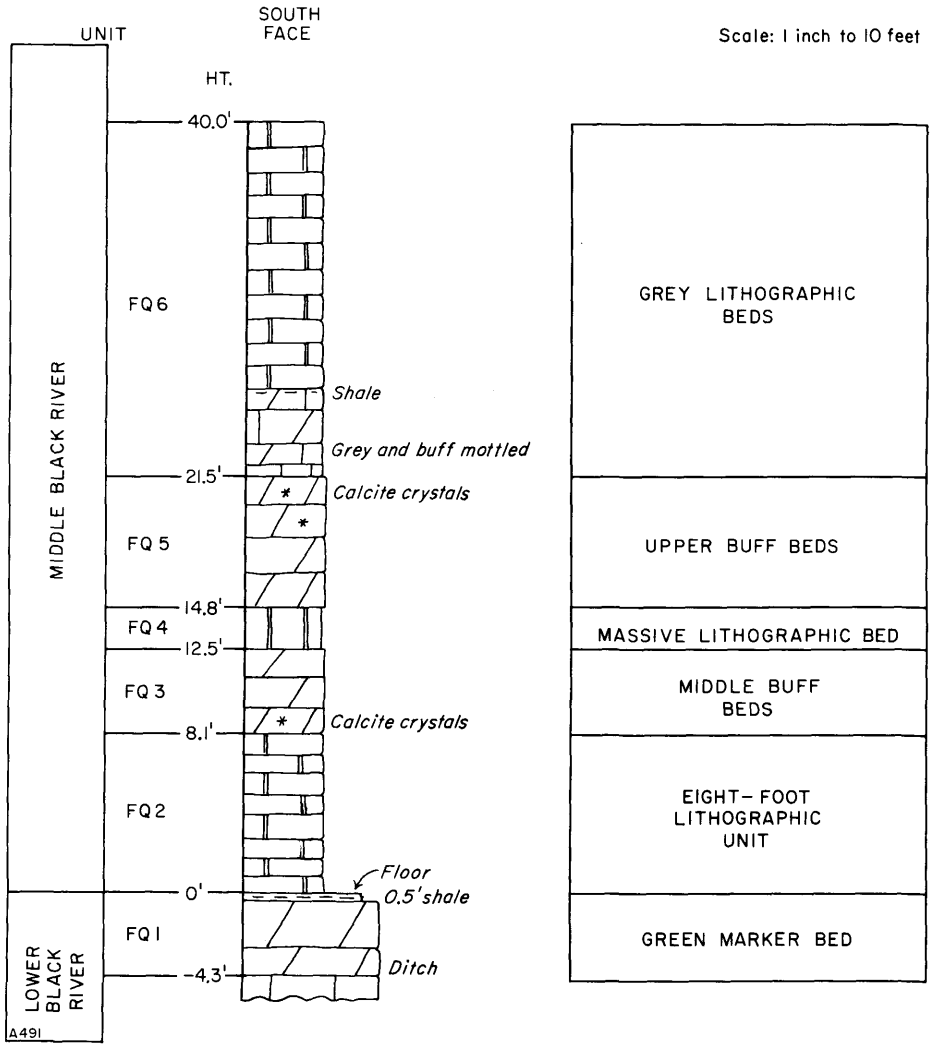
The quarry operated by Frontenac Quarries Limited is located on the east side of Division Street in Kingston, just south of highway No. 401.

Geology

The quarry faces are in Middle and Upper Black River beds, with the Lower Black River beds exposed in a ditch in the quarry floor. The stone is dark-brownish grey, white-weathering, lithographic limestone interbedded with buff-weathering, silty dolomite. A section (60) illustrates and describes the south face of the quarry. The prominent greenish buff weathering, sandy dolomite, which makes a characteristic marker bed at the top of the Lower Black River in this area, the "green marker bed" of the Montreal Street reference section, is exposed in a ditch in the quarry floor behind the quarry office.

An east-west striking fault, dipping 70°N., passes through the centre of the quarry. The north side has moved down 12–15 feet, so that the measured section on the south wall cannot be readily correlated with the active north quarry face. The upper beds on the north face are coquinoid calcarenite of the Upper Black River formation. The "upper greenish beds," which make a notable horizon marker in the Montreal Street section, appear to

(60) QUARRY SECTION—FRONTENAC QUARRIES, LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
FQ6	Limestone: calcilutite; in part dolomitic; medium dark brownish grey, light grey weathering; aphanitic to microcrystalline; medium to thick bedded; shaly partings; calcite crystals ("birdseye" beds); fossiliferous, *Tetradium*.	18.5
FQ5	Dolomite: medium grey, buff to grey buff weathering; aphanitic; thick bedded; calcite crystals up to 4 inches in size	6.7
FQ4	Limestone: calcilutite; dark brownish grey, light grey weathering; microcrystalline; thick bedded; single 2.3-foot bed	2.3
FQ3	Dolomite: silty; medium grey, buff weathering; aphanitic; medium bedded; calcite crystals	4.4
FQ2	Limestone: calcilutite; medium dark brownish grey, light grey weathering; microcrystalline to aphanitic; thin bedded; shaly partings	8.1
FQ1	Dolomite: sandy; medium grey, greenish buff weathering; aphanitic; thick bedded; easily decomposes on weathering; forms an excellent marker bed in this area	4.3
	Total	44.3

be present in the north quarry face 15–20 feet from the top of the face. This suggests a displacement of 12–15 feet on the fault. On the east wall of the quarry the fault appears to have two branches, with displacements of about 5 feet on the south branch and 10 feet on the north branch fault. The section on the north quarry face was not measured, and its exact correlation with the reference section was not established.

Quarry Operation

The 40- to 55-foot quarry face is drilled on a 12- by 18-foot pattern by a churn-drill equipped with a 5¼-inch bit. The blasting agents are dynamite and prilled ammonium nitrate. Secondary breaking is done by a 1,400-pound drop ball. A ¾-cubic-yard Northwest shovel loads two 5-ton (G.M.C.) dump trucks, which haul to the 15- by 30-inch, Sawyer-Massey, primary jaw-crusher. The jaw-crusher is followed by a 3- by 5-foot scalping screen, with secondary crushing done by a 15- by 30-inch set of Holland rolls. Sizing is done by a set of 4- by 8-foot, Niagara, 3-deck vibrating screens. The oversize is recrushed by a Gilson, Model 14, two-in-one, Hammermill, followed by a Cedarapids, 2- by 8-foot, screen. The main sizes produced are 4-inch crusher run, 2-inch, 1½-inch, ¾-inch, ½-inch, and dust. Stone is loaded from stockpiles by an overhead loader. Transportation is entirely by truck. The plant capacity is about 60 tons per hour, with an average production of 600 tons per 10-hour shift. The stone is mainly used for road construction. An asphalt plant is located in the quarry.

McGINNIS & O'CONNOR LIMITED, KINGSTON

The McGinnis & O'Connor quarry is located in Pittsburgh township, Frontenac county, on the west side of highway No. 15, about 2 miles north of Barriefield, south of highway No. 401.

Geology

The 52-foot quarry face is composed of Lower and Middle Black River beds, mainly light-grey lithographic limestone, dolomitic limestone, and shaly, silty, buff dolomite. The quarry section is illustrated and described in (62). The quarry is operated in four or five lifts. The "green marker bed" of silty to shaly greenish-buff dolomite (see section at Montreal Street (60)), which marks the top of the Lower Black River section, forms the uppermost bed of Lift 3 with its top 32.7 feet above the lowermost quarry floor. This marker bed is unit MG4 in (62). Below this the Lower Black River consists of interbedded buff, silty dolomite and light-grey-weathering lithographic limestone, with shaly partings. Above the marker bed there is 20 feet of Middle Black River lithographic limestone and interbedded buff dolomite and dolomitic limestone. The grey, massive, lithographic limestone marker of the Montreal Street reference section is recognized here as unit MG7.

Chemical analyses of composite chip samples taken up the quarry face are given in (61).

The chemical analyses indicate a relatively high percentage of silica, alumina, and magnesia in both the Lower and Middle Black River beds.

Quarry Operation

The quarry is operated in a series of lifts either 12 or 24 feet in height, to a total quarry height of 52 feet. The 12-foot lift from the top of the "green marker bed" downward is quarried separately, since it is said to be unsuitable for concrete aggregate. Drilling is done by two Ingersoll-Rand wagon drills with 2⅛-inch bits, on a 6- by 6-foot pattern. Air is supplied by a 600-cubic-foot-per-minute Jaeger compressor. The blasting agent is forcite. Stone is loaded by a 1½-cubic-yard Northwest shovel and a 1¼-cubic-yard Manitowoc shovel. Some secondary breaking is done by drop ball attached to the shovel buckets. Two 5-ton (G.M.C.) trucks with Euclid dump-bodies haul to the primary crusher.

The primary crusher is a Kennedy Van Saun (KVS), 24- by 36-inch, jaw-crusher, fed by a Cedarapids feeder and followed by a scalping screen. Secondary crushing is done by a 20- by 20-inch, Cedarapids, impact crusher in parallel with a No. 25½, KVS, gyratory crusher. Sizing is done by a KVS, 2-deck, 4- by 10-foot, vibrating screen under a water-spray system, which reduces the amount of dust in the products. The stone goes to bins and is stockpiled from the bins by truck. Two Trojan overhead loaders load stone for truck haulage to the consumer. The plant has a capacity of about 150 tons per hour. The main sizes produced are 4-inch crusher run, 3- by 2½-inch, 1- by ⅜-inch, ¾-inch, ⅝-inch, ⅜-inch, and 1-inch crusher run. The stone is mainly used for road construction and concrete aggregate, with some production of rubble stone as contracts require.

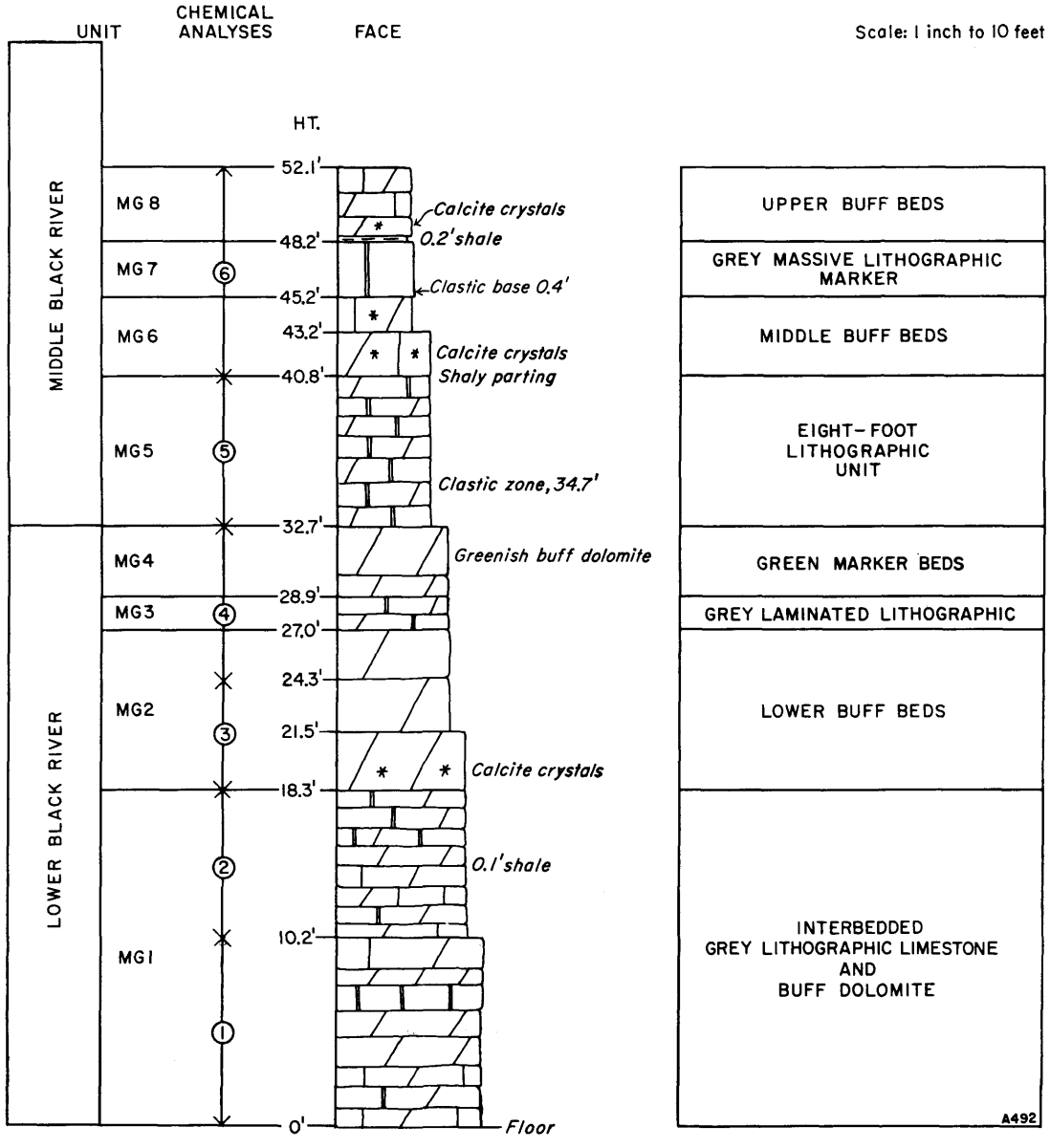
A portable plant located in the quarry gives additional production capacity as required.

(61) CHEMICAL ANALYSES—McGINNIS & O'CONNOR LIMITED

(Chemical Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample	Stratigraphic Unit	Footage Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
			percent	percent	percent	percent	percent	percent	percent	percent
1.....	MG1	0.0–10.2	5.24	1.64	0.82	7.45	43.30	39.40	0.21	98.06
2.....	MG1	10.2–18.3	8.38	3.04	0.70	3.49	45.30	38.28	0.03	99.22
3.....	MG2	18.3–24.3	17.98	5.73	1.40	10.40	28.78	33.27	0.69	98.25
4.....	MG2, MG3, MG4	24.3–32.7	14.92	4.97	1.47	13.90	26.80	36.43	0.23	98.72
5.....	MG5	32.7–40.8	9.34	2.67	0.89	4.99	42.76	38.45	0.11	99.21
6.....	MG6, MG7, MG8	40.8–52.1	9.63	3.81	1.03	7.82	38.34	38.18	0.46	99.27

(62) QUARRY SECTION—McGINNIS & O'CONNOR LIMITED



(62) QUARRY SECTION—McGINNIS & O'CONNOR LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
MG8	Dolomitic Limestone: medium light grey to buff, buff weathering; aphanitic to fine crystalline; thick bedded; laminated; calcite crystals; 0.2 feet shale at base	3.9
MG7	Limestone: calcilutite; medium dark grey, light grey to white weathering; microcrystalline; one massive 3-foot bed	3.0
MG6	Dolomite: silty; medium grey, buff weathering; fine crystalline to aphanitic; thick bedded; thin laminated; in part calcarenite; showing graded bedding; calcite crystals; marcasite	4.4
MG5	Dolomitic Limestone: calcilutite; medium brownish grey, light grey weathering; microcrystalline; medium bedded; microlaminations; ostracods	8.1
MG4	Dolomite: silty to shaly; greenish grey, greenish to buff weathering; aphanitic; thick bedded; 2.7-foot bed above, 1.1-foot buff bed below; breaks down easily on weathering	3.8
MG3	Limestone: silty calcilutite; medium dark grey, grey to slightly buff weathering; aphanitic to microcrystalline; medium bedded; finely laminated; no sharp break with MG4 above	1.9
MG2	Dolomite: sandy, silty; light brownish grey, greenish buff weathering; aphanitic; thick bedded; blocky fracturing	8.7
MG1	Limestone and Dolomite, interbedded. Dolomite: silty; medium grey, buff weathering; aphanitic; medium to thick bedded. Limestone: medium brownish grey, medium grey weathering; microcrystalline; medium to thick bedded; shaly partings; in part shows thin colour laminations	18.3
	Total	52.1

Ottawa–St. Lawrence Basin

The Trenton–Black River limestones occupy a basin in eastern Ontario extending from Ottawa and Hawkesbury on the Ottawa River, to Cornwall on the St. Lawrence River. The northern part of the basin is much disturbed by northwest-by-west-trending normal faulting. Distribution of these limestones is indicated on A. E. Wilson's map of the Ottawa-Cornwall area.[1]

The principal quarry centre in eastern Ontario is Ottawa, where Frazer Duntile Limited, Ottawa Valley Crushed Stone, and Dibblee Construction Limited operate quarries in the Black River limestone. A small quarry, operated in Ottawa by D. Grandmaitre, is in the Hull beds of the Trenton. Across the river at Hull, Que., Canada Cement Company operates a large quarry in the Trenton limestone.

In 1958 the only other quarries operating in the Trenton–Black River limestones of the Ottawa–St. Lawrence basin were Bertrand & Frère quarry at L'Orignal near Hawkesbury, and the Durham Wells quarry in Williamsburg township northeast of Morrisburg. The Ontario Hydro quarry, operated by C. A. Pitts General Contractors Limited at Cornwall Centre as a source of aggregate for the St. Lawrence Seaway project, was closed, and the plant dismantled in 1958.

[1]Map No. 852A, Geol. Surv. Can. (to accompany: Alice E. Wilson, *Geology of the Ottawa–St. Lawrence Lowland, Ontario and Quebec*, Geol. Surv. Can., Memoir 241, 1946).

In the Ottawa-Bonnechere graben to the west of Ottawa there are several outliers of Trenton–Black River limestone. These are described by Kay (1942, pp. 610–20). The only quarry operating in this area is that of Bonnechere Lime Company near Fourth Chute, southeast of Eganville.

Lithology

The Trenton–Black River limestones of the Ottawa–St. Lawrence basin are separated from those of the Georgian Bay–Lake Ontario area by the Precambrian rocks of the Frontenac axis extending northwest from Gananoque. Conditions of sedimentation varied somewhat between the two areas, and the formations show some variations. In the Ottawa area the Black River beds rest unconformably on the underlying Beekmantown and Chazy formations of Lower Ordovician age. These formations are absent to the west of the Frontenac axis.

The basal clastic beds of the Black River group consist of over 50 feet of dolomitic sandy limestone, shaly limestone, sandy dolomite, shale, and dolomitic sandstone. The Lower Black River formation consists of impure, grey, lithographic limestone interbedded with greenish-buff, sandy, dolomitic limestone with shaly layers. This formation may be seen in the floor of the Frazer Duntile, Ottawa Valley, and Dibblee Construction quarries at Ottawa and is distinctly higher in magnesia, silica, and alumina than the overlying beds. Drilling at

the Ottawa Valley Crushed Stone quarry indicates a thickness of 72 feet for the Lower Black River formation. The top of the Lower Black River formation is marked by a sandy, greenish-buff, dolomitic limestone bed.

The Middle and Upper Black River formations, and the lowermost unit of the Lower Trenton formation, are grouped together in the Ottawa area since they are lithologically and chemically similar. They consist of medium brownish grey, medium-grey weathering, medium-crystalline to microcrystalline limestone with shaly partings. They contain less than 2 percent magnesia, but silica content is 3–11 percent, with alumina content 1–4 percent. A diamond-drill hole at the Hull plant of Canada Cement Company indicates at least 190 feet of this lithologic unit below the Lower Trenton Hull beds. The maximum thickness of this unit examined by the author was about 85 feet at the Ottawa Valley Crushed Stone quarry. These beds are also quarried at the Frazer Duntile and Dibblee Construction properties.

The next higher recognizable lithologic unit is the Hull beds of the Lower Trenton formation. In the Ottawa area this unit consists of a light-bluish grey, medium-crystalline, thick-bedded, cross-laminated calcarenitic limestone of high purity. This unit is well exposed in a 40-foot thickness at the Grandmaitre quarry in Ottawa. Its lower contact with the Rockland beds of the Lower Trenton is exposed in this quarry. About 60 feet of this crystalline Hull unit is exposed in the Canada Cement Company quarry at Hull. The typical thin-bedded, shaly, limestone characteristic of the Lower Trenton in the Georgian Bay–Lake Ontario area is not present in the Ottawa area. However, the overlying Middle and Upper Trenton beds are composed of shaly limestone. These latter formations are not quarried at present in the Ottawa area.

FRAZER DUNTILE LIMITED (CLYDE AVENUE QUARRY, OTTAWA)

The quarry operated by Frazer Duntile Limited is located on Clyde Avenue, just south of Carling Avenue in the western part of the city of Ottawa.

Geology

The 60- to 70-foot quarry face consists of dark-grey to medium-brownish grey, fine-crystalline to microcrystalline, medium- to thick-bedded limestone with shaly partings, belonging to the Middle and Upper Black River formations. The section exposed at the quarry is illustrated and described (63). A ditch in the quarry floor exposes about 2 feet of greenish-grey, buff weathering, sandy dolomitic limestone. This is overlain by 65 feet of limestone assigned to the Middle Black River formation. The lower 30 feet of this unit is calcarenite to calcirudite; the next 9 feet is transitional from calcarenite to calcilutite; and the upper 26 feet is black to dark-grey calcilutite. The upper 5 feet or so of the quarry section is fossiliferous, rubbly calcarenite assigned tentatively to the Upper Black River formation (Leray beds). The contact between Middle and Upper Black River beds is gradational.

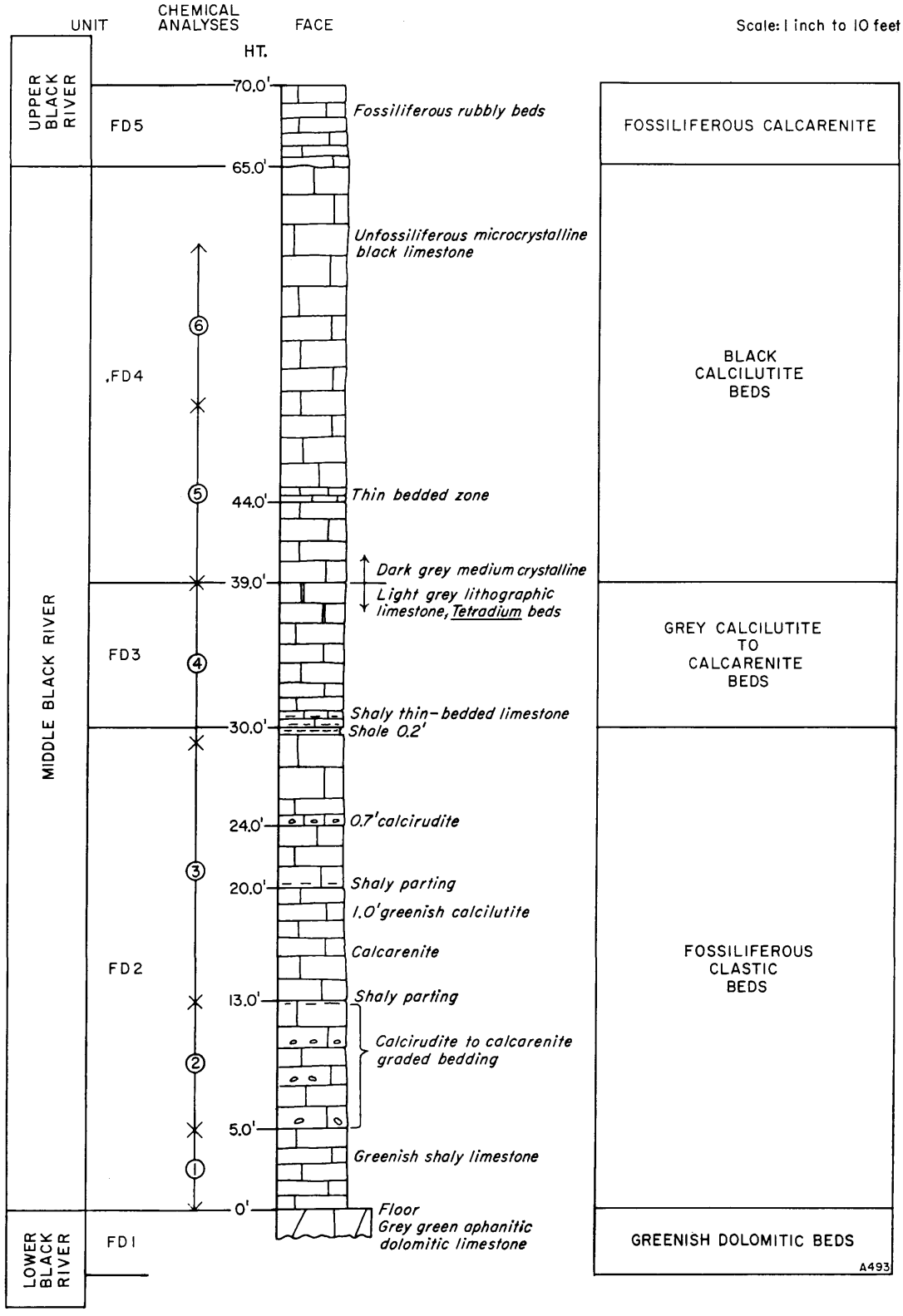
Chemical analyses of composite chip samples, taken up the quarry face, as indicated in (63), are given in (64).

The chemical analyses indicate that the Middle Black River limestone of the Ottawa area is much higher in silica and alumina and lower in lime than its counterpart in the Georgian Bay–Lake Ontario area. The magnesia content, however, is low.

(63) QUARRY SECTION—FRAZER DUNTILE LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
FD5	Limestone: dark brownish grey, medium grey weathering; microcrystalline to fine crystalline; medium bedded; shaly partings; fossiliferous	5.0
FD4	Limestone: calcilutite; dark grey, medium grey weathering; medium to thick bedded; microcrystalline; black shaly partings; unfossiliferous	26.0
FD3	Limestone: calcilutite to calcarenite; dark brownish grey, light grey weathering; fine crystalline to cryptocrystalline; medium bedded; clastic and fossiliferous to cryptocrystalline; shaly partings	9.0
FD2	Limestone: calcirudite, calcarenite, calcilutite; dark olive grey, medium grey weathering to slightly buff in places; medium crystalline to microcrystalline; medium to thick bedded; highly fossiliferous clastic section, prominent graded bedding; calcite crystals; shaly partings; calcilutite fragments up to 1 inch in calcirudite (intraformational conglomerate)	30.0
FD1	Dolomitic Limestone: greenish grey, buff weathering; aphanitic; medium bedded	2.0
	Total	72.0

(63) QUARRY SECTION—FRAZER DUNTILE LIMITED



(64) CHEMICAL ANALYSES—FRAZER DUNTILE LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Footage From Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
		percent	percent	percent	percent	percent	percent	percent	percent
1	0– 5	11.82	2.86	1.00	1.62	43.70	36.86	0.10	97.96
2	5–13	8.67	3.07	1.12	1.60	45.80	36.88	0.02	97.16
3	13–28	11.48	3.65	1.42	2.06	42.84	36.63	0.11	98.19
4	28–39	5.86	2.01	0.76	0.85	49.50	40.12	0.07	99.17
5	39–50	5.56	1.19	0.55	0.82	49.94	40.28	0.11	98.45
6	50–60	12.61	2.97	0.72	1.46	43.80	36.53	0.09	98.18

Quarry Operation

The quarry is operated in a single 60- to 70-foot lift. Overburden is light. Two electric churn-drills bore 6½-inch holes on a 14- by 17-foot pattern. Twenty-foot helper holes are drilled by a Gardner Denver Air-Trac drill with a 3-inch bit. This drill is operated on air supplied from a Jaeger 600-cubic-foot-per-minute compressor. Blasting agents are forcite and prilled ammonium nitrate. Some secondary blasting is required owing to the thick-to-massive-bedded character of the limestone.

Stone is loaded on three International R-190 trucks, with 16-ton Easton side-dump trailers, by a Bucyrus-Erie 22T, 2½-cubic-yard shovel. A second 1-cubic-yard Lorrain shovel may also be used.

The primary crusher is a 26½-inch Kennedy Van Saun (KVS) gyratory crusher set at 4–5 inches. The product from this crusher is conveyed to the secondary crushers, a KVS No. 39 gyratory and a 4-foot Symons cone. The products from the secondary crushers are conveyed to the screen house where sizing is done by tandem 5- by 12-foot Niagara vibrating screens. The main sizes produced are 2-inch, 1-inch, ⅝-inch, ⅜-inch, and dust. These go to storage bins.

The plant has a rated capacity of about 150 tons per hour, and average production is 1,500 tons per day. Crusher run is also produced by a portable plant. There is an asphalt plant on the property. Haulage is by truck.

OTTAWA VALLEY CRUSHED STONE LIMITED, OTTAWA

The Ottawa Valley Crushed Stone quarry is located in lots 12–14, concession II, Ottawa front, Gloucester township, Carleton county, just south of highway No. 17 on the eastern outskirts of Ottawa, between Eastview and Orleans. Ottawa Valley Crushed Stone Limited is a subsidiary of Canada Cement Company Limited.

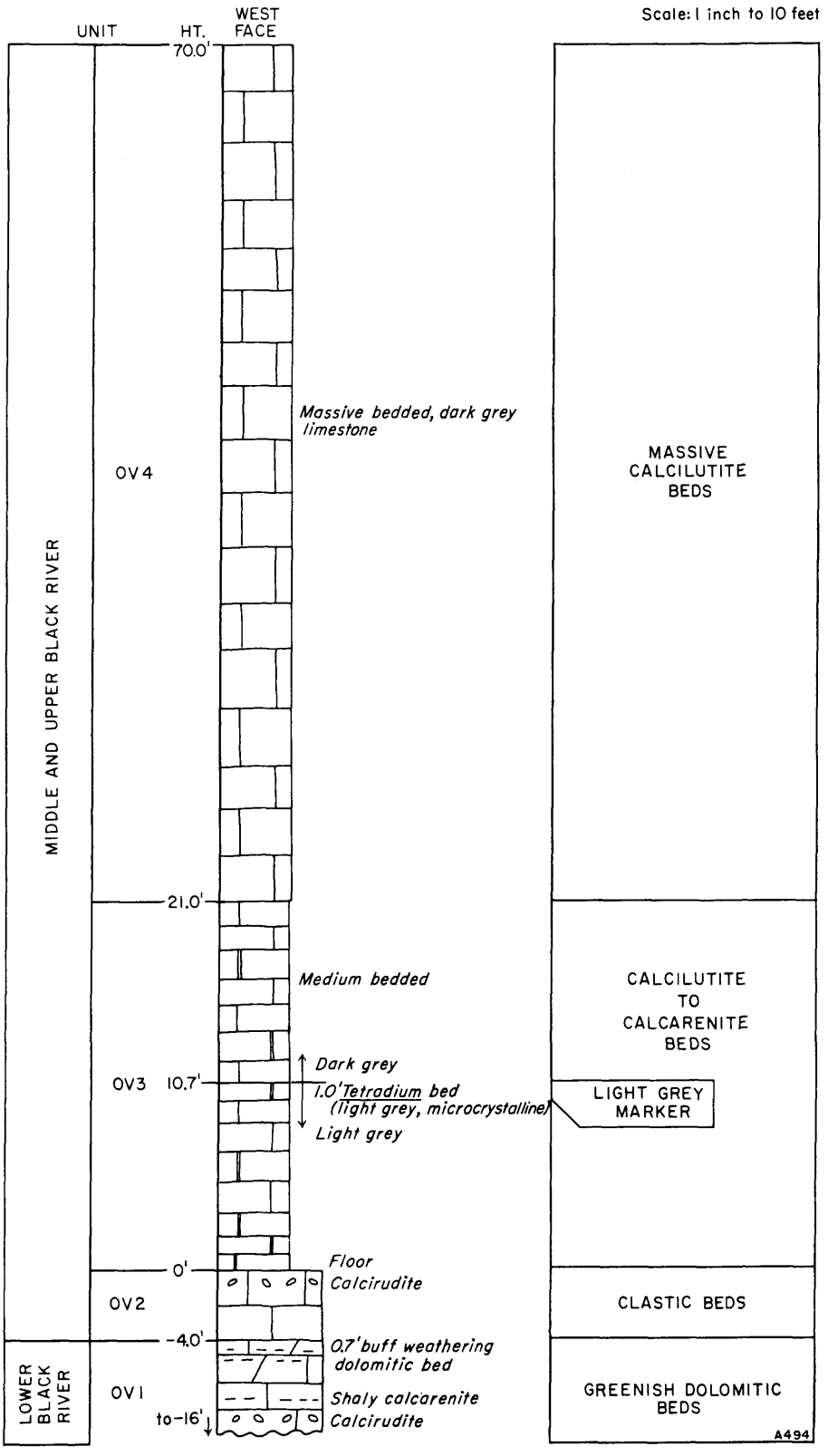
Geology

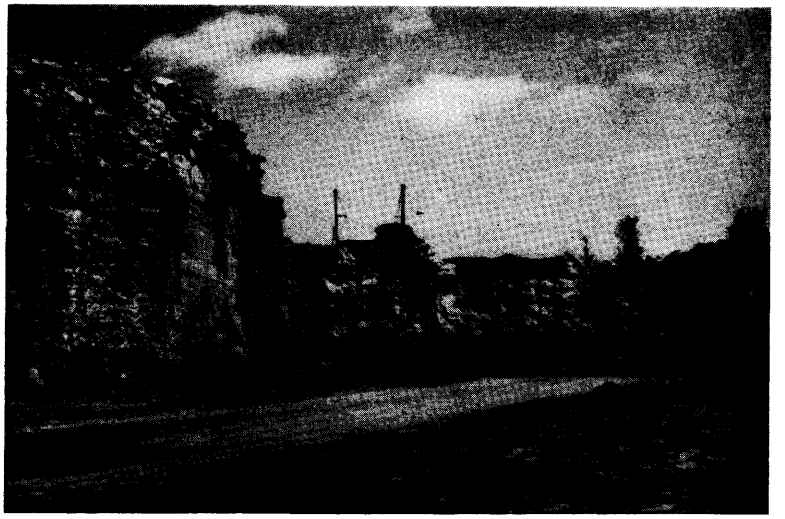
The 70-foot quarry face consists of medium brownish grey, microcrystalline to fine-crystalline, massive- to medium-bedded limestone with black shaly partings, belonging to the Middle and Upper Black River formations. The quarry section is illustrated and described in (65).

(65) QUARRY SECTION—OTTAWA VALLEY CRUSHED STONE LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
OV4	Limestone: calcilutite, minor calcarenite; medium brownish grey, light grey weathering; microcrystalline, in part fine crystalline; massive bedded; brownish mottling in places with fine crystalline clastic limestone in a microcrystalline matrix; irregular dark grey shaly partings; regular dimpled weathered surface; some fossiliferous coquinoid layers. Some thin rubbly weathering beds near top	49.0
OV3	Limestone: calcilutite to calcarenite; medium brownish grey, light grey to medium grey weathering; fine crystalline to microcrystalline; medium bedded; shaly partings; light grey marker bed carrying *Tetradium* at 9.7 to 10.7 feet	21.0
OV2	Limestone: calcarenite to calcirudite; medium grey, grey to buff weathering; medium bedded; calcirudite (intraformational conglomerate) makes up top 0.7 feet of this unit—fragments of grey and buff silty aphanitic dolomitic limestone in calcarenite matrix—fragments up to 2 inches in size	4.0
OV1	Dolomitic Limestone: shaly silty; calcarenite, calcirudite, alternating with calcilutite; medium grey, buff to greenish weathering; medium bedded; medium crystalline to aphanitic; graded bedding; calcirudite with calcilutite fragments to 1 inch in size. Top 0.7-foot bed buff coloured, shaly	12.0
	Total	86.0

(65) QUARRY SECTION—OTTAWA VALLEY CRUSHED STONE LIMITED





The quarry of Ottawa Valley Crushed Stone Limited, near Ottawa, exposes 70 feet of Middle and Upper Black River limestone. Churn drills may be seen operating in the background.

In a cut below the quarry floor, another 16 feet of limestone is exposed. The first 4 feet below the quarry floor is medium-grey to buff calcarenite with dolomitic limestone fragments. It is assigned to the Middle Black River. Below this is 12 feet of silty and shaly, greenish buff weathering, medium-bedded dolomitic limestone, which is classed as Lower Black River formation.

In the quarry itself the lower 21 feet of the quarry face is calcilutite to calcarenite. A light-grey marker bed carrying abundant *Tetradium* was noted at 9.7–10.7 feet. The upper 49 feet of the quarry face is rather uniform, thick- to massive-bedded, dark-grey calcilutite with some fossiliferous calcarenite layers. The Middle and Upper Black River contact is thought to occur near the top of the section, but the contact appears to be gradational.

Two narrow basic dikelets were observed cutting the quarry floor. They strike west and dip vertically.

Canada Cement Company Limited supplied chemical analyses (66) of a diamond-drill hole (No. 1), located about 20 feet north of the east end of the quarry. This 200-foot drill hole gives an excellent representative section of the Upper and Middle Black River beds being quarried, as well as the underlying Lower Black River and Basal beds.

The base of the Middle Black River formation is placed at the top of the sandy, greenish, dolomitic beds; the chemical analyses show a notable increase in silica and magnesia in the underlying Lower Black River beds. The top of the basal clastic beds of the Black River is placed at the dolomitic sandstone at 150–55 feet.

Quarry Operation

Overburden is light, averaging less than 5 feet. The 60- to 70-foot quarry face is worked in a single lift. One "bottom-hole" impact-type drill bores 6-inch holes on a 16- by 21-foot pattern. Ammonium nitrate and Nitrone are used for blasting. Stone is loaded by a 3-cubic-yard Bucyrus-Erie 85-B shovel or a 2-cubic-yard Dominion 500 shovel. Haulage is done by three or four 15-ton Euclid rear-dump trucks.

The primary crusher is a 48- by 60-inch, Traylor jaw-crusher, followed by a 4¼-foot Symons cone secondary crusher. Stone from the secondary crusher passes over a 2-inch scalping screen, and oversize is recrushed by a 3-foot Symons cone. The crusher products go to the screenhouse for sizing and then to five storage bins. The main sizes produced are 2-inch, 1½-inch, 1-inch, ⅝-inch, ⅜-inch, and dust. The stone is stockpiled by truck. Haulage is entirely by truck. The stone is mainly used for concrete aggregate and road stone. The plant capacity is about 170 tons per hour, and production averages 2,250 tons per day.

(66) CHEMICAL ANALYSES—OTTAWA VALLEY CRUSHED STONE LIMITED

(Company data by permission of Canada Cement Company Limited)

	Depth From Collar	SiO_2	R_2O_3	CaO	MgO	L. O. I.	Total
MIDDLE AND UPPER BLACK RIVER	feet	percent	percent	percent	percent	percent	percent
(Quarry lip at 4 feet)	0– 5	4.40	1.96	51.02	1.53	40.74	99.65
	5– 10	3.86	1.84	50.18	1.12	40.88	97.88
	10– 15	5.44	2.94	49.48	1.34	39.42	98.12
	15– 20	10.76	5.06	44.51	1.50	35.88	97.71
	20– 25	7.50	2.92	47.94	1.20	38.56	98.12
	25– 30	11.78	2.74	46.05	1.05	37.00	98.62
	30– 35	5.90	1.78	50.24	0.94	40.12	98.98
	35– 40	10.94	3.16	46.56	1.05	37.24	98.95
	40– 45	5.30	1.76	50.51	1.11	40.60	99.28
	45– 50	7.64	2.02	48.58	1.35	39.24	98.83
	50– 55	5.14	1.30	51.21	1.10	40.98	99.73
	55– 60	6.16	1.72	49.53	1.41	39.82	98.64
	60– 65	7.00	3.74	47.83	1.37	38.28	98.72
	65– 70	6.58	2.78	49.02	1.18	39.26	98.82
(Quarry floor at 74 feet)	70– 75	3.56	1.98	50.63	1.19	40.50	97.86
(Base of Middle Black River at 78.0 feet)	75– 80	8.60	4.54	45.53	1.63	37.60	97.99
LOWER BLACK RIVER	80– 85	18.78	6.10	36.25	4.12	33.46	94.59
	85– 90	15.72	5.62	39.23	3.26	34.82	98.65
	90– 95	9.84	4.92	44.34	2.12	37.62	98.84
	95–100	20.62	7.40	34.30	4.35	32.08	98.75
	100–105	15.24	6.10	37.32	4.52	33.80	96.98
	105–110	4.82	3.02	49.08	1.59	39.90	98.41
	110–115	5.68	3.34	47.41	2.39	39.76	98.58
	115–120	5.78	3.12	47.34	2.53	39.88	98.65
	120–125	12.44	4.67	39.60	3.84	37.52	98.16
	125–130	10.05	4.58	42.77	3.76	37.00	98.16
	130–135	15.84	6.90	37.11	3.81	34.23	97.99
	135–140	10.24	5.10	41.53	3.42	37.79	98.08
	140–145	12.06	5.48	42.68	3.64	34.04	97.90
(Base of Lower Black River at 150 feet)	145–150	8.42	3.48	44.88	3.36	37.61	97.75
BASAL CLASTIC BEDS	150–155	37.62	8.70	19.89	7.49	22.72	96.42
	155–160	21.34	10.58	26.31	8.84	29.17	96.24
	160–165	11.42	6.48	40.48	3.43	24.13	95.94
	165–170	14.26	5.00	41.18	1.35	34.53	96.32
	170–175	27.26	9.26	30.09	2.90	25.10	94.61
	175–180	31.42	11.34	20.86	6.80	23.16	93.38
	180–185	43.00	17.48	15.58	2.33	14.94	93.33
	185–190	8.16	4.12	44.88	2.62	35.29	95.07
	190–195	19.04	6.06	38.34	1.92	31.45	97.01
	195–200	43.58	14.14	18.90	4.13	16.76	95.51
	End of hole						

DIBBLEE CONSTRUCTION COMPANY LIMITED, (McCARTHY ROAD QUARRY), OTTAWA

The McCarthy Road quarry operated by Dibblee Construction Company Limited is located in lots 3 and 4, concession III, Gloucester township, Carleton county, on McCarthy Road, 1 mile south of Walkley Road.

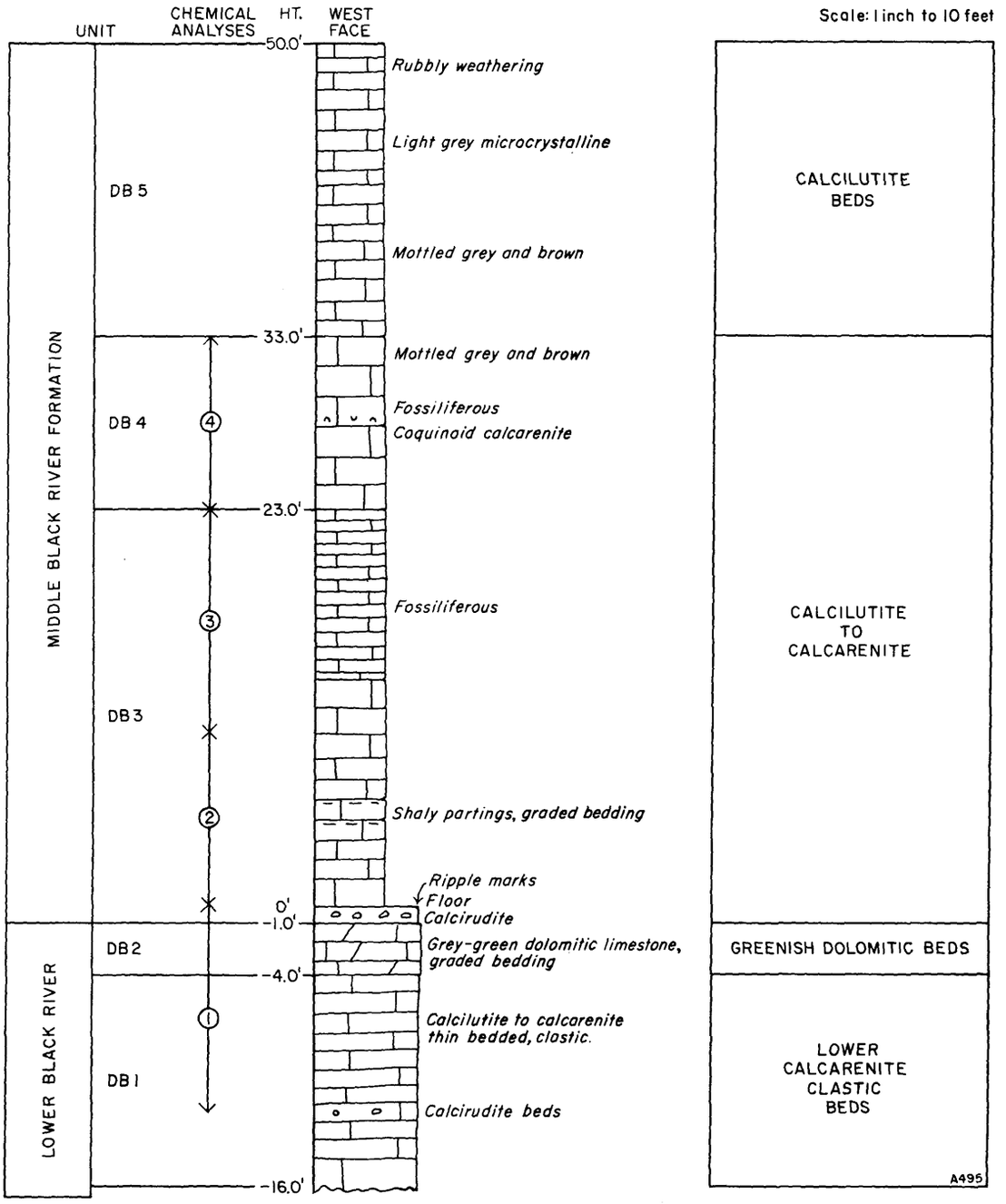
Geology

The 50-foot quarry face consists of medium-grey, medium-crystalline to microcrystalline, medium- to thick-bedded limestone of the Middle Black River formation. The quarry has been worked in two lifts, and a third 20-foot lift was being opened in the quarry floor in May, 1958. This lower lift below the present quarry floor exposed 1 foot of clastic Middle Black River limestone with pebbles in it, and 15 feet of Lower Black River beds. The top of the Lower Black River is marked by a 3-foot section of shaly, silty, greenish buff weathering, dolomitic limestone. The section is illustrated and described in (67).

Chemical analyses of composite chip samples from a part of the quarry face are given in (68); stratigraphic location of the samples is indicated in (67).

Analyses indicate a marked chemical unconformity between the Lower and Middle Black River beds.

(67) QUARRY SECTION—DIBBLEE CONSTRUCTION COMPANY LIMITED
(McCARTHY ROAD QUARRY)



A 30-foot face of medium-bedded Middle Black River limestone is quarried at the McCarthy Road quarry of Dibblee Construction Company. An Air-Trac drill operates on the quarry floor, drilling a lower lift.

(67) QUARRY SECTION—DIBBLEE CONSTRUCTION COMPANY LIMITED (McCARTHY ROAD QUARRY)

UNIT	DESCRIPTION	THICKNESS Feet
DB5	Limestone: calcilutite; medium grey, light grey weathering; microcrystalline to aphanitic, sometimes cryptocrystalline; medium bedded; fossiliferous, in part coquinoid, abundant *Tetradium*; in part mottled grey and brown	17.0
DB4	Limestone: calcilutite to coquinoid calcarenite; brownish grey, light to medium grey weathering; medium crystalline to microcrystalline; thick bedded; fossil debris; upper 4 feet mottled grey and brown; irregular shaly partings	10.0
DB3	Limestone: calcilutite to calcarenite; dark brownish grey, light grey weathering; fine crystalline to cryptocrystalline; medium to thin bedded; fossiliferous; irregular shaly partings; graded bedding. Lowest 1-foot bed, calcirudite with calcilutite fragments in fine crystalline calcarenite matrix. Green shaly partings	24.0
DB2	Dolomitic Limestone: shaly, silty; greenish grey, greenish to buff weathering; aphanitic to fine crystalline; medium bedded; graded bedding	3.0
DB1	Limestone in part dolomitic; calcilutite to calcarenite; dark brownish grey, light grey weathering; fine crystalline to microcrystalline; thin to medium bedded; shaly partings; graded bedding; some intraformational calcirudite conglomerate	12.0
	Total	66.0

(68) CHEMICAL ANALYSES—DIBBLEE CONSTRUCTION COMPANY LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Footage Above Quarry Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	—12– 0	15.20	4.35	1.49	3.40	38.90	34.65	0.10	98.09
2	0–10	6.80	2.80	1.30	1.25	46.57	38.70	0.52	97.94
3	10–23	4.78	2.07	0.85	1.01	49.80	40.26	0.20	98.97
4	23–33	8.22	1.70	0.56	1.14	47.80	38.62	0.06	98.10

Quarry Operation

The quarry, which does not operate in the winter months, is worked in 20-foot lifts. Holes 2½-inch diameter are drilled by a Gardner Denver Air Trac drill on a 6- by 8-foot or 7- by 7-foot pattern. Air is supplied by a Jaeger 600-cubic-foot-per-minute compressor. Stone is loaded on three 5-ton dump trucks by a Northwest, model No. 6, 1½-cubic-yard shovel for haulage to the primary crusher.

The crushing plant consists of a 36-inch, Lippmann, jaw-crusher followed by two Symons cone-crushers, a 3-foot and a 4-foot, in parallel. Screening is done by two Symons vibrating screens, of 3- by 14-foot and 4- by 14-foot size. The stone is stockpiled by three 5-ton trucks. The main sizes produced are 1½-inch crusher run, 1¼-inch crusher run, ⅝-inch (coarse peastone), ⅜-inch (fine peastone), and dust. Haulage is by truck, and the plant production is used wholly by Dibblee Construction Company Limited. The capacity of the plant is about 200 tons per hour; this large capacity is achieved owing to the large amount of crusher run produced at this quarry. An asphalt plant on the property uses the peastone.

D. GRANDMAITRE LIMITED, EASTVIEW

The Grandmaitre quarry is located on the south side of highway No. 17 in Eastview, in the eastern suburbs of the city of Ottawa.

Geology

The 40-foot quarry face is composed entirely of light-grey to bluish-grey, medium-crystalline, thick- to massive-bedded, cross-laminated, clastic limestone of high purity. This distinctive, medium-crystalline, calcarenite unit is an easily recognizable marker unit in the Trenton–Black River sequence in the Ottawa area, since it stands out in colour and texture from the finer-grained, brownish-grey, more shaly limestone beds above and below it. It comprises the Hull beds of the Lower Trenton in this area and has a maximum thickness of 60 feet at the Canada Cement quarry in Hull. The finer-grained, more shaly beds in the floor of the Grandmaitre quarry probably belong to the underlying Rockland beds of the Lower Trenton. The section is illustrated and described in (69).

Quarry Operation

This quarry produces man-size blocks for the pulp and paper mills. The stone is drilled by jack-hammers using 10-foot steel. The man-sized blocks are hand-loaded into trucks for shipment to pulp and paper mills in the vicinity of Hull, Que. The stone is of high purity except in the lower few feet where shaly interbeds begin to appear, rendering it unsuitable for paper production.

Chemical analyses of composite chip samples representative of the 40-foot quarry face are given in (70).

BERTRAND & FRÈRE CONSTRUCTION COMPANY LIMITED (L'ORIGNAL QUARRY, L'ORIGNAL)

The L'Orignal quarry of Bertrand & Frère Construction Company Limited is located on the north side of highway No. 17 in Longueuil township, Prescott county, 3 miles west of L'Orignal.

Geology

The 18-foot quarry face consists of limestone described as follows: medium-grey to dark-grey or black; medium-crystalline to aphanitic; medium- to thin-bedded; shaly partings; fossiliferous; rare black chert. These beds are tentatively assigned to the Upper Black River.

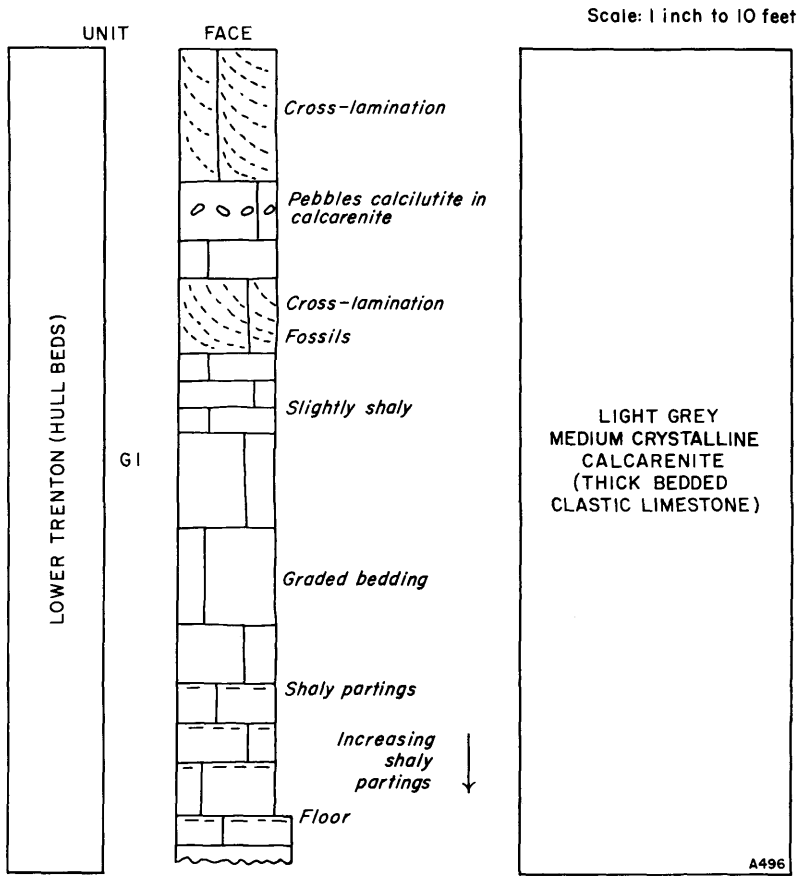
Quarry Operation

Overburden is shallow. Drilling is carried out by a Chicago Pneumatic drill equipped with a 2½-inch bit, drilling 20-foot holes on a 4- by 4- to 6- by 7-foot pattern. Air is supplied by a 315-cubic-foot-per-minute Le Roi Airmaster compressor. The stone is loaded on 5-ton dump trucks by a ¾-cubic-yard Unit diesel shovel. The crushing plant consists of a jaw-crusher and rolls. Sizing is done by a 4- by 8-foot, triple-deck screen. Production is seasonal and consists mainly of ⅞-inch crusher run stone used for road construction.

ONTARIO HYDRO QUARRY, CORNWALL CENTRE

In 1953 and 1954 the Hydro-Electric Power Commission of Ontario conducted a program of diamond-drilling in the Cornwall area to locate a source of aggregate for the St. Lawrence Seaway powerhouse and dam installations at Cornwall. As a result of the exploration program, a property was acquired at Cornwall Centre in lot 20, concession IV, Cornwall township, Stormont county, 6 miles northwest of Cornwall. The quarry was opened and operated under contract by C. A. Pitts General Contractors Limited. The plant went into operation at Cornwall Centre in October, 1955; the contract for over 2,000,000 tons of stone and stone-sand was completed in 1957, and the plant was closed and dismantled in 1958.

(69) QUARRY SECTION—D. GRANDMAITRE LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
G1	Limestone: calcarenite; light grey, buff and bluish grey tones; medium crystalline, rarely aphanitic; thick bedded to massive bedded, cross laminations in massive beds; thin black shaly partings more common towards base of section; more finely crystalline in lower part of section. A distinctive medium crystalline light grey calcarenite unit.....	40.0

(70) CHEMICAL ANALYSES—D. GRANDMAITRE LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Quarry Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent	percent
1.....	0–10	2.23	0.73	0.30	1.13	54.40	41.71	0.27	0.11	100.88
2.....	10–20	1.23	0.15	0.29	1.01	54.60	41.69	0.33	0.06	99.36
3.....	20–30	1.00	0.15	0.32	1.10	55.20	42.41	0.24	0.01	100.43
4.....	30–40	0.78	0.10	0.34	1.18	55.20	42.76	0.21	trace	100.57

Geology

Overburden averaged 15–25 feet thick, and was removed by scrapers and dragline. The deposit was developed to a depth of 60 feet, with two 30-foot lifts. The stone is a medium- to medium-dark grey, light-grey weathering, fine-crystalline to aphanitic, medium-bedded limestone with shaly partings. The quarry face is tentatively assigned to the Middle and Lower Black River formations. Diamond-drill hole No. 791 drilled by Ontario Hydro in lot 20, concession IV, just north of the New York Central railway line, was supplied to the author for examination and chemical analysis. Overburden was 24 feet thick. The log of this diamond-drill hole is given graphically in (72). The core was ground up and analyzed in 10-foot sections. The chemical analyses are given in (71).

As indicated in (72), the drill hole intersected 46 feet of limestone, mainly calcarenite and calcirudite, which the author tentatively assigned to the Middle Black River formation. Below this there were 58 feet of dolomitic grey limestone and dolomite, which the author assigns to the Lower Black River. The top of the Lower Black River is placed at the upper dolomite bed. As indicated in the analyses, the contact is marked by a distinct chemical unconformity. The range in lime, magnesia, silica, and alumina content in the sections here assigned to the Lower and Middle Black River formations agree with the range of composition of those formations in the Ottawa area.

(71) CHEMICAL ANALYSES—ONTARIO HYDRO DRILL HOLE NO. 791

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Depth	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent	percent
Overburden	0– 24	.....	.....	.....	.....	.....	.....	.....	.....	.....
1	24– 34	1.02	0.55	0.47	1.07	54.59	42.67	0.14	0.22	100.73
2	34– 44	4.44	1.46	0.58	1.06	51.08	41.05	.....	0.20	99.87
3	44– 54	8.86	2.86	0.70	1.48	46.20	39.21	.....	0.17	99.48
4	54– 64	5.24	1.90	0.58	1.17	50.59	40.08	.....	0.15	99.71
5	64– 74	12.94	2.96	1.20	3.55	39.82	35.12	.....	0.60	96.19
6	74– 84	12.90	3.60	1.00	2.15	42.02	34.23	.....	0.17	96.07
7	84– 94	9.40	2.16	1.00	2.41	44.88	37.07	.....	0.32	97.24
8	94–104	5.24	2.23	0.85	3.76	46.35	41.18	.....	0.14	99.75
9	104–115	13.92	4.60	1.06	5.61	36.97	35.45	.....	0.19	97.80
10	115–128	10.48	2.47	0.85	7.19	41.05	36.48	.....	0.25	98.77

DURHAM WELLS QUARRY, WILLIAMSBURG TOWNSHIP, DUNDAS COUNTY

The Durham Wells quarry, owned by the Ontario Department of Highways, is located in lot 4, concession IV, Williamsburg township, Dundas county, about 10 miles northeast of Morrisburg. The quarry was operated in 1958 by Dibblee Construction Company Limited.

Geology

The 35-foot quarry face consists of dark-grey to medium-grey, microcrystalline to aphanitic, medium- to thick-bedded dolomitic limestone with shaly partings. The section is illustrated in (73). Alice E. Wilson's map of the Ottawa-Cornwall area,[1] indicated the area to be within the Leray beds of the Ottawa formation (Upper Black River).

Chemical analyses of composite chip samples taken up the quarry face are given in (74).

Quarry Operation

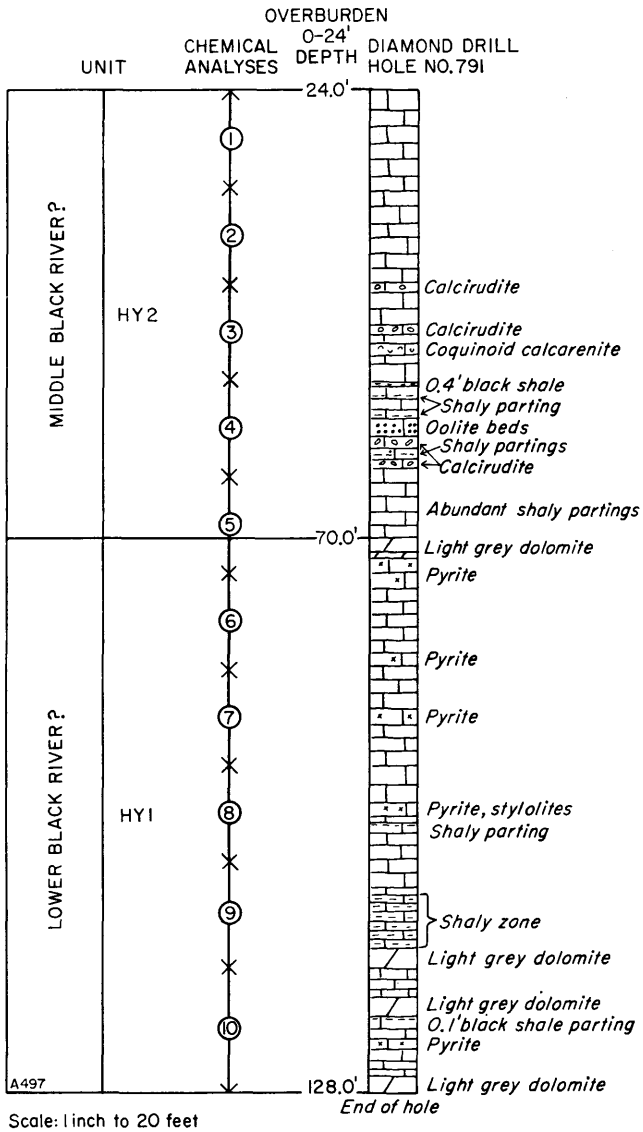
The 35-foot quarry face is operated in two lifts. A Gardner Denver Air Trac drill bores 2½-inch by 20-foot holes. The stone is loaded by a P & H 1½-cubic-yard shovel. Haulage is by 5-ton Mack dump trucks. The primary crusher is a 24- by 30-inch jaw-crusher. The stone is conveyed to a 4- by 8-foot, 3-inch scalping screen. The oversize goes to a 4-foot Symons cone-crusher. The crusher products are sized by a double-deck vibrating screen. Recrushing of the oversize material is done by a 3-foot Symons cone-crusher.

The entire quarry production is used for road construction and is mainly 1-inch crusher run.

[1]Map No. 852A, Geol. Surv. Can., 1946.

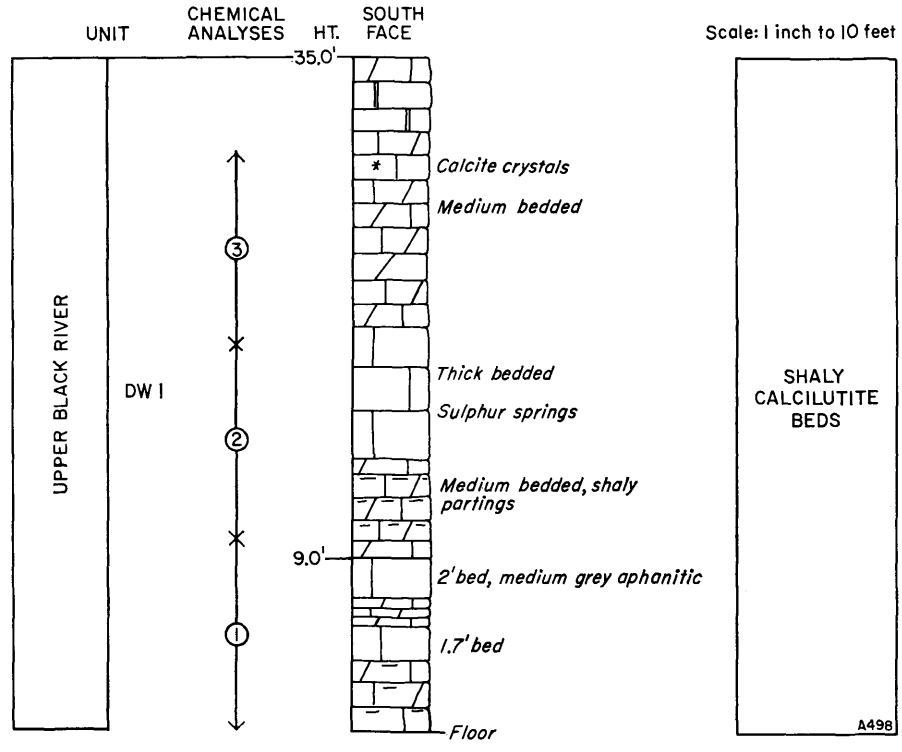
(72)

DRILL HOLE—ONTARIO HYDRO QUARRY



UNIT	DESCRIPTION	THICKNESS Feet
HY2	Limestone: calcarenite to calcirudite; medium grey; fine crystalline, rarely microcrystalline; medium bedded; abundant black shale partings; fossiliferous, stylolitic	46.0
HY1	Dolomitic Limestone and Dolomite. Dolomite: light grey; aphanitic to fine crystalline; medium bedded; beds at 70–72.5 feet, 113–15, 118–20, and 126–28 feet. Dolomitic Limestone: calcilutite to calcarenite; medium dark grey to dark grey; aphanitic to fine crystalline, sometimes microcrystalline; shaly; thin black shale partings; laminated; thin to medium bedded; pyrite, stylolites	58.0

(73) QUARRY SECTION—DURHAM WELLS QUARRY



UNIT	DESCRIPTION	THICKNESS Feet
DW1	Dolomitic Limestone: dark grey to medium grey; microcrystalline to aphanitic; medium to thick bedded; shaly partings; calcite crystals; springs and sulphur water.....	35.0

(74) CHEMICAL ANALYSES—DURHAM WELLS QUARRY

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1.....	0–10	11.42	3.39	1.42	8.31	36.20	38.20	0.16	99.10
2.....	10–20	10.75	3.25	1.05	4.79	40.40	37.60	0.06	97.90
3.....	20–30	4.40	1.64	0.94	5.78	45.20	41.55	0.07	99.58

(75) CHEMICAL ANALYSIS—BONNECHERE LIME COMPANY LIMITED

(Analysis from Goudge, p. 178)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	CaO	MgO	$CaCO_3$	$MgCO_3$	Total
	percent	percent	percent	percent	percent	percent	percent	percent	percent
1.....	2.12	0.30	0.29	0.07	52.71	1.04	94.07	2.18	99.03

BONNECHERE LIME COMPANY LIMITED

The quarry of Bonnechere Lime Company Limited is located at Fourth Chute in Grattan township, Renfrew county, 5 miles southeast of Eganville. The lime plant is located 1 mile northwest of the quarry on the river road. The lime plant and quarry were formerly operated by Shane Lime and Charcoal Company Limited.

Geology

The 12-foot quarry face consists of limestone, calcilutite to calcarenite; medium-brownish grey, grey-weathering; medium-crystalline to microcrystalline, thick-bedded, highly fossiliferous; with black bituminous partings and stylolites. The quarry section is referred to the Rockland (Lower Trenton) by Kay (1942, p. 616).

An analysis of the quarry face (then 9 feet) sampled in 1935 by Goudge (p. 178) is given in (75).

Quarry and Lime Plant

Jackhammers run by a 125-cubic-foot-per-minute Joy compressor are used to drill the quarry face. Man-sized stone is loaded by hand into 3-ton boxes for haulage to the lime plant.

The lime plant consists of three wood-fired stack kilns with a total capacity of 25–30 tons of lime per day. The lime is mainly shipped to uranium mills at Bancroft.

Summary of Chemical Characteristics

In (76) the chemical analyses of selected quarry sections and diamond-drill holes in the Black River and Trenton limestones of the Georgian Bay–Lake Ontario area are plotted as bar diagrams to show the range in composition of lime, magnesia, silica, and alumina in the plotted sections. The six sections plotted extend from Uhthoff near Lake Simcoe in the west, to Kingston in the east.

Section 1, Uhthoff, indicates the major change in magnesia and silica content between the Lower and Middle Black River formations. The Middle and Upper Black River formations in the Lake Simcoe area are characterized by their high purity, both silica and alumina being low.

Section 2, Hampshire Mills, is very similar to the Uhthoff section, but the drilling cut 30 feet of Lower Trenton beds, which here overlie the Upper Black River formation. The increase in silica content in the Lower Trenton over that in the underlying Upper Black River is noteworthy.

Section 3, at Marmoraton pit, Marmora, indicates that as these formations are traced eastward the Middle and Upper Black River formations are still low in magnesia, but the lower beds of the Middle Black River formation show a marked increase in silica and alumina, apparently due to an influx of shale in early Middle Black River times. This feature is also apparent in Section 4 at the Canada Cement Company quarry at Point Anne, near Belleville. Section 4 also indicates the higher magnesia and silica content in the Lower Black River formation.

In Section 5, taken farther to the northeast at Roblindale Quarries, Roblindale Station, although the magnesia content of the Middle and Upper Black River formations remains low, the silica and alumina content has increased appreciably over that indicated in the Lake Simcoe area.

Section 6, taken in the highway No. 401 roadcut at Montreal Road in Kingston, indicates that the Middle Black River beds in the eastern part of the area show a very marked increase in shale content as indicated by the high and variable silica and alumina content. The magnesia content is also high and irregular.

In summary, it may be pointed out that the highest purity calcium limestone in the Black River group occurs in the Middle and Upper Black River beds of the Lake Simcoe–Uhthoff area. To the east and west the shale content increases. High-purity limestone (containing less than 3 percent impurities) may be found in the Lake Simcoe area in thicknesses up to about 12 feet, but it is difficult to find a quarriable face of 40 feet thickness or more that will reach the high-purity classification.

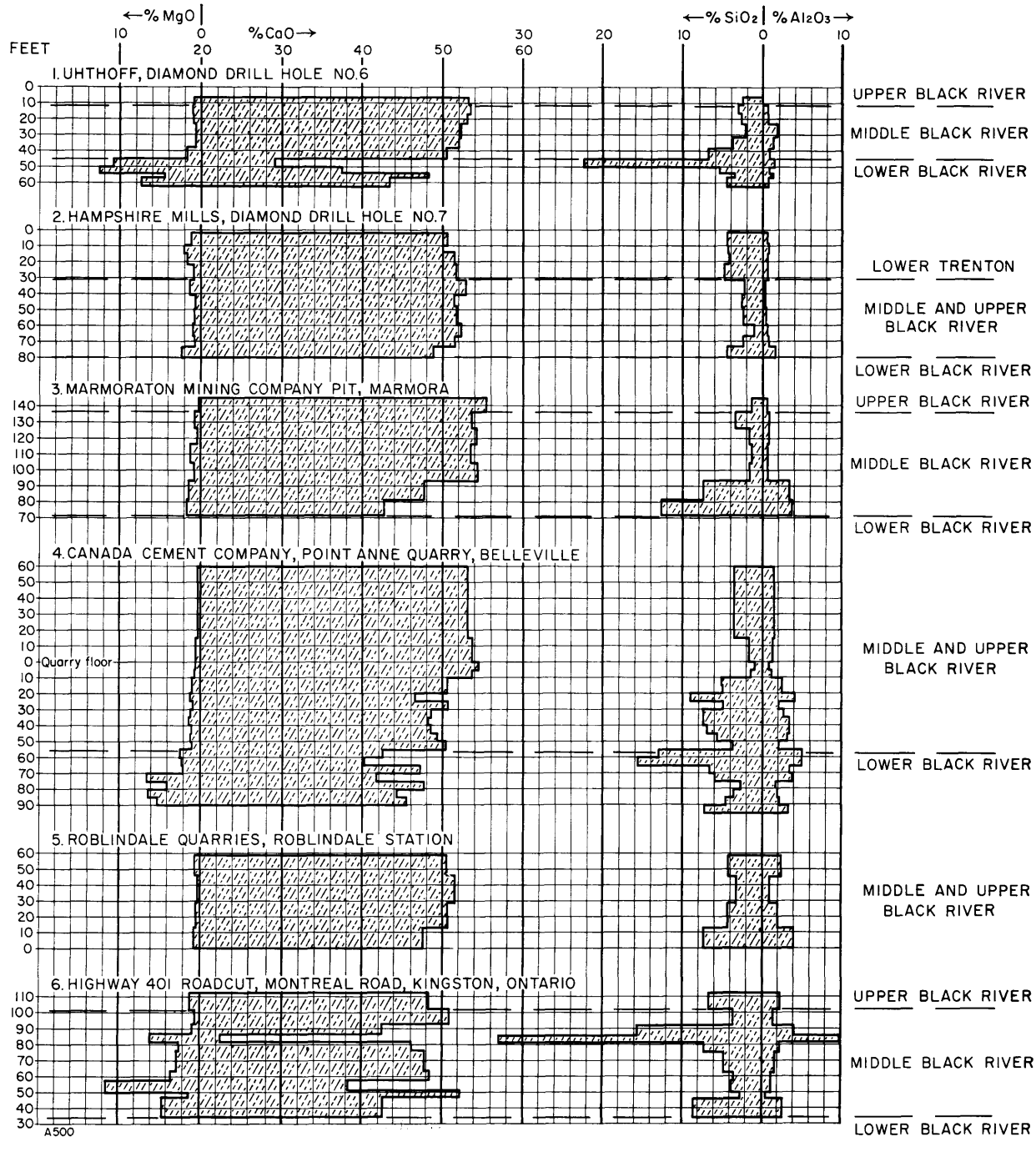
The general change in average chemical composition in the Black River limestones from west to east is also indicated in (77) giving the average chemical analyses of the Black River and Trenton limestone of the Georgian Bay–Lake Ontario area and Ottawa area.

This table also indicates the average chemical characteristics of the Trenton limestones. It can be noted that these limestones in the Lake Ontario area are, in general, somewhat higher in silica and alumina than the Black River limestones owing to the increase in shaly interbeds. These analyses also bring out the distinct difference between the Upper Hallowell beds of the Upper Trenton in comparison with the beds above and below.

In the Ottawa area, the Middle and Upper Black River is much more sandy and shaly than in the Lake Ontario region, with the silica content ranging from 4.89 to 9.33 percent. No high-calcium limestone is available in the Black River of the Ottawa area, but about 40 feet of high-calcium limestone makes up the crystalline Hull beds of the Lower Trenton.

Stratigraphic thicknesses of the various formations are graphically shown in the Black River–Trenton Sections (in map case).

(76) CHEMICAL COMPOSITION OF SELECTED QUARRY SECTIONS AND DRILL HOLES OF BLACK RIVER AND TRENTON LIMESTONES—LAKE ONTARIO AREA



(77) AVERAGE CHEMICAL ANALYSES OF THE BLACK RIVER AND TRENTON LIMESTONES

Location	Stratigraphic Section	Average Analysis				
		SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
		percent	percent	percent	percent	percent
Georgian Bay–Lake Ontario Area:						
	Black River:					
	feet					
Coldwater	Upper and Middle Black River...35	1.56	0.38	0.54	54.32	0.51
Uhthoff	Upper and Middle Black River...38	2.94	0.44	2.11	52.40	1.03
Uhthoff Drill Hole No. 10	Upper and Middle Black River...51	3.25	0.12	0.58	53.40	0.29
Uhthoff Drill Hole No. 6	Upper and Middle Black River...38	3.58	0.33	0.94	52.33	0.98
Hampshire Mills	Upper and Middle Black River...40	2.48	0.56	0.53	52.39	1.14
Longford	Upper and Middle Black River...26	1.72	0.56	0.77	53.49	0.40
Coboconk	Upper and Middle Black River...29	1.25	0.30	0.55	54.16	0.34
Marmoraton (lower 20 feet)	Middle Black River.....20	10.11	0.86	3.38	45.40	1.56
Marmoraton (upper 65 feet)	Middle and Upper Black River...65	2.08	0.43	0.56	54.22	0.75
Belleville (Point Anne)	Upper Black River.....45	3.60	0.37	0.79	53.02	0.36
Belleville (Point Anne)	Middle Black River.....55	5.48	2.26		50.26	1.08
Roblindale	Middle and Upper Black River...46	4.99	1.05	2.13	49.97	0.69
Napanee	Middle and Upper Black River...82	5.88	1.00		48.30	1.46
Kingston (highway No. 401)	Middle and Upper Black River...78	8.40	0.69	2.97	44.43	3.48
Kingston	Middle Black River.....20	9.49	0.96	3.24	40.55	6.40
	Trenton:					
Uhthoff Drill Hole No. 10	Lower Trenton.....22	7.49	0.17	1.04	49.96	0.47
Hampshire Mills	Lower Trenton.....20	4.16	0.63	0.51	50.99	1.36
Kirkfield	Lower Trenton.....40	4.21	0.47	1.69	51.46	1.17
Lakefield	Middle Trenton.....50	12.41	4.79		45.15	1.74
Ogden Point	Upper Trenton (Hillier).....60–90	12.85	1.45	3.99	42.94	1.83
Ogden Point	Upper Trenton (Upper Hallowell)40	7.66	1.15	2.25	47.33	1.55
Ogden Point	Middle Trenton, including the Lower Hallowell (Cobourg) and Upper Sherman Fall..10–80	13.09	1.95	4.33	43.07	1.57
Brighton	Upper Trenton (Hillier).....30–60	12.62	1.78	3.23	43.03	1.90
Brighton	Upper Trenton (Upper Hallowell) 40	7.39	1.71	1.77	47.46	1.80
Brighton	Middle Trenton, including the Lower Hallowell (Cobourg) and Upper Sherman Fall..30–50	13.37	2.28	3.82	42.42	1.82
Picton	Upper Trenton (Upper Hallowell) 30	7.67	1.97	1.46	48.20	1.46
Milltown	Lower Trenton.....17	7.00	2.49	0.57	45.00	5.33
Ottawa Area:						
	Trenton:					
Ottawa (Frazer Duntile quarry)	Middle and Upper Black River...60	9.33	0.93	2.62	45.93	1.40
Ottawa (Ottawa Valley Crushed Stone quarry)	Middle and Upper Black River...75	7.07	2.69		48.52	1.23
Ottawa (Ottawa Valley Crushed Stone quarry)	Lower Black River.....70	11.82	4.99		41.70	3.34
Ottawa (Dibblee Construction quarry)	Middle Black River.....33	6.60	0.90	2.19	48.06	1.13
Ottawa (Grandmaitre quarry)	Lower Trenton (Hull).....40	1.31	0.31	0.28	54.85	1.10
Cornwall	Middle Black River.....40	4.89	0.58	1.69	50.59	1.19
Cornwall	Lower Black River.....64	10.81	0.99	3.00	41.85	4.11
Morrisburg	Middle and Upper Black River...30	8.86	1.13	2.76	40.60	6.29

4. GUELPH-LOCKPORT DOLOMITE

The Guelph-Lockport (Albemarle) dolomite belongs to the Niagaran series of Middle Silurian age.

The lower part of the dolomite forms the Niagara escarpment extending from Niagara Falls through Hamilton, north through Georgetown and Orangeville to the Bruce Peninsula. The formation dips southwest and forms a wide band extending back from the escarpment for several miles. From Niagara Falls to Hamilton the dolomite outcrops in a band 8–10 miles wide, south of the escarpment. From Hamilton northwest to the Bruce Peninsula the Guelph-Lockport dolomite (in this area called the Guelph-Amabel dolomite) is exposed in a belt 20–25 miles wide extending west from the escarpment.

The Guelph-Lockport has a total thickness of 170–250 feet in the outcrop area but thickens considerably in subsurface to the southwest.

The outcrop area of the Guelph-Lockport dolomite is shown on the following geological maps published by the Geological Survey of Canada:

Map No. 584A, Toronto-Hamilton Area; (accompanies Memoir No. 224, 1941).

Map No. 624A, Waterloo Sheet; (accompanies Memoir No. 226, 1941).

Preliminary maps accompanying Paper 45-18, Owen Sound Area.

The Guelph-Lockport dolomite has recently been restudied by T. E. Bolton,[1] whose memoir gives the latest revised stratigraphy and many excellent descriptions of sections along the escarpment. The stratigraphic nomenclature used here follows that of Bolton and is given in (78).

[1]See References, p. ix.

The reference sections and quarry sections in the Lockport and Amabel formations examined by the author, along or near, the Niagara escarpment are graphically illustrated in Lockport-Amabel Sections (in map case).

Lockport Formation

From Niagara Falls to Dundas and Clappisons Cut the Lockport dolomite formation is divided into three members as indicated in (78): the Gasport member, the Goat Island member, and the Eramosa member.

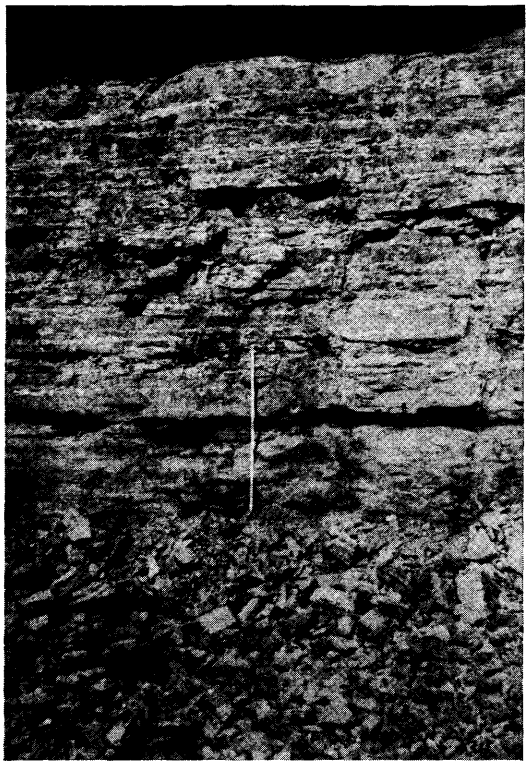
GASPORT MEMBER

The Gasport, the lowest member of the Lockport formation, is a medium-crystalline, crinoidal, dolomitic limestone or dolomite, generally massive to thick-bedded, bluish-grey to light-buff in colour. It varies in thickness, as indicated in the sections (map case), from 4.4 feet at Stoney Creek to 33 feet at Queenston Quarries. This member is quarried for building stone at Queenston Quarries and Niagara Cut Stone. The Gasport member rests unconformably on the Decew dolomite or, where this formation has been removed by erosion, directly on the Rochester shale. The unconformable contact between the Gasport and the underlying Decew dolomite is well shown at Walker Brothers quarry near Thorold, where the rolling surface of the Decew dolomite shows at least 20 feet of relief. Goudge (p. 278) describes these mounds of Decew dolomite as "reef-like masses extending upwards into the Gasport." It is most likely that the irregu-

(78) STRATIGRAPHIC NOMENCLATURE—GUELPH–LOCKPORT DOLOMITE

(After T. E. Bolton)

	NIAGARA FALLS–DUNDAS AREA		WATERDOWN–GEORGETOWN–BRUCE PENINSULA	
	Formations	Members	Formations	Members
Albemarle Group	Guelph Dolomite		Guelph Dolomite	
	Lockport Dolomite	Eramosa Goat Is. (Ancaster Chert Beds) Gasport	Amabel Dolomite	Eramosa Wiarton Colpoy Bay Lions Head



The Ancaster chert beds of the Goat Island member of Lockport Dolomite are well exposed in the roadcut on highway No. 20 at Stoney Creek.

lar character of the contact is due entirely to erosional unconformity. The Gasport greyish crinoidal member grades upward into brownish to light-buff, fine-crystalline to aphanitic dolomite of the Goat Island member. There is a change of lithology and colour.

GOAT ISLAND MEMBER

The Goat Island member is an aphanitic to fine-crystalline, light-buff to light-brownish grey, massive to thick-bedded dolomite. In places bluish-grey and white chert are abundant, and the chert-bearing facies has been distinguished as the "Ancaster chert beds." The chert beds generally occur at the base of the Goat Island member and are most common in the Ancaster–Stoney Creek area; they may be seen at the King City Sand and Crushed Stone quarry, at the Sydenham roadcut (Dundas), at the base of the section of Canada Crushed and Cut Stone (Dundas quarry), at the Ancaster roadcut, at the Wentworth Street roadcut in Hamilton, at the highway No. 20 cut at Stoney Creek, at the base of the section at Armstrong Brothers Vinemount quarry, and at Decew Falls. The Goat Island member at Queenston Quarries, Walker Brothers quarry, St. Catharines Crushed Stone, and Vineland Quarries shows no chert. The thickest section of Goat Island dolomite measured was that at St. Catharines Crushed Stone where the member is 32 feet thick, but it may be considerably thicker in other places. Bolton (p. 50) suggests a variable thickness for the Goat Island up to 60–80 feet. The upper limit of the Goat Island is arbitrarily drawn at the first appearance of the dark-brown to black bituminous material characteristic of the dark-brown sugary Eramosa member.

ERAMOSA MEMBER

The Eramosa member is a dark-brown to medium-brownish grey, aphanitic to sugary, medium- to thin-bedded, dark-grey streaked dolomite with bituminous or shaly partings. The typical Eramosa is exposed in the 50-foot quarry face at the Dundas quarry of Canada Crushed and Cut Stone Limited. It is also exposed at Vinemount Quarries and the A. Cope and Son quarry, Stoney Creek. In these latter quarries the Vinemount shale beds of the Eramosa member are exposed near the base of the Eramosa and have a maximum thickness of 17 feet. This shaly unit has poor soundness and is unsatisfactory for concrete aggregate. The lateral extent of this shaly unit is unknown, but it was observed from Dundas to Vinemount, and its thickness and extent is of interest to operators planning commercial aggregate quarries in the area.

The Eramosa member extends throughout the Niagara Peninsula and northward to the Bruce

Peninsula and apparently attains its maximum thickness at Dundas where 58 feet are exposed in the old quarry of Canada Crushed Stone. It is overlain by the light-buff dolomite of the Guelph formation.

Amabel Formation

Throughout the Niagara Peninsula and as far as Clappisons Cut, the Lockport formation is divided into three members; Gasport, Goat Island, and Eramosa. However, in the Clappisons Cut–Waterdown area there is a noteworthy facies change, and this stratigraphic unit is replaced by a reefy, medium-crystalline, light-buff dolomite, which extends from Waterdown through Georgetown to the Bruce Peninsula. This facies,[1] which is the lateral equivalent of the Lockport, is named the Amabel formation by Bolton. The Lockport therefore changes its name and lithology in the Waterdown area to the Amabel formation.

As indicated in the Sections (in map case) the quarry sections from Waterdown to Georgetown are all in the reefy Amabel formation. In this area the formation is not divisible into members but consists of a light-grey to buff, buff-weathering, medium- to coarse-crystalline, massive to irregularly-bedded and reefy, fossiliferous dolomite. The maximum thickness exposed is 84 feet at the Milton quarry of Gypsum Lime and Alabastine Company. All the quarry faces are composed of Amabel dolomite at Nelson Crushed Stone, Lowville Quarries, Milton Quarries, Halton Quarries, and the quarries in the Georgetown area.

In the Bruce Peninsula, Bolton (pp. 51–57) divided the Amabel formation into four members; Lions Head, Colpoy Bay, Wiarton, and Eramosa; but in the Waterdown-Georgetown area, where most of the commercial quarries utilizing Amabel dolomite are located, the formation is not divided into members but is remarkably uniform, except for reefy zones. No chert is present.

As described earlier, the lower member of the Lockport formation rested on the underlying Decew dolomite or Rochester shale of the Clinton group as indicated in the Sections (in map case). Below the Rochester shale there are the Irondequoit limestone and the Reynales dolomite. These may be seen in the highway No. 20 section at Stoney Creek, at Wentworth Street (Hamilton), at Ancaster, at Sydenham Road (Dundas), at the King City quarry (Clappisons Cut), and at the old Nelson quarry east of Waterdown. However there is a lateral change in the formations of the Clinton group as they pass to the north, and the Rochester shale and Irondequoit limestone pinch out in the vicinity of Waterdown. The last vestiges of the Rochester shale are seen in the old Nelson quarry east of Waterdown as a thin, grey, shaly zone, 1–2 feet thick, with white gypsum spots. At the Nelson Crushed Stone quarry north of highway No. 5, the Amabel formation rests directly on the Reynales dolomite.

The Reynales dolomite is a medium-grey to grey, mottled to streaky, buff-weathering, aphanitic, medium-bedded dolomite easily distinguished in colour and texture from the overlying medium-crystalline Amabel dolomite. The Reynales dolomite is 6–8 feet thick and rests on Thorold sandstone and shale; it is an easily distinguished marker bed marking the base of the quarriable dolomite of the Niagara escarpment from Nelson to Georgetown. It forms the quarry floor at quarries of: Nelson Crushed Stone Limited, Milton Quarries Limited, Gypsum Lime & Alabastine Limited (Milton quarry), Armstrong Brothers Company Limited (Georgetown quarry), and Industrial Sand and Gravel (Georgetown). Below this horizon are the shales and sandstones of the Clinton group.

Guelph Formation

The Guelph formation, which overlies the Lockport and Amabel formations, consists of light-creamy buff, light-buff weathering, aphanitic to fine- or medium-crystalline, porous dolomite, generally thick-bedded. The lower contact with the underlying Eramosa is marked by the change to medium- to dark-brown, bituminous dolomite with dark-grey, shaly streaks.

The Guelph formation is also characterized by reefy facies. These consist of medium- to coarsely crystalline, irregularly bedded or massive areas of highly fossiliferous, porous dolomite standing out as mounds within the surrounding bedded dolomite.[2]

The contact of the Guelph formation and the underlying Eramosa member of the Lockport or Amabel formations is seen at Canada Crushed Stone quarry (Dundas) where 7 feet of Guelph overlies 43 feet of Eramosa along the north quarry face.

The Guelph formation is quarried at Glen Christie by Gypsum Lime and Alabastine and at Guelph by Canadian Gypsum Company for the production of dolomitic lime. The contact with the underlying Eramosa is exposed at Guelph.

The Guelph is overlain by the gypsum-bearing shales of the Salina formation.

[1] See discussion of reefs, p. 172.

[2] See discussion of reefs, p. 172.

Quarries and Geological Sections

QUEENSTON QUARRIES LIMITED, QUEENSTON

The quarry of Queenston Quarries Limited is located on the brow of the Niagara escarpment, 2 miles west of Queenston, in lots 47–49, concession X, Niagara township, Lincoln county. It is the principal building-stone quarry in Ontario, producing a stone well-known in the trade as Queenston Limestone. The quarry is also a large producer of crushed stone, and a new aggregate plant commenced operation in April, 1959. The company is a subsidiary of Canada Crushed and Cut Stone Limited, Hamilton. Much of the dimension stone is marketed by other subsidiaries, Ritchie Cut Stone Company Limited and National Cut Stone Limited. Transportation is by truck or railway (C.N.R.).

Geology

The quarry section exposed is illustrated in (79). The 38-foot quarry face consists of 33 feet of light-grey to buff, Gasport crinoidal calcitic dolomite overlain by 5 feet of brownish, aphanitic, Goat Island dolomite. Both of these units are members of the Lockport dolomite formation. The upper Goat Island dolomite is distinguished from the underlying Gasport member by a change in colour and lithology. The lower 14.5 feet of the 33-foot section of Gasport is the building-stone ledge from which mill blocks of Queenston Limestone are quarried. The stone overlying this ledge is quarried for crushed stone. Within the massive-bedded building-stone ledge, bedding partings are not regular over the whole quarry and they govern the quarrying practice. At the present east face there is a 4.5-foot bed underlain by a 10-foot bed.

Underlying the Gasport member there is 6 feet of dark-grey, aphanitic, buff-weathering, Decew dolomite, the upper 8 inches of which is conglomerate. This unit is underlain by Rochester shale.

Chemical analyses of diamond-drill hole No. 11E, located near the east quarry face, are given in (80).

Quarry Operation

The building-stone ledge, 10–16 feet thick, is overlain by 10–24 feet of dolomite, which must be stripped off and is used for crushed stone. Since the building-stone ledge is worked only from April to September owing to moisture in the stone, the stripping of the overlying aggregate stone allows quarry operation all year round.

CRUSHED STONE OPERATION

There is 5–12 feet of clay overburden, which is stripped by a Dominion 450, 1½-cubic-yard backhoe. Haulage on stripping is by contract. Where no building-stone ledge is present, the 30- to 40-foot face is drilled on a 10- by 12-foot pattern by a Joy Challenger 500 drill boring 4-inch holes. The blasting agents are 50-percent Dynamex and prilled ammonium nitrate, detonated with short-period caps. Secondary breaking is done by a 3-ton drop ball on a 1-cubic-yard Osgoode shovel with a 40-foot boom.

Where the stone must be stripped from the building-stone ledge, drilling is carried out by three Joy L-57 wagon drills boring 2½-inch holes on a 5- by 5½-foot pattern. Holes are drilled to about 1 foot above the building-stone layer to protect the stone. If the blast does not break to the building-stone layer, black powder is used to trim to the top of the building-stone layer.

HAULAGE AND PRIMARY CRUSHING

Stone is loaded by a Dominion 480, 1½-cubic-yard, shovel into four 12-ton Mack rear-dump trucks for haulage to the primary crusher located on the quarry floor. A 4- by 14-foot, Steven Adamson feeder precedes the Allis-Chalmers, 32- by 42-inch, jaw-crusher set at 5 inches. A 30-inch conveyor carries the stone to a 1,200-ton live surge pile. A second 30-inch conveyor, in a reclaiming tunnel under the surge pile, is fed by a Syntron vibrating feeder and carries the stone to the secondary-crusher building.

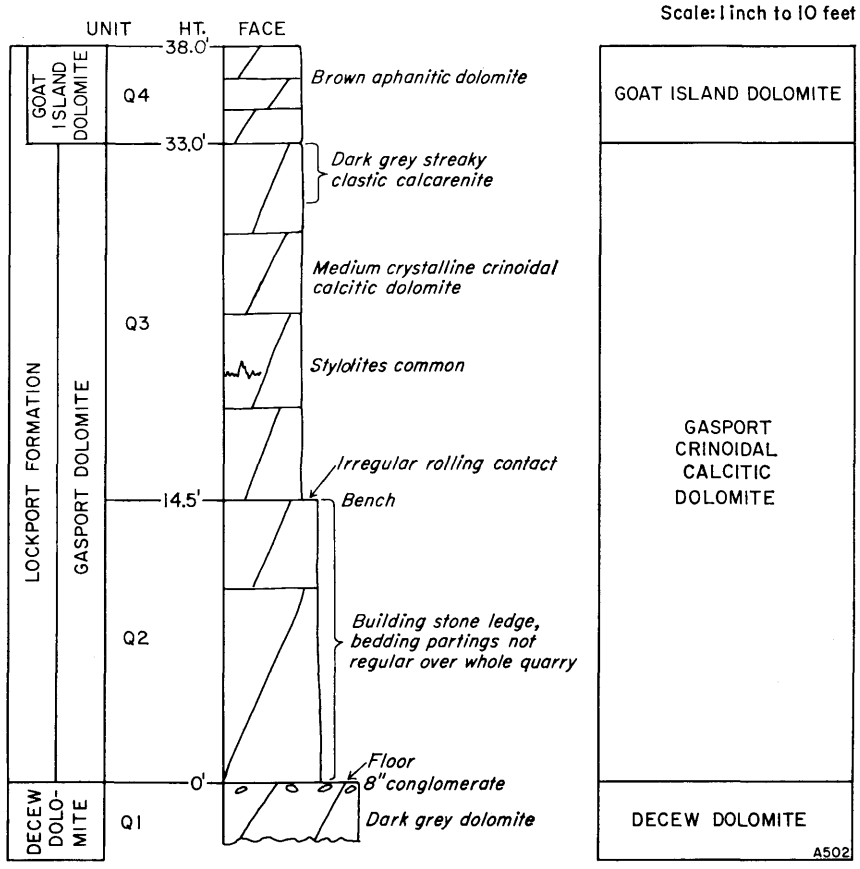
SECONDARY-CRUSHER BUILDING

At the secondary-crusher building the stone discharges on an F-600 Tyler, triple-deck, 4- by 10-foot screen. The top deck, with 8- by 8-inch square openings, produces one-man rubble stone; the middle deck, with 2½-inch square openings, produces plus 2½-inch stone. If these sizes are not required, the products go to a 4¼-foot Symons standard cone, whose product goes to No. 3 conveyor to be transferred to the screen house. The bottom deck, with 1¾-inch openings, produces 2½- by 1¾-inch stone, which goes to the screen house on No. 3 conveyor. The minus 1¾-inch throughs are crusher run or may go to the screen house via No. 3 conveyor for further sizing.

SCREENING

No. 3 conveyor discharges the stone at the screenhouse on two 5- by 10-foot F600 Tyler double-deck screens in parallel. These screens have 1¼-inch and ⅝-inch openings. The plus 1¼-inch

(79) QUARRY SECTION—QUEENSTON QUARRIES LIMITED

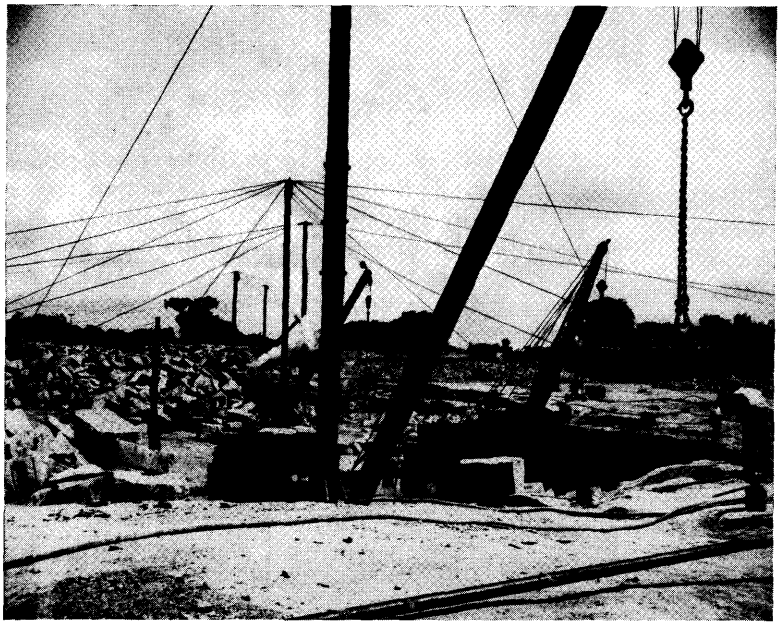


UNIT	DESCRIPTION	THICKNESS Feet
GOAT ISLAND DOLOMITE		
Q4	Dolomite: medium brown, buff weathering; aphanitic; medium bedded; lower contact marked by change in colour, buff to grey; texture, aphanitic to medium crystalline	5.0+
GASPORT DOLOMITE		
Q3, Q2	Calcitic Dolomite: light grey to light brown, grey weathering; medium crystalline; massive bedded; in part crinoidal; stylolites; bedding surfaces not regular throughout whole quarry. Q2 is the 14.5-foot building stone ledge from which mill blocks of Queenston Limestone are produced	33.0
DECEW DOLOMITE		
Q1	Dolomite: medium dark grey, buff weathering; aphanitic; massive bedded; easily weathered; upper 8 inches is a conglomerate	6.0+

(80) CHEMICAL ANALYSES—QUEENSTON QUARRIES LIMITED

(Diamond-Drill Core Supplied by Queenston Quarries Limited: Chemical Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Depth Below Surface	Description	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	L. O. I.	P_2O_5	S	Total
	feet		percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
.....	0–14	Overburden	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Q1.....	14–27	Crushed stone ledge	2.08	1.07	1.21	18.24	30.64	41.60	45.18	0.05	0.19	98.66
Q2.....	27–39	Building stone ledge	1.76	0.87	1.35	8.89	42.86	41.00	44.16	0.04	0.15	100.08



Queenston Quarries Limited, Queenston, Ontario. This is the largest building-stone quarry in Ontario.

(Courtesy of Canada Crushed and Cut Stone Limited)

stone goes to two 4- by 8-foot, double-deck tandem screens with 2½-inch and 1⅞-inch square openings. The plus 2½-inch stone goes via No. 4 conveyor for recrushing to a 4-foot Symons short-head cone. The product of the cone returns to the initial tandem, 5- by 10-foot, screens for resizing or goes to market as ⅝-inch crusher run. The 2½- by 1⅞-inch stone from the 4- by 8-foot tandem screens goes to the 2-inch bin. The 1⅞- by 1¼-inch stone goes to the 1½-inch bin.

The 1¼- by ⅝-inch stone from the 5- by 10-foot screens goes to the ¾-inch bin. The minus ⅝-inch stone goes via T_1 and T_2 conveyors to two F600 Tyroc, 5- by 10-foot, screens with 5/16-inch and ⅛-inch openings. The ⅝- by 5/16-inch stone goes to the ½-inch bin, the 5/16- by ⅛-inch stone to the ¼-inch bin, and the minus ⅛-inch stone goes to the screenings bin.

There is provision for blending of stone to customers' requirements. The 2-inch, 1½-inch, and ¾-inch stone from the bins can be discharged to No. 4 conveyor for recrushing if desired. The plant capacity is about 250 tons per hour.

DIMENSION STONE OPERATION

The building stone occurs in a ledge 10–16 feet thick, with beds 2–7 feet thick. When a sufficient area has been stripped of the overlying rock, the beds are examined for vertical joints, which may occur 10–50 feet apart. The Knox quarrying method using drilling and blasting is employed, and the method requires three free faces. The free quarry face is established at right angles to the jointing by removal of a key block. The block to be quarried is then bounded by the free quarry face on one side and by two joints at either end, or by a joint and an open end where the adjacent block has been removed. Quarry blocks are split off by making a back-wall cut parallel to the free quarry face at a distance of 10–12 feet from the face. A series of 1½-inch holes are drilled, 12–14 feet deep, on 2-foot centres in a line parallel to the quarry face, at the required distance from the face. Jackhammers or Joy wagon drills are used for drilling. The line of holes may be 10–50 feet long depending on the joint spacing.

In the Knox system the drill holes are reamed by a Knox bit, which grooves the hole on each side in the direction along which the break is to be made. The holes are loaded lightly with black powder and fired with instantaneous caps. An air space is left in each hole between the charge and the tamping. This air space is essential to the Knox method and results in the force of the explosion being exerted on a relatively wide surface. Where there is horizontal bedding in the block to be quarried, a charge is placed for each bed.

The quarry block is separated from the solid ledge by the blast and is then drilled and split by plug and feather into random mill blocks 4–20 tons in size. Horizontal holes may be drilled to lift beds where necessary.

The quarry blocks are handled in the quarry by six 20-ton derricks, four electric and two steam. Five of the derricks are on production, while one is used for stockpiling. Mill blocks may be loaded directly on railway flatcars or hauled to the mill building by a Mack truck with a semi-trailer 20-ton float.

STONE-CUTTING PLANT

A stone-cutting plant is operated at the quarry. A 30-ton Morris travelling crane services the mill, and a 7½-ton Provincial travelling crane serves customers from the mill yard. The mill is equipped with 8 gang-saws using silica sand as the abrasive to cut the mill blocks, a 60-inch diamond-saw, and a 36-inch diamond-saw. Guillotines are used to make split-faced ashlar.

Queenston limestone is a medium-crystalline, crinoidal stone, which weathers to a pleasing silver-grey colour. It is readily sawn, machined, and carved but is somewhat harder than the soft Indiana limestone. Queenston limestone is very durable and has a low porosity and permeability. It is the most widely used limestone building stone in Canada and may be seen in many buildings, including the East Block of the Parliament Buildings in Toronto.

WALKER BROTHERS LIMITED, THOROLD

The quarry of Walker Brothers Limited is located on the brow of the Niagara escarpment, 1 mile east of Thorold, in lots 31 and 32, concession X, Stamford township, Welland county.

Geology

The quarry section exposed is illustrated in (81). The 30- to 40-foot quarry face consists mainly of light-grey to buff, medium-crystalline, Gasport crinoidal dolomite. This is overlain by up to 10 feet of medium-brownish grey, aphanitic, streaky Goat Island dolomite. The Gasport member rests with unconformity on the underlying dark-grey, buff-weathering, aphanitic, Decew dolomite, known locally as "cement rock." This dolomite surface is irregular, and mounds of Decew dolomite 10–20 feet high extend upwards as hills in the Gasport floor. Goudge has suggested that these structures are "reef like," but they do not show the structure, texture, or faunal assemblage of the usual reefs; they are unfossiliferous and aphanitic. It seems more likely that the Decew irregularities are due to an erosional unconformity. The Decew is entirely absent a few miles west at the quarry of St. Catharines Crushed Stone and again appears a short distance to the west at Decew Falls. The Decew dolomite is underlain by dark-grey fissile Rochester shale.

Chemical analyses of the Gasport and Decew dolomite from Walker Brothers quarry, as given by Goudge (p. 287), are given in (82).

Quarry Operation

From 10 to 35 feet of clay overburden is stripped by dragline. Drilling on the 30- to 40-foot face is done by a Joy Heavyweight Champion rotary drill using a 6-inch bit. Holes are drilled on a 8- by 12-foot pattern. Blasting agents are 70-percent Dynamex and prilled ammonium nitrate. Due to the massive-bedded character of the dolomite, some secondary blasting is required. The stone is loaded by a 4½-cubic-yard Marion model IIIM electric shovel. Three 22-ton Euclid rear-dump trucks haul to the primary crusher. A 2-cubic-yard Dominion diesel shovel is on standby duty; equipped with a dragline, this unit strips the overburden.

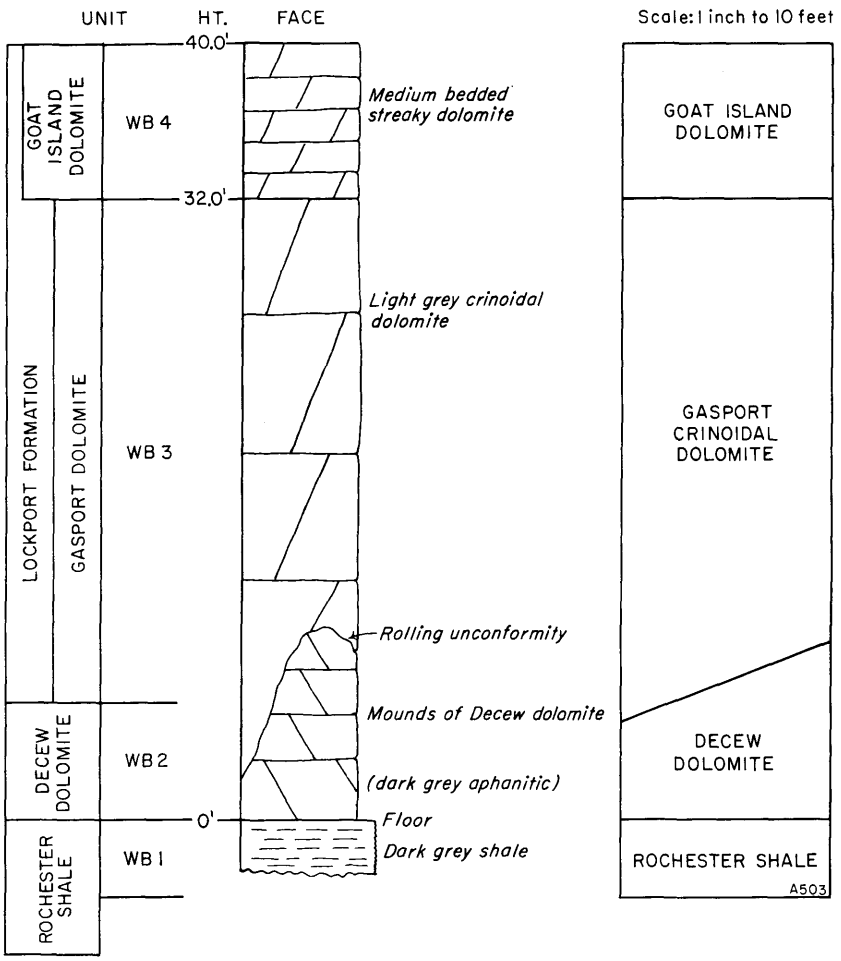
CRUSHING AND SCREENING

The primary crusher is a 48- by 60-inch Traylor jaw-crusher. An 8-inch scalping screen is used to remove man-sized rubble stone for shipment to the pulp and paper mills for use in the tower method of sulphite-pulp manufacture. The remaining stone goes via 42-inch conveyor to a live surge pile, which feeds via conveyor to the secondary crusher, a 4-foot Traylor gyratory. The product of this gyratory goes via 30-inch transfer conveyor to the screen house. Screening is done by one triple-deck, 5- by 12-foot, screen and two 5- by 12-foot, double-deck screens. The oversize is recrushed by a 4-foot Symons standard cone, whose product is returned to the screen house for resizing. The main products produced are riprap, rubble, 2-inch, 1½-inch, ¾-inch, ½-inch, ¼-inch, screenings, agricultural limestone, and ¾-inch crusher run. The 2½-, 1½-, and ¾-inch stone may be sent to the recrushing bin for recrushing if desired.

The stone is mainly used for road material and concrete aggregate, but a substantial tonnage of pulverized stone, flux stone, and pulp-and-paper mill stone is produced. The Decew and Rochester dolomite and shale are quarried for raw material for rock-wool production in Thorold.

The plant has a rated capacity of 350–400 tons per hour and averages about 3,000 tons per day when in full production on a one-shift basis. There are asphalt and ready-mix concrete plants on the quarry property. Stone from stockpiles is loaded by overhead loaders or by a ¾-cubic-yard Dominion Model 375 shovel.

(81) QUARRY SECTION—WALKER BROTHERS LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
GOAT ISLAND DOLOMITE		
WB4	Dolomite: medium brownish grey, black streaked; aphanitic; medium bedded	8.0+
GASPORT DOLOMITE		
WB3	Calcitic Dolomite: light grey to light buff; medium crystalline, crinoidal; massive irregularly bedded; calcite crystals	30.0±
DECEW DOLOMITE		
WB2	Dolomite: dark grey; aphanitic; massive bedded; occurs in mound-like hills overlain unconformably by the Gasport dolomitic limestone	0–10
ROCHESTER SHALE		
WB1	Shale: dolomitic; dark grey; aphanitic; thin bedded	3+

(82) CHEMICAL ANALYSES—WALKER BROTHERS LIMITED

(Analyses from Goudge, p. 287)

Sample No.	Position	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
		percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
330	Upper 12 feet Gasport	0.92	1.36	0.97	0.07	55.30	41.45	100.07	0.41	31.01	19.82
330A	Lower 12 feet Gasport	2.90	1.09	1.28	0.07	67.75	26.37	99.46	0.54	37.98	12.61
330B	Reef-like Decew	8.22	1.79	2.89	0.15	61.63	24.49	99.17	0.57	34.59	11.71
330C	9-foot Decew bed	19.10	1.80	5.60	0.11	43.59	28.46	98.66	0.35	24.47	13.61

Niagara Cut Stone quarry near Thorold, showing the steel derricks and quarry bars used in this building-stone operation.

NIAGARA CUT STONE LIMITED, THOROLD

The Niagara quarry of Niagara Cut Stone Limited is located in Thorold township on the brow of the Niagara escarpment, 1 mile east of Thorold. The quarry is across the road from Walker Brothers quarry. The company produces building stone exclusively.

Geology

The quarry section exposed consists of 20–22 feet of Gasport, crinoidal, calcitic dolomite. The upper 6 feet of the section is dark-grey, medium-crystalline, medium-bedded, crinoidal dolomite, which is stripped off and sold to the Walker Brothers quarry for crushed stone. The lower 14–16 feet of the section, which is quarried for building stone, is a light-grey, medium-crystalline, crinoidal, massive-bedded, calcitic dolomite. A further 5 feet of Gasport dolomite is exposed in the quarry sump.

Quarry Operation

Some 6–20 feet of overburden is stripped by bulldozer or dragline. The upper 6 feet of dolomite is drilled, blasted, loaded, and trucked to Walker Brothers quarry for crushed stone. The upper 12 inches of the building-stone ledge is stripped off by drilling and black powder. The rest of the 14- to 16-foot building-stone ledge is worked in two beds, 5–8 feet thick.

Drilling is done by jackhammers, two of which are mounted on each of three quarry bars. These drills cut vertical channels in two directions, one set normal to the quarry face, the second set parallel to the quarry face at a distance of 15 feet from the face. The blocks are lifted by horizontal holes drilled 24 inches apart, wedged by plug and feather. The quarry blocks are split vertically by rows of holes, 6–12 inches deep, spaced about 4 inches apart and wedged by plug and feather.

The quarry blocks are handled by two 20-ton steel derricks. The blocks are used by the mill on the site and are also shipped by trucks to plants at Niagara Falls and Hamilton for sawing and dressing.

On the quarry site there is a mill, equipped with a 20-ton gantry, 60- by 192-foot, and three gang saws to cut the quarried blocks into slabs of various thicknesses. These slabs are then shipped to the Niagara Falls and Hamilton mills for further processing.

The stone-cutting plant at Niagara Falls is equipped with a 72-inch, a 60-inch, and a 24-inch diamond saw and a wire saw for cutting the stone. A planing machine makes special shapes and mouldings. Facing stone, smooth-faced ashlar, rock-faced ashlar, coping, sills, flagstone, and random flagstone are produced.

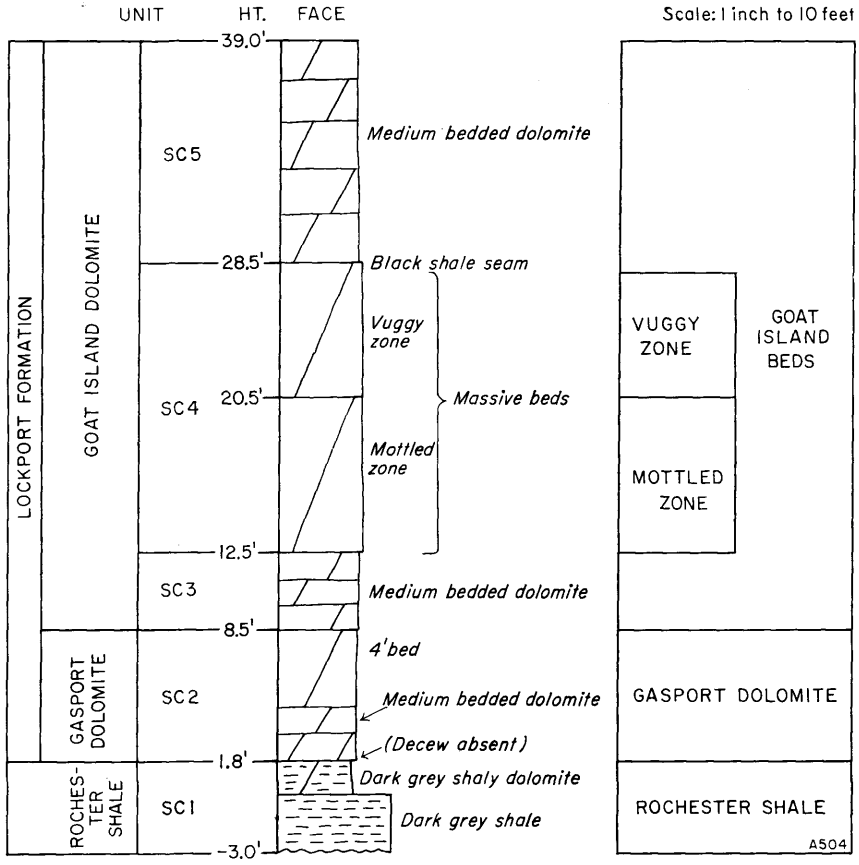
ST. CATHARINES CRUSHED STONE LIMITED, ST. CATHARINES

The quarry of St. Catharines Crushed Stone Limited is located on the Merrittville highway south of St. Catharines, on the brow of the Niagara escarpment, in lots 16 and 17, concession X, Grantham township, Lincoln county. A new 350-tons-per-hour plant was opened on the property in July, 1957. The company is owned and operated by Walker Brothers of Thorold.

Geology

The 39-foot quarry face is illustrated and described in (83). The section consists of 30.5 feet of medium-brownish grey, medium- to massive-

(83) QUARRY SECTION—ST. CATHARINES CRUSHED STONE LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
GOAT ISLAND DOLOMITE		
SC5	Dolomite: medium brownish grey, buff weathering; aphanitic; medium bedded; black shaly partings	10.5
SC4	Dolomite: medium brownish grey, upper 8 feet vuggy, lower 8 feet mottled light and dark brown; aphanitic; massive bedded; black shale partings	16.0
SC3	Dolomite: medium brownish grey; aphanitic; medium bedded; black shale partings	4.0
GASPORT DOLOMITE		
SC2	Dolomite: dark grey; fine crystalline; medium to massive bedded; shale partings	6.7
ROCHESTER SHALE		
SC1	Shaly Dolomite and Shale: dark grey; aphanitic; medium to thin bedded; platy	4.8

bedded, aphanitic, buff-weathering, Goat Island dolomite of the Lockport formation, underlain by 6.7 feet of medium-dark grey, fine-crystalline, medium-bedded, Gasport dolomite of the Lockport formation. The lowermost 1.8 feet of the quarry face, not now quarried, is dolomitic grey shale of the Rochester formation. This shale is also exposed in ditches. The Decew dolomite is absent.

The Goat Island dolomite beds are divided into three units; an upper medium-bedded zone, a central massive-bedded vuggy and mottled zone, and a lower medium-bedded zone. Black shaly partings are common.

Quarry Operation

From 6 to 12 feet of clay overburden is stripped from the flat-lying dolomite. The 39-foot quarry face is drilled on a 7- by 8-foot pattern by a Gardner Denver Air Trac drill equipped with a 2¾-inch bit. A Gardner Denver 600 cubic-feet-per-minute rotary air compressor supplies the drill. The blasting agents are 40-percent Dynamex and prilled ammonium nitrate. Secondary breaking is done entirely with a 2-ton drop-ball.

Stone is loaded on two 22-ton Euclid rear-dump trucks by a Bucyrus-Erie 54B, 2½-cubic-yard, electric shovel for haulage to the primary crusher. The primary crusher is a 42- by 48-inch Traylor jaw-crusher. A 30-inch conveyor transfers the crusher product to the 5-inch surge pile. Stone from the surge pile is fed by a Jeffrey feeder to a conveyor carrying the stone to the secondary-crusher building. The stone discharges on a 4- by 10-foot, 2-deck scalping screen with 2⅝-inch and ⅞-inch openings. The minus ⅞-inch throughs may be stockpiled as ¾-inch crusher run. The plus ⅞-inch stone goes to a Symons 4¼-foot standard cone-crusher. The crusher product is carried by No. 3 conveyor to the screen house where there are six sets of screens in two parallel lines of three each. Each line consists of two 5- by 12-foot, and one 4- by 10-foot screens in series. Products made are 2-inch, 1½-inch, ¾-inch, ½-inch, ¼-inch, dust, and agricultural lime. These products go to bins. The 2-inch, 1½-inch, and ¾-inch stone bins can be discharged on a conveyor carrying these sizes to a 4-foot Symons shorthead cone for recrushing. The recrushed product is returned to the screen house for sizing. A 15-ton Euclid truck stockpiles stone from the bins. Trucks are loaded by overhead Pemco loaders. Haulage is entirely by truck.

The plant has a rated capacity of 350 tons per hour or 2,800–3,000 tons per 9-hour shift. The plant is not operated during the winter. The production is mainly used for road construction and concrete aggregate.

VINELAND QUARRIES AND CRUSHED STONE LIMITED, VINELAND

The quarry of Vineland Quarries and Crushed Stone Limited is located near the edge of the Niagara escarpment south of Vineland, in lot 6, concession I, Clinton township, Lincoln county, at the corner of Victoria Avenue and Fly Road.

Geology

The quarry section, illustrated in (84), consists of 35 feet of Lockport dolomite. The upper 6 feet is light- to medium-brown, buff-weathering, aphanitic dolomite of the Goat Island member of the Lockport. The lower 29 feet consists of grey to light-buff, medium-crystalline, crinoidal, medium-bedded, Gasport dolomite of the Lockport formation. The Gasport rests on an uneven surface of dark-grey aphanitic Decew dolomite, which appears in the floors and ditches of the quarry.

Chemical analyses of chip samples taken up the north quarry face are given in (85).

The stratigraphic position of the samples analysed is indicated in (84).

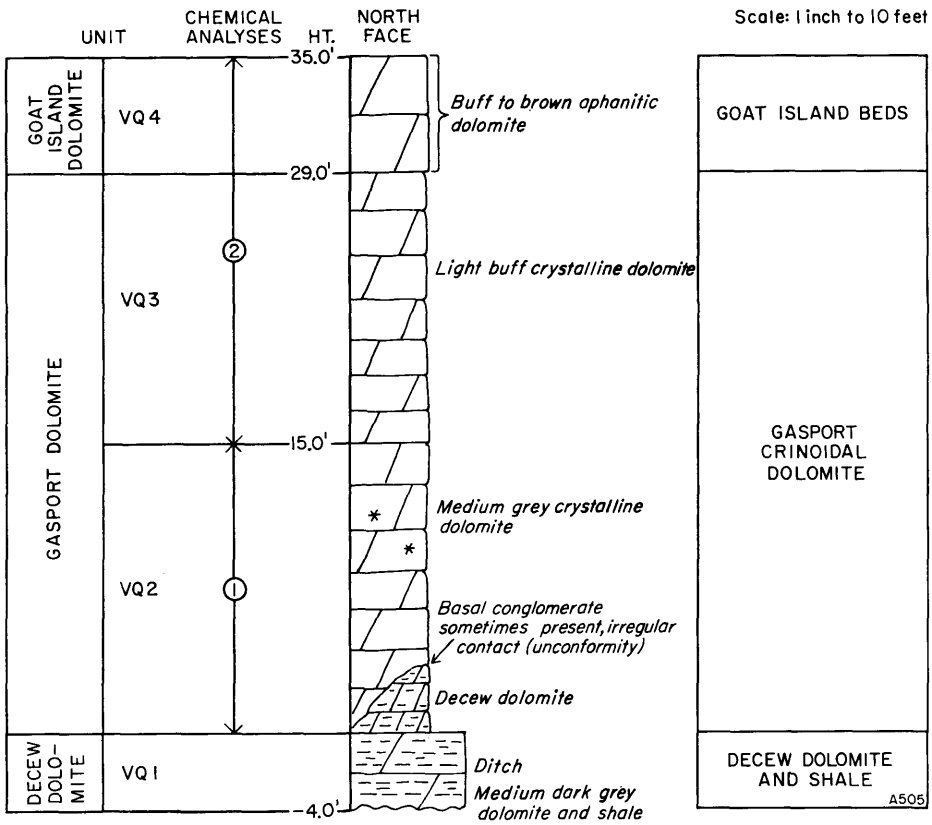
Quarry Operation

Overburden is light, ranging from 1 to 3 feet thick. The 35-foot quarry face is drilled on a 7- by 9-foot pattern by a Joy Model 401 wagon drill with a 3-inch bit. Air is supplied by a Holman 500-cubic-feet-per-minute compressor. The blasting agent is Dupont 60-percent dynamite. The stone is loaded on two 15-ton Euclid rear-dump trucks by a Northwest Model 6 diesel, 1½-cubic-yard shovel for haulage to the primary crusher.

The primary crusher is a No. 8 Austin gyratory crusher. The crusher product is conveyed to a Niagara, 4- by 12-foot, 2-deck scalping screen with 2½- and ⅞-inch openings. The oversize (plus ⅞-inch stone) is split and goes to a 36-inch Bates gyratory crusher or a 3-foot Telsmith standard cone. The undersize (minus ⅞-inch) goes to the ¾-inch crusher-run bin. The crusher products are conveyed to the screen tower, which has one 5- by 12-foot, triple-deck, Dillon screen. This produces 2-inch, ¾-inch, and ⅝-inch stone. The minus ½-inch stone goes to a set of 4- by 12-foot, Dillon, two-deck screens, which produce ⅜-inch and ¼-inch stone, and dust. The oversize stone from No. 1 screen is recrushed in a 3-foot Symons standard cone and returned to the screening circuit. The finished products go to bins and are stockpiled by truck. Stone is shipped by truck haulage, being loaded by overhead loader or directly from bins.

Plant capacity is 100–125 tons per hour with production of about 1,200 tons per 9½-hour shift.

(84) QUARRY SECTION—VINELAND QUARRIES AND CRUSHED STONE LIMITED

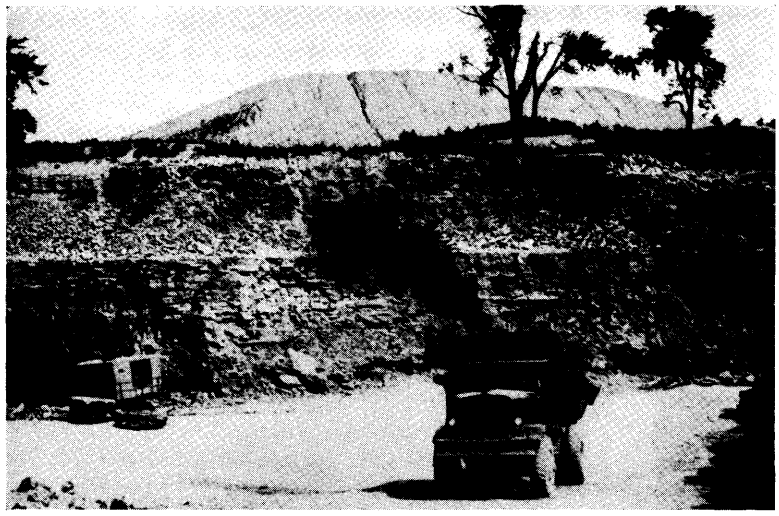


UNIT	DESCRIPTION	THICKNESS Feet
VQ4	Dolomite: light to medium brown, buff weathering; aphanitic; massive bedded; dense, hard; 4-foot bed at top	6.0
VQ3	Dolomite: light buff to brown, light buff weathering; medium crystalline, crinoidal; medium bedded	14.0
VQ2	Dolomite: medium grey, light grey weathering; medium crystalline, crinoidal; medium bedded	15.0
VQ1	Dolomite and Shale: medium dark grey; aphanitic; medium to thick bedded; easily weathered; irregular contact with overlying Gasport. Underlain by thin bedded, dark grey, shaly dolomite and shale	0–4

(85) CHEMICAL ANALYSES—VINELAND QUARRIES AND CRUSHED STONE LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	0–15	2.66	2.45	0.85	30.01	19.70	43.45	0.84	99.96
2	15–35	3.38	1.06	0.70	29.90	20.48	45.10	0.08	100.70



Eramosa dolomite of the Lockport formation at the Vinemount quarry of Armstrong Brothers Company Limited. A Euclid truck is seen in the foreground.

BEAMSVILLE QUARRY, BEAMSVILLE

A small inactive quarry on the brow of the Niagara escarpment south of Beamsville in lots 12 and 13, concession VI, Clinton township, Lincoln county, exposes the Gasport-Decew contact. The quarry section consists of 15 feet of light-grey to buff, medium-crystalline, crinoidal, medium- to massive-bedded, Gasport dolomite, resting with sharp contact on 3.6 feet of shaly, medium-grey, buff-weathering, aphanitic, thin-bedded, Decew dolomite. The contact between the Decew dolomite and the underlying grey Rochester shale is gradational. The Gasport contact shows a basal conglomerate in places.

ARMSTRONG BROTHERS COMPANY LIMITED, VINEMOUNT

The Vinemount quarry, operated by Armstrong Brothers Company Limited, is located southeast of Vinemount on the Niagara escarpment, in lot 5, concession V, Saltfleet township, Wentworth county.

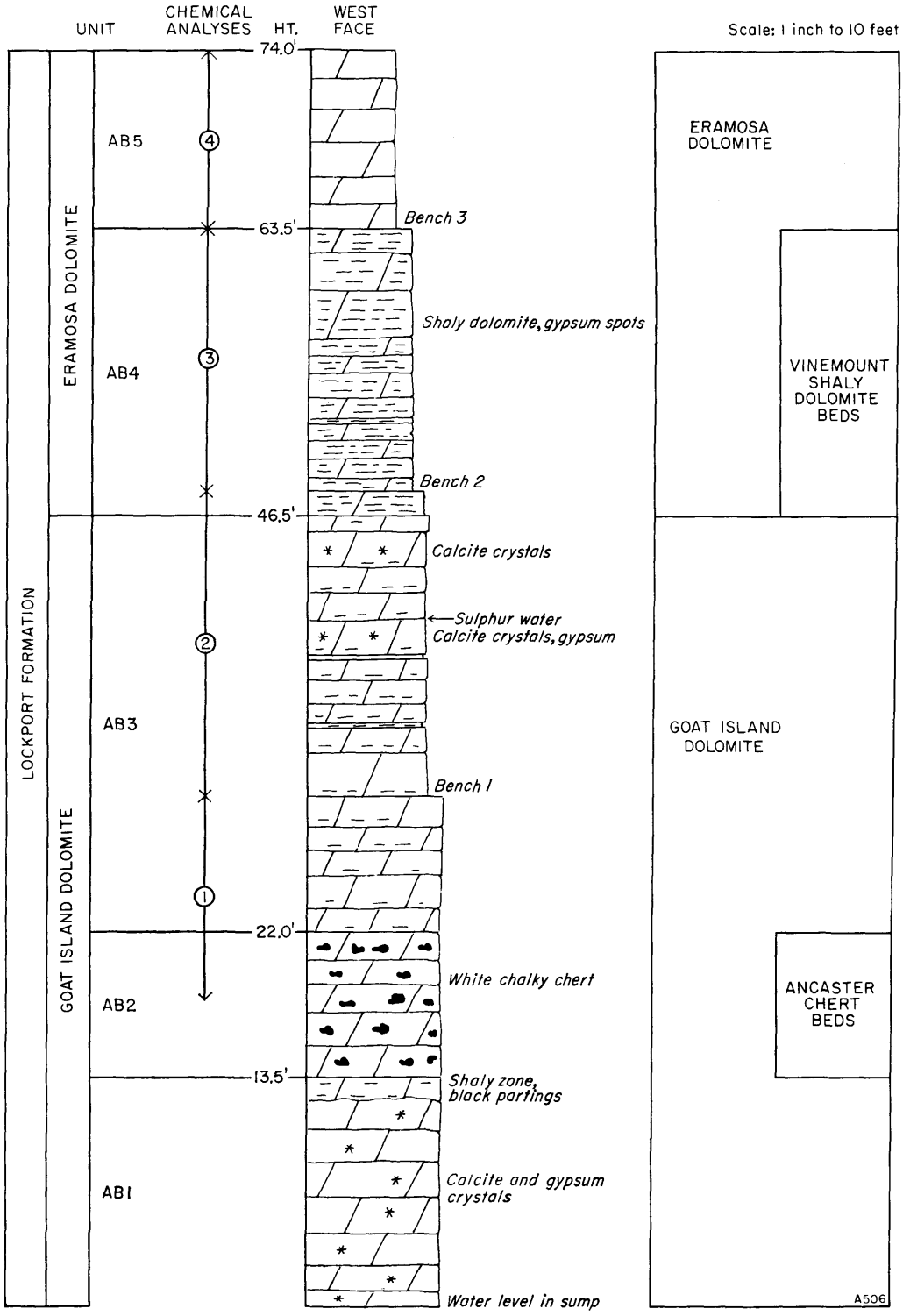
Geology

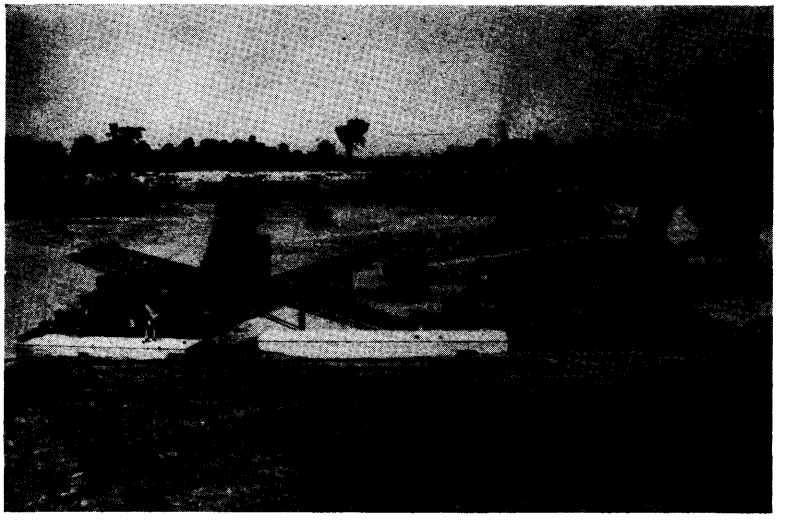
The 74-foot quarry section, illustrated and described in (86), belongs to the Lockport dolomite formation. The upper 10.5 feet consists of medium-brown, medium-bedded, aphanitic dolomite of the Eramosa dolomite member. Below this is 17 feet

(86) QUARRY SECTION—ARMSTRONG BROTHERS COMPANY LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
AB5	Dolomite: silty; medium brown, dark grey streaks; medium-bedded; aphanitic; black shaly partings; lower part of unit shaly	10.5
AB4	Shaly Dolomite and Shale: medium grey; aphanitic; thin to medium bedded; fissile; easily weathered	17.0
AB3	Dolomite: shaly; medium brownish grey, black streaks and colour laminations; aphanitic; medium to thick bedded; black shaly partings; white calcite crystals to 3 inches; white gypsum spots; silty	24.5
AB2	Dolomite: cherty; similar to AB3; chalky white chert nodules	8.0
AB1	Dolomite: similar to AB3	13.5+
	Total	73.5+

(86) QUARRY SECTION—ARMSTRONG BROTHERS COMPANY LIMITED





One of the largest portable aggregate plants in Canada was in operation at the Vinemount quarry of Armstrong Brothers Company Limited in 1958.

of silty, shaly, medium-grey, aphanitic, thin- to medium-bedded dolomite. These shaly beds are called the Vinemount shale beds of the Eramosa dolomite and form a unit that can be traced westward through the A. Cope and Sons quarry near Stoney Creek to Dundas. The lower 46 feet consists of medium-brownish grey, aphanitic, medium- to thick-bedded, silty and shaly dolomite with calcite crystals and white gypsum spots. These beds are assigned to the Goat Island dolomite member of the Lockport. White chert nodules occur in an 8-foot section of the Goat Island as indicated in (86). These are assigned to the Ancaster chert beds of the Goat Island member, Lockport formation.

Chemical analyses of four composite chip samples, taken up the quarry face as indicated on the section (86), are given in (87).

The chemical analyses indicate the silty and shaly character of the lower part of the section.

Quarry Operation

The 74-foot quarry section is worked in four or five lifts of 12–17 feet in height. Drilling is done by three Joy wagon drills equipped with 2-inch bits drilling on a 4- by 4-foot pattern. A Jaeger 600-cubic-foot-per-minute compressor supplies air for the drills. Blasting agents are 75-percent Forcite and 50-percent Dynamex. Secondary breaking is done by a 2-ton drop ball. Stone is loaded by one 1½-cubic-yard Link-Belt Speeder diesel shovel and one 1½-cubic-yard Lima diesel shovel. Five 15-ton Euclid rear-dump trucks haul stone to the primary crushers, and two 15-ton Euclid trucks stockpile stone.

The permanent crushing plant consists of an Austin No. 7½ gyratory crusher, followed by a 4- by 10-foot, 2-deck, Cedarapids vibrating screen and a 4- by 12-foot, 2-deck, Cedarapids screen, in series. Oversize from the first screen goes to a 3-foot Symons standard cone for recrushing, and

(87) CHEMICAL ANALYSES—ARMSTRONG BROTHERS COMPANY LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor (Sampled July, 1958, before quarry was deepened.)	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	0 –12	12.26	2.49	1.63	17.15	25.62	38.34	0.63	98.12
2	12 –30	14.04	3.18	1.98	16.70	24.15	37.65	0.64	98.34
3	30 –45.5	14.52	4.18	2.32	15.61	24.89	36.70	0.46	98.68
4	45.5–56	4.58	1.97	0.85	19.31	29.90	43.41	0.09	100.11

the product is returned to the conveyor feeding the screening plant. Sizes produced are 2-inch, 1-inch, ¾-inch, ½-inch, ⅜-inch, and dust as well as ¾-inch crusher run. The permanent plant has a capacity of about 100 tons per hour.

At the time of the author's visit to the property, a large 240-tons-per-hour Cedarapids portable crushing plant was operating in the quarry. This plant consisted of a feeder, a 32- by 42-inch jaw-crusher, a 4- by 12-foot set of 2-deck screens, a 4½-foot Symons standard cone-crusher, and a 4- by 14-foot triple-deck set of vibrating screens. This portable plant was later moved to a new quarry opened in 1958 by Armstrong Brothers at Georgetown. Most of the stone is used for road construction. Haulage is by truck.

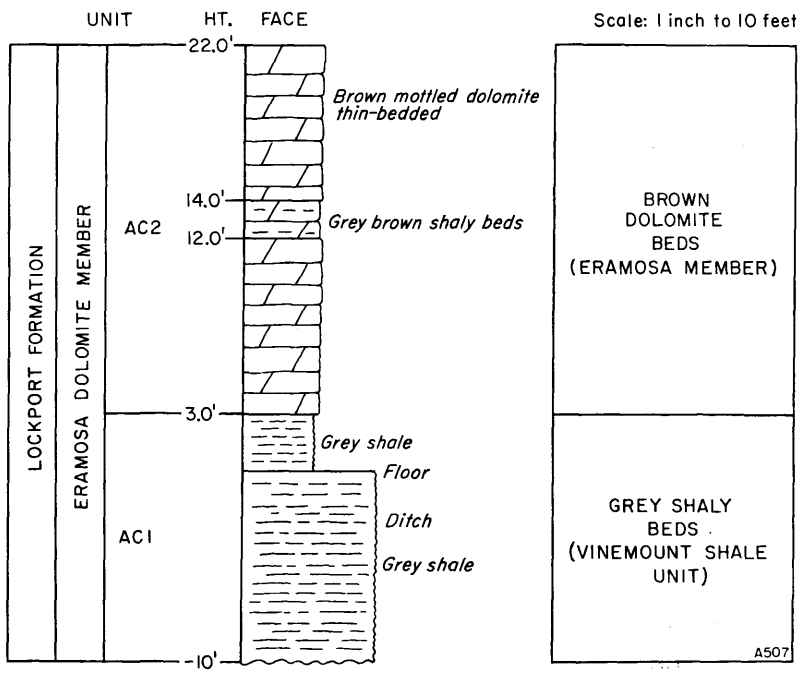
A. COPE AND SONS LIMITED, STONEY CREEK

The quarry of A. Cope and Sons Limited is located on top of the Niagara escarpment, in lots 27 and 28, concession VI, Saltfleet township, Wentworth county, south of Stoney Creek and west of highway No. 20.

Geology

The quarry section, illustrated in (88), consists of 19 feet of medium-brownish grey to light-brown, aphanitic, thin-bedded dolomite belonging to the Eramosa member of the Lockport formation. Below this is 3 feet of grey shale and shaly dolomite

(88) QUARRY SECTION—A. COPE AND SONS LIMITED



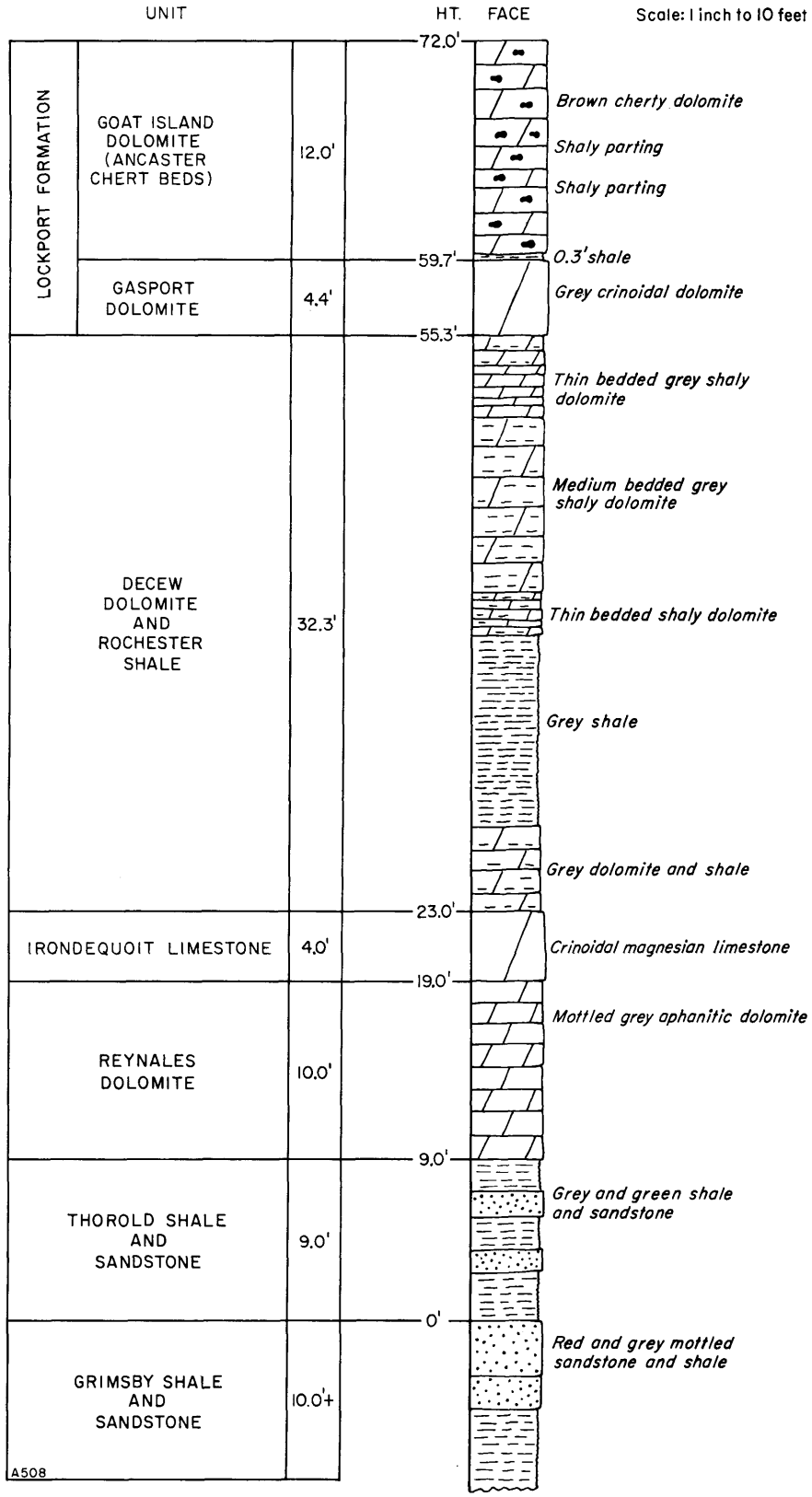
UNIT	DESCRIPTION	THICKNESS Feet
AC2	Dolomite: medium-brownish-grey, light-brown-mottled in part, brown-weathering; aphanitic; thin-bedded; calcite crystals; in part vuggy; grey shale partings; some brownish-grey shaly dolomite beds at 12–14.0 feet	19.0
AC1	Shale and Shaly Dolomite: medium-dark-grey; thin-bedded to platy; weathers easily	13.0+

(89) CHEMICAL ANALYSES—A. COPE AND SONS LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
1	0–12	6.26	2.29	0.85	19.04	28.40	41.99	trace	98.83
2	12–20	2.28	1.13	0.73	20.62	30.40	46.27	0.14	101.47

(90) COLUMNAR SECTION—HIGHWAY NO. 20 ROADCUT, STONEY CREEK



at the base of the quarry section. A further 10 feet of the grey shale unit, which is referred to as the Vinemount shale beds of the Eramosa, is exposed in a ditch in the quarry floor.

Chemical analyses of chip samples, taken by the author up in the quarry face is given in (89).

Quarry Operation

The overburden ranges from 1 to 5 feet in thickness, and the rock surface is flat. The 22-foot quarry face is drilled by two Gardner-Denver, Model 123, and one Ingersoll-Rand wagon drills with 3-inch bits, on a 10- by 10-foot pattern. Air is supplied by one 600-cubic-feet-per-minute portable compressor and two Gardner-Denver electric compressors. The blasting agents are dynamite and prilled ammonium nitrate.

The stone is loaded by a 2½-cubic-yard, Northwest Model 80D, diesel shovel. Haulage to the primary crusher is done by three 15-ton, Euclid rear-dump trucks. The primary crusher is a 40- by 40-inch, Cedarapids impact breaker. A 36-inch conveyor carries the stone from the impact crusher to a 5- by 10-foot Tyroc 3-deck scalping screen with 2-inch, 1¼-inch, and ¾-inch openings. The plus 2-inch stone goes to a 4-foot Symons standard cone-crusher and then via the No. 2, 30-inch conveyor to the screen tower. The 2- by 1¼-inch stone goes to a 4-foot, Symons shorthead cone, and the product goes by conveyor to the 30-inch No. 2 conveyor to the screen tower. A hopper and conveyor is arranged to feed the 4-foot Symons shorthead crusher so that stone from the bins can be drawn by truck and dumped into the hopper for recrushing. The 1¼- by ¾-inch stone goes to a bin under the scalping screen, and the ¾-inch throughs go to a second bin for ¾-inch crusher run (granular base course) at the scalping screen.

The stone carried by No. 2 conveyor to the screen tower discharges on a 5- by 12-foot Dillon 2-deck screen and then to two 4- by 12-foot, 3-deck screens in parallel. These screens produce 1½-inch, ¾-inch, ½-inch, ⅜-inch, ¼-inch stone, and screenings.

The plant has a capacity of 300 tons per hour. Haulage is entirely by truck. Most of the stone is used for road construction; there are two asphalt plants in the quarry. About 10 percent of the stone is used for concrete aggregate.

HIGHWAY No. 20 ROADCUT, STONEY CREEK

The highway No. 20 roadcut, on the brow of the Niagara escarpment south of Stoney Creek, provides a good 72-foot reference section for the lowermost Lockport formation and underlying Clinton group sediments. The section is illustrated and described in (90), after Bolton (p. 89, section 14).

The upper 16.7 feet of the section belongs to the Lockport formation and consists of 12.0 feet of medium-brownish grey to light-brown, thick-bedded, aphanitic dolomite with abundant white chert nodules and black shaly partings (Ancaster chert beds of the Goat Island member of the Lockport), underlain by 0.3 feet of shale and 4.4 feet of Gasport medium-grey, mottled, medium-crystalline, thick-bedded, crinoidal dolomite.

The Decew dolomite and Rochester shale, which underlie the Gasport dolomite, are not separated in this section and consist of 32.3 feet of dark-grey shale and thin-bedded shaly dolomite. Below the Rochester is 4.0 feet of Irondequoit dolomitic limestone, a light-brownish grey, medium-crystalline, massive-bedded, crinoidal unit. This is underlain by 10 feet of mottled light- and dark-grey, aphanitic, medium- to thick-bedded, Reynales dolomite. This latter unit is the lowermost Silurian dolomite in the escarpment and is underlain by 9 feet of grey and green Thorold sandstone and shale and 10 feet of red and grey mottled Grimsby sandstone and shale.

WENTWORTH STREET ROADCUT, HAMILTON

Another excellent reference section may be seen at the brow of the escarpment at Wentworth Street in Hamilton. This section is measured and described by Bolton (p. 91, section 16) and consists of the units given in (91).

(91) SECTION—WENTWORTH STREET ROADCUT

	THICKNESS Feet
Lockport Formation:	
Goat Island Dolomite Member (Ancaster Chert Beds)	12
Gasport Dolomite	8
Rochester Shale	14
Irondequoit Limestone	4
Reynales Dolomite	9.5
Thorold Sandstone and Shale (grey and green)	13
Grimsby Shale and Sandstone (red and grey to green)	29

ANCASTER ROADCUT, HIGHWAY No. 8, ANCASTER

Another good section is exposed where highway No. 8 climbs the escarpment at Ancaster. This is described by Bolton (p. 92, section 18) and consists of the units given in (92).

In this section the typical medium-brown, black-streaked, sugary, Eramosa dolomite is exposed at the top of the section.

CANADA CRUSHED AND CUT STONE LIMITED (DUNDAS QUARRY, DUNDAS)

The Dundas quarry of Canada Crushed and Cut Stone Limited is located in lots 10 and 11, concession II, West Flamboro township, Wentworth county, on the south side of highway No. 5, north of Dundas. A new quarry is being opened on the north side of highway No. 5 in lots 10 and 11, concession III, and is connected with the crushing plant in the main quarry by a tunnel, 18 by 30 feet, under the highway.

The main crushing plant is located in the quarry, but the screening and recrushing plant is 2½ miles south of the quarry on the brow and face of the Niagara escarpment at Dundas, on the Canadian National railway line.

The quarry, which is one of the largest in Ontario, with a production of over 1,000,000 tons a year, produces crushed stone for concrete aggregate, road stone, and railway ballast, as well as agricultural limestone, stone for lining open-hearth furnaces, flux stone for the steel industry, and stone for the dead-burned dolomite refractory plant of Steetley of Canada Limited. About half the quarry production is used in the metallurgical industry.

The plant has a capacity of 550–600 tons per hour.

Geology

The 50-foot quarry face, exposed along the north quarry wall at the south side of highway No. 5, consists of 6 feet of Guelph dolomite underlain by 44 feet of Eramosa dolomite of the Lockport formation. The section is described in (93).

On a 14-foot face on the east side of the quarry, south of the Steetley plant, abundant white- and brown-banded chert occurs in the quarry face.

A 15-foot lift, below the main quarry floor in the southern part of the quarry, exposes brown Eramosa dolomite, more thin bedded and shaly than that exposed above in the quarry section. Gypsum, pyrite, and chert occur in the lower part of the section.

Chemical analyses of cuttings from an exploratory drill hole furnished by the company are quoted from Goudge's report (p. 300) in (94).

Chemical analyses of a diamond-drill core, located 500 feet north of highway No. 5 on the new quarry property, were supplied by the company and are given in (95). These analyses apparently represent a 6- to 12-inch grab sample taken at the footage indicated. They indicate an increase of silica and alumina in the section below 45 feet in depth. This is confirmed on visual examination of the quarry face by the increase in shaly material and the appearance of chert in the lower lifts. The upper 40 feet of the quarry face is reported to average less than 0.50 percent silica and less than 0.50 percent alumina plus iron oxide, and may therefore be classed as a high-purity dolomite.

Quarry Operation

Some 2–10 feet of overburden is stripped by a 4-cubic-yard, Bucyrus-Erie electric shovel. Haulage for the stripping operation is by contract. The quarry is worked in three lifts, two of which were being operated at the time of the author's visit. The upper lift of 41–50 feet is high-purity dolomite used for metallurgical flux and refractories. The second lift of 17 feet and the third lift, also 17 feet high, are somewhat higher in silica and are used for commercial crushed stone. Drilling is done by two Joy Heavyduty Champion rotary drills, one drilling a 6¼-inch hole, the other a 6¾-inch hole. The pattern varies from 14 by 15 feet to 24 by 20 feet. The quarry surface is fairly even and flat.

The blasting agents are 70-percent Dynamex and prilled ammonium nitrate. Primacord and electric millisecond blasting caps are used as initiators for detonation. Fragmentation is good. Stone is loaded by a 5-cubic-yard, Bucyrus-Erie 120B electric shovel mounted on crawler tracks. The 4-cubic-yard shovel mentioned earlier is on standby duty when not on stripping. Haulage to the primary crusher is done by two Mack, diesel tandem trucks each hauling two 18-ton Easton side-dump trailers, and one Mack gasoline-powered truck with an 18-ton Easton side-dump trailer.

QUARRY CRUSHING PLANT

The layout of the quarry crushing plant is illustrated in (96). The primary crusher is a 42-inch Allis-Chalmers gyratory crusher. Hang-ups are handled by an Easton electric hoist. Some secondary blasting is required. The crusher product is discharged on a 60- by 48-inch Jeffrey feeder feeding a 42-inch conveyor, which carries the stone to the secondary-crusher building. The conveyor discharges on a Nordberg, 5- by 5-foot, vibrating,

(92) SECTION—ANCASTER ROADCUT, HIGHWAY NO. 8

	THICKNESS Feet
Lockport Formation:	
Eramosa Dolomite (dark brown, petroliferous)	43
Covered interval	55
Goat Island Dolomite (Ancaster chert beds; cherty, buff, aphanitic dolomite)	25
Gasport Dolomite (grey, medium crystalline, crinoidal)	13.3
Decew Dolomite (aphanitic, medium grey)	6
Rochester Shale	9
Irondequoit Limestone (medium crystalline, massive, crinoidal)	4.6
Reynales Dolomite (buff, aphanitic, medium bedded)	7.0+

(93) SECTION—CANADA CUT AND CRUSHED STONE LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
GUELPH FORMATION	Dolomite: light grey, light buff weathering; aphanitic; medium bedded; shows a distinct colour break with the lower beds and represents a change from clastic sedimentation below to reefy biohermal facies above	6
ERAMOSA DOLOMITE (Lockport Formation)	Dolomite: medium dark brown to light brown, buff to brown weathering; aphanitic; medium to thick bedded, even bedded; thin colour lamination with black shaly partings in the lower part of the section; not notably porous or fossiliferous; rare cross-lamination; occasional marcasite, gypsum, sphalerite	44

(94) CHEMICAL ANALYSES—CANADA CUT AND CRUSHED STONE LIMITED

(Analyses from Goudge, p. 300)

Depth	SiO_2	$Al_2O_3 + Fe_2O_3$	$CaCO_3$	$MgCO_3$	S	Total
feet	percent	percent	percent	percent	percent	percent
1–10	0.76	0.80	53.67	43.17	0.07	98.47
10–20	0.50	0.80	53.85	43.39	0.05	98.59
20–40	0.68	0.80	53.67	44.10	0.07	99.32

(95) CHEMICAL ANALYSES—CANADA CUT AND CRUSHED STONE LIMITED

(Analyses supplied by the company)

Depth	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	L. O. I.
feet	percent	percent	percent	percent	percent	percent
7	0.48	0.16	0.49	34.08	18.51	46.28
12	0.24	0.16	0.23	33.62	19.22	46.53
17	0.39	0.15	0.39	32.82	19.91	46.34
22	0.83	0.14	0.26	32.74	18.80	47.23
25	0.10	0.16	0.22	32.20	20.72	46.60
30	0.16	0.16	0.39	34.16	18.31	46.82
35	0.68	0.21	0.22	34.84	16.97	47.08
40	0.26	0.14	0.27	34.08	17.95	47.30
45	0.76	0.16	0.38	34.98	16.26	47.46
50	5.27	0.21	0.63	33.21	14.31	46.36
55	1.08	0.16	0.80	33.13	18.19	46.64
60	0.49	0.21	0.51	32.59	19.60	46.60
65	2.23	0.16	1.18	32.59	17.38	46.46

Nearly 50 feet of well-bedded Eramosa dolomite of the Lockport formation are exposed in the main quarry face at the Dundas quarry of Canada Crushed and Cut Stone Limited. The upper few feet are Guelph dolomite.

4-inch bar grizzly. The oversize goes to the secondary crusher, a 20-inch Superior McCully gyratory set at 2½ inches on the close side. The undersize passing the grizzly, together with the crusher product, discharge on a 36-inch conveyor and are carried to the Hydrocone building.

At the Hydrocone building the rock is discharged on a 6- by 12-foot, 2-deck, Simplicity scalping screen. The top deck has 4-inch square and 5-inch round openings; the bottom deck has 3-inch and 2½-inch square openings. The oversize from the top deck feeds via a transfer conveyor to a 12- by 60-inch, Allis-Chalmers, Hydrocone crusher. If the run is commercial stone the oversize from the bottom deck (plus 2½-inch stone) also goes to the Hydrocone crusher. If the run is metallurgical stone or refractory stone the plus 2½-inch stone may go directly to the rock surge pile for chemical stone. The minus 2½-inch stone (throughs from the scalper) goes to a Tyler 3-deck, 5- by 14-foot, F800 screen. The top deck has 1¾-inch openings; the middle deck ⅞-inch by 5-inch slots; and the lower deck has 3/16-inch by 1¼-inch openings. The throughs (screenings) are conveyed to a hopper and stockpiled. The plus 1¾-inch, the 1¾- by ⅞-inch, and the ⅞- by 3/16-inch stone go to three sets of bins. These bins feed either a 36-inch conveyor (RC2), which carries the stone to the rock surge piles to the south of the Hydrocone building, or a 24-inch conveyor (RC6), which carries the stone to the east stacking tower. Chemical stone for use in the Steetley kiln is stacked to the north of the stacking tower by a stacking conveyor, while commercial stone is stacked to the south of the stacking tower.

The product of the Hydrocone crusher also goes to a 36-inch conveyor (RC2) and on to the surge piles to the south of the Hydrocone building. The stacker conveyor is a 36-inch, Barber Greene, radial stacker, and two separate surge piles, one for commercial stone and one for chemical flux stone, are maintained.

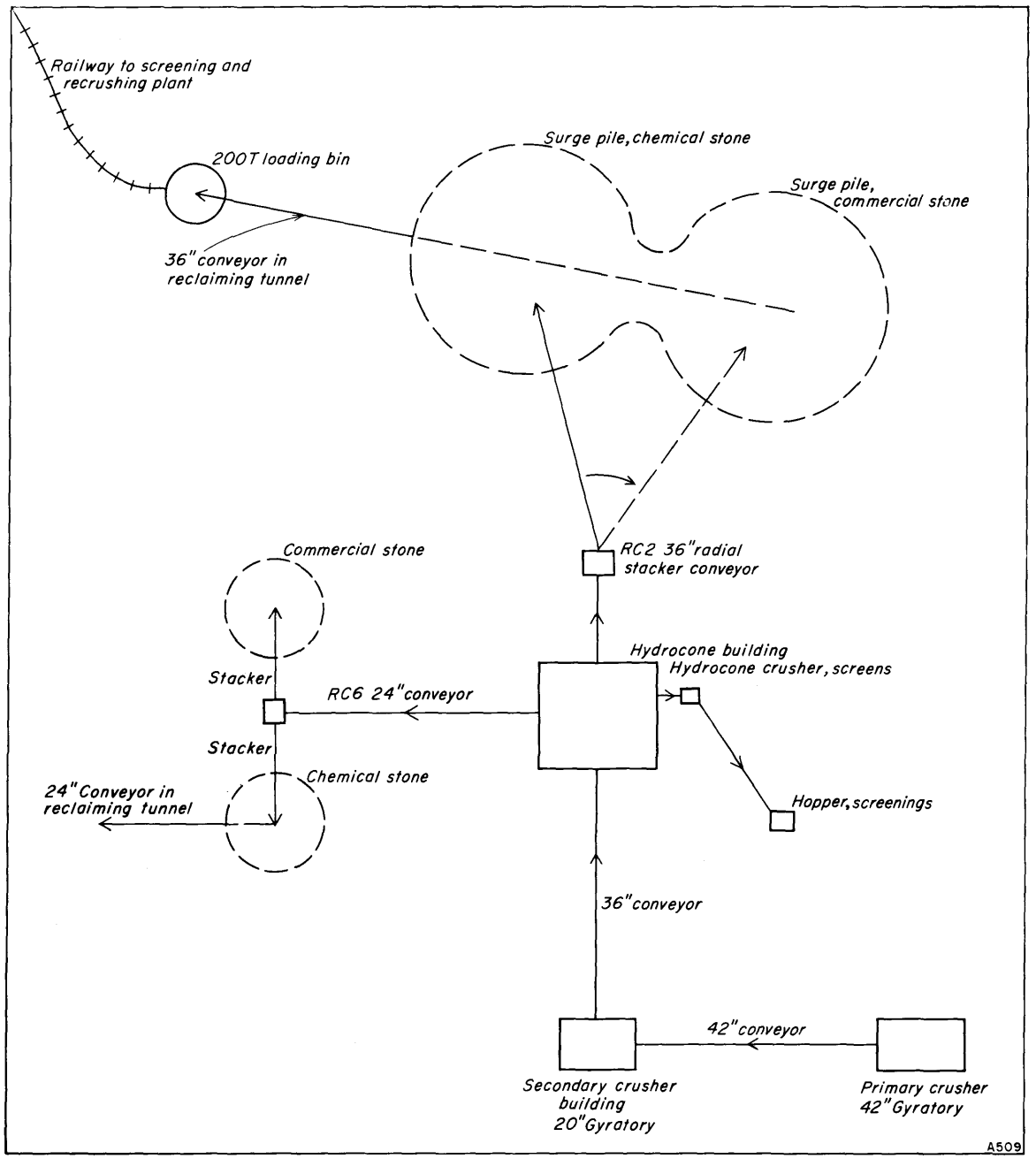
Stone from the surge piles feeds via a 42- by 48-inch Syntron feeder onto a 36-inch reclaiming conveyor in a tunnel below the surge piles. This conveyor discharges to a 200-ton loading bin, which serves the electric trains hauling stone from the quarry to the screening and recrushing plant, 2½ miles to the south on the brow of the escarpment at Dundas. The three electric trains used for the haulage consist of three or four Easton side-dumping tandem cars carrying about 26 tons each.

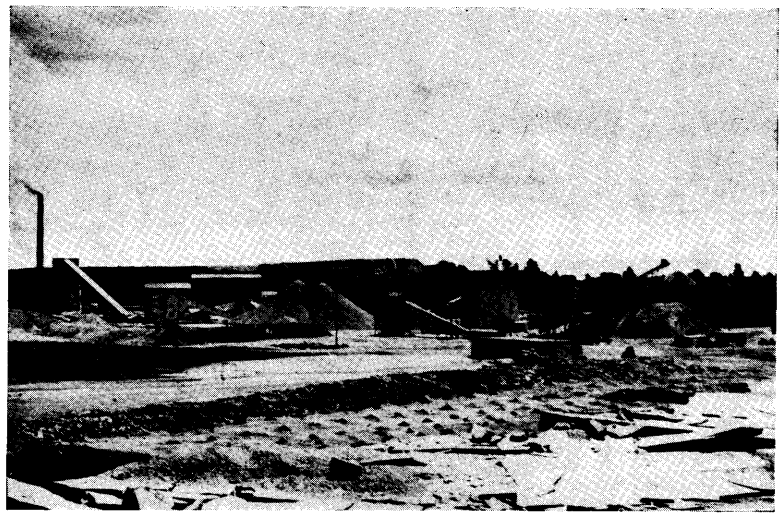
SCREENING AND RECRUSHING PLANT

The screening and recrushing plant on the side of the escarpment consists of two parallel duplicate installations, an east and a west line. The trains dump into two 250-ton surge bins on the mountain brow. These bins discharge via feeders onto two 30-inch conveyors each feeding two 5- by 24-foot trommel screens. Sizes discharged from the trommels are plus 2¾-inch stone, 2¾- by 1¾-inch stone, 1¾- by 1-inch stone, and minus 1-inch stone. The initial three sizes are conveyed to separate compartments of the loading bins.

The minus 1-inch stone goes to four 2-deck, 4- by 8-foot, Niagara screens. The top decks have ½-inch openings, and the 1- by ½-inch stone goes to the loading bins. The lower decks have 3/16- by 1¼-inch openings. The throughs from the bottom

(96) PLANT LAYOUT—CANADA CRUSHED AND CUT STONE LIMITED





The Dundas quarry of Canada Crushed and Cut Stone Limited is one of the largest in Canada and produces chemical flux stone and aggregate. The dead-burned dolomite kiln of Steetley of Canada Limited may be seen in the background.

decks go as screenings to the loading bins. The ½- by 3/16-inch stone from the bottom decks go to two Hummer screens in series. (Each pair of Niagara screens feeds two Hummer screens in series.) The first Hummer screen has 0.070 Tyler openings, the throughs are agricultural limestone. The second Hummer screen has 3/16- by 1¼-inch openings. The oversize (chips) goes to the loading bins. The throughs go to the screening bins.

RECRUSHING

The loading bins consist of two duplicate sets of six bins, one for the east line and one for the west line. Conveyors under the bins feed the recrushing units, a 5½-foot Symons standard cone-crusher, a 4-foot Symons shorthead cone-crusher, and a 3-foot Symons standard cone-crusher. The products from the recrushing units are elevated by a 30-inch conveyor to the screen house, where the feed is split three ways and may feed into the trommels on the east and west lines if the load in these circuits permits, or part may go to a 5- by 10-foot, converted Niagara, 2-deck screen. This screen produces 1¾- by 1-inch stone, which is conveyed to the loading bins. The minus 1-inch stone goes to a 5- by 12-foot, 2-deck screen for production of chips, agricultural lime, and screenings.

The main products are 5- by 2¾-inch blast furnace flux; 2¾- by 1¾-inch blast furnace flux; 1¾- by 1-inch and 1-inch by ½-inch commercial stone; ½- by 3/16-inch chips; agricultural lime; and screenings.

WASH PLANT AND CHEMICAL STONE

The chemical stone from the surge pile north of the RC6 stacker in the quarry is recrushed, sized, and washed by Canada Crushed and Cut Stone for feed to the dead-burned dolomite refractory kiln of the Steetley Company of Canada Limited.

A 24-inch conveyor in a reclaiming tunnel below the surge piles feeds the wash-plant crusher, a Symons 4-foot shorthead cone. The product from this crusher is taken by a 24-inch conveyor to the screening and wash house where it passes over a Tyroc 2-deck, 5- by 12-foot screen and ½-inch and 7/16-inch openings in the top deck and 5-mesh openings in the lower deck.

The plus ½-inch stone is returned to the 4-foot, Symons shorthead cone for recrushing. The ⅜-inch by 5-mesh stone from the bottom deck is split into two parts, each part going to a washing screen. One washing screen is an Allis-Chalmers low-head, 4- by 9-foot screen having 5/16-inch upper-deck openings and 5-mesh lower-deck openings. The other washing screen is a Tyroc F600, 4- by 9-foot, screen with 5-mesh openings. The plus 5-mesh products of both screens go via 24-inch conveyor to the Steetley plant.

The throughs from the washing screens and the screenings from the primary screen, go to an Akins classifier for dewatering. The sand-sized product is stockpiled by stacker conveyor, The overflow goes to settling ponds.

This plant has a production of about 70 tons of kiln stone and 20 tons of sand per hour.

STEETLEY OF CANADA LIMITED (Dead-Burned Dolomite Refractory Plant)

The dead-burned dolomite kiln of Steetley of Canada Limited is located at the east end of the Dundas quarry of Canada Crushed and Cut Stone Limited. The Steetley Company controls Canada Crushed and Cut Stone Limited.

The short 24-inch conveyor from the Canada Crushed and Cut Stone wash plant feeds over a weigh-scale and then to the 24-inch conveyor of the Steetley plant. The washed ⅜-inch by 5-mesh stone is conveyed to two 1,300-ton silos. The silo building also has one 500-ton silo used for magnetite fines, which are added to the kiln stone to assist sintering and to assist fluxing in the dead-burned dolomite used in the steel furnaces.

The stone feeds from the silos via automatic-weighing Pandan feeders to an 18-inch conveyor. Approximately 3–3½ percent magnetite is also fed to the conveyor. The kiln feed is about 18½ tons of stone per hour.

The kiln charge is fed to a 349-foot, F. L. Smidth rotary kiln measuring 8 feet 10 inches in diameter at the feed end and 9 feet 10 inches at the firing end. The kiln is fired with powdered coal. The clinker is discharged to an 80-foot by 88-inch cooler. The cooler discharges to a 5-inch bar grizzly. Oversize clinker is crushed in a small jaw-crusher.

The clinker feeds via a conveyor to the oiling plant where it passes over a Tyroc F100, 3- by 4-foot screen with ⅜-inch or 5/16-inch openings, depending on the size of product being made. The oversize goes to a Symons 3-foot shorthead cone-crusher in closed circuit with the Tyroc screen.

The screened product goes to a paddle mixer where it is oiled with Bunker B oil to control dust and decrease air slaking. The oiled product goes to storage bins, which supply truck or rail transportation. The dead-burned dolomite product is used by steel producers in Hamilton, Sault Ste. Marie, and Sydney, N.S.

Chemical specifications for kiln stone require less than 0.5 percent silica. A small percentage of alumina is not objectionable.

JAMES D. GRAY AND SON, WEST FLAMBORO TOWNSHIP

The quarry of James D. Gray and Son is located in lot 6, concession IV, West Flamboro township, on the west side of the Brock road.

Geology

The quarry face consists of 20 feet of light-brown to medium-dark brown, aphanitic, thin-bedded, Guelph-Lockport dolomite. The upper 8 feet is a light grey buff, light-grey weathering, aphanitic, sugary, thin-bedded, porous, even-bedded dolomite assigned to the Guelph formation. The underlying 12 feet is similar to the above section, but is medium-brown in colour and may represent the top of the Eramosa member of the Lockport formation. The contact is gradational.

Quarry Operation

Overburden is 0–4 feet thick. The 20-foot quarry face is drilled on contract by a well-driller using a churn-drill. The 6-inch holes are spaced 12–15 feet apart. Stone is loaded on 5-ton dump trucks by a ¾-cubic-yard Unit Crane and Shovel diesel shovel. Primary crushing is done by a 12- by 30-inch, Sawyer Massey jaw-crusher. A 24-inch conveyor carries the crusher product to a 3- by 10-foot, Woodstock 3-deck screen producing 2-inch stone, ¾- or ½-inch stone, ⅜-inch chips, and screenings. The oversize is recrushed by a Symons 2-foot standard cone, and the product is returned to the screen. The quarry production is largely used for road construction, and haulage is by truck. Plant capacity is rated at about 500 tons per day.

BROCK ROAD DRILLING

A property in lots 7 and 8, concession VI, West Flamboro township, across the road from the quarry of James D. Gray and Son has been diamond-drilled by Canada Crushed Stone (now Canada Crushed and Cut Stone).

Chemical analyses of an 82-foot diamond-drill hole on this property as reported by Goudge (p. 299) are given in (97). The analyses indicate high-purity dolomite to a depth of 60 feet.

(97) CHEMICAL ANALYSES—BROCK ROAD DRILLING

(Analyses from Goudge, p. 299)

Depth	SiO_2	$Al_2O_3 + Fe_2O_3$	$CaCO_3$	$MgCO_3$	Total
feet	percent	percent	percent	percent	percent
1–30	0.50	0.80	55.90	42.66	99.86
31–60	0.60	0.70	54.00	44.60	99.90
61–82	2.00	1.00	52.50	44.50	100.00

KING CITY SAND AND CRUSHED STONE LIMITED (CLAPPISONS CUT QUARRY, CLAPPISONS CUT)

The quarry of King City Sand and Crushed Stone Limited is located on the top of the escarpment just east of highway No. 6 at Clappisons Cut, in lots 12 or 13, concession II, East Flamboro township, Wentworth county.

Geology

The 35-foot quarry face is illustrated in (98). In the floor of the quarry, Thorold sandstone and grey green shale are exposed. This is the only commercial stone quarry using the Rochester, Irondequoit, and Reynales formations of the Clinton group.

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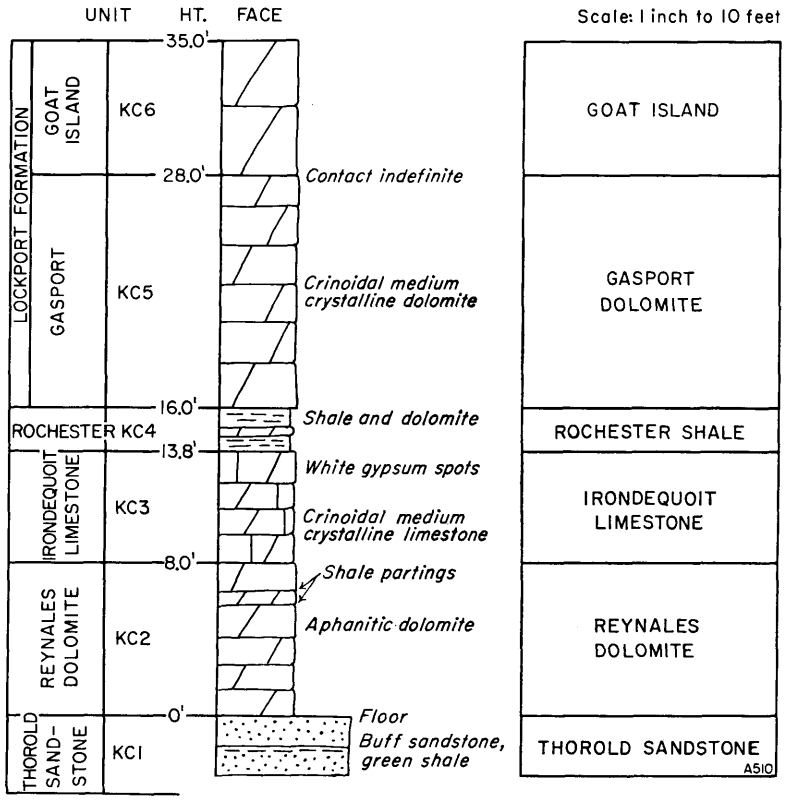
(98) QUARRY SECTION—KING CITY SAND AND CRUSHED STONE LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
KC6	Dolomite: light buff, buff weathering; medium crystalline; thick to massive bedded; even bedded; porous; fossiliferous; very similar to Gasport dolomite, distinguished by colour, bedding	7.0+
KC5	Dolomite: medium grey, light grey to buff weathering; coarse to medium crystalline; crinoidal; medium bedded; even-bedded; fossiliferous; porous	12.0
KC4	Shale and Dolomite: grey shale and medium grey argillaceous dolomite; thin bedded	2.2
KC3	Dolomitic Limestone: medium-grey; crinoidal, medium-crystalline; medium-bedded; white gypsum nodules and dolomitic shale fragments in upper beds; marcasite; grey shale partings.	5.8
KC2	Dolomite: light grey with dark grey streaky banding, light buff weathering; aphanitic; medium-bedded; dark-grey shale partings, prominent at 6.0 and 6.5 feet	8.0
KC1	Sandstone: buff to grey; medium to fine grained; thick to medium bedded; some grey-green shale; marcasite coatings on joints	3.0+
	Total	38.0+

Quarry Operation

Overburden is light, ranging from 0 to 2 feet in thickness. The 35-foot quarry face is drilled by contract; 6-inch holes on a 16- by 18-foot pattern are loaded with 70-percent dynamite and prilled ammonium nitrate. Secondary breaking is done by a 2,000-pound drop ball attached to the shovel bucket. The stone is loaded on one 3-ton and one 5-ton dump truck by a 1¼-cubic-yard Lorain Model 75B shovel, for haulage to the primary crusher.

The primary crusher is a Cedarapids, 22- by 36-inch jaw-crusher. The product from the crusher goes to a 4- by 8-foot Seco 2-deck scalping screen, which scalps off 4-inch and 2-inch products; the throughs are ¾-inch crusher run stone. Recrushing is done by a Cedarapids portable plant consisting of a Cedarapids super tandem 10- by 36-inch jaw-crusher, 16- by 24-inch rolls, and a triple-deck 4- by 14-foot screen. The feed for this plant is mainly 4-inch stone from the scalping screen.

The products made are 4-inch stone, 2-inch stone, ¾-inch stone, ¾-inch crusher run, and ⅝-inch crusher run. A ¾-cubic-yard and a 1¼-cubic-yard shovel load stone from the stockpiles. The plant capacity is about 80 tons per hour.

OLD NELSON QUARRY, WATERDOWN

The old quarry of Nelson Crushed Stone is located on the brow of the escarpment in Nelson township, just east of the East Flamboro township line, in lot 24, concession I, S.D.S., 2 miles east of Waterdown, and 1½ miles south of highway No. 5.

Geology

The quarry is of considerable geological interest as it is in the transition area between well-bedded Lockport dolomite of the Niagara Peninsula–Dundas area, and the crystalline, irregularly-bedded to well-bedded, reefy dolomite of the Amabel formation of the Waterdown–Georgetown–Bruce Peninsula area. Here also is seen the pinching out of the Rochester shale unit, which, with the Decew dolomite, underlies the Guelph-Lockport throughout the Niagara escarpment.

The Irondequoit limestone also appears to pinch out in the area to the north, so that the Amabel dolomite (which is the lateral equivalent of the Lockport dolomite) rests directly on the medium-grey, aphanitic, Reynales dolomite.

The 40-foot quarry section is described in (99).

NELSON CRUSHED STONE LIMITED (MOUNT NEMO QUARRY, NELSON)

The quarry of Nelson Crushed Stone Limited is located 2½ miles north of Nelson Corners on highway No. 5, in lots 1 and 2, concession III, Nelson township, Halton county. This quarry, which is one of the largest in Ontario, with a production of over 1,000,000 tons of stone per year, produces crushed stone largely for road construction and concrete aggregate. Transportation is entirely by truck. The plant, which has a capacity of 500 tons per hour began production in 1954. A second quarry was opened in 1957 in lots 1 and 2, concession II. The company is a subsidiary of King Paving Company Limited of Oakville.

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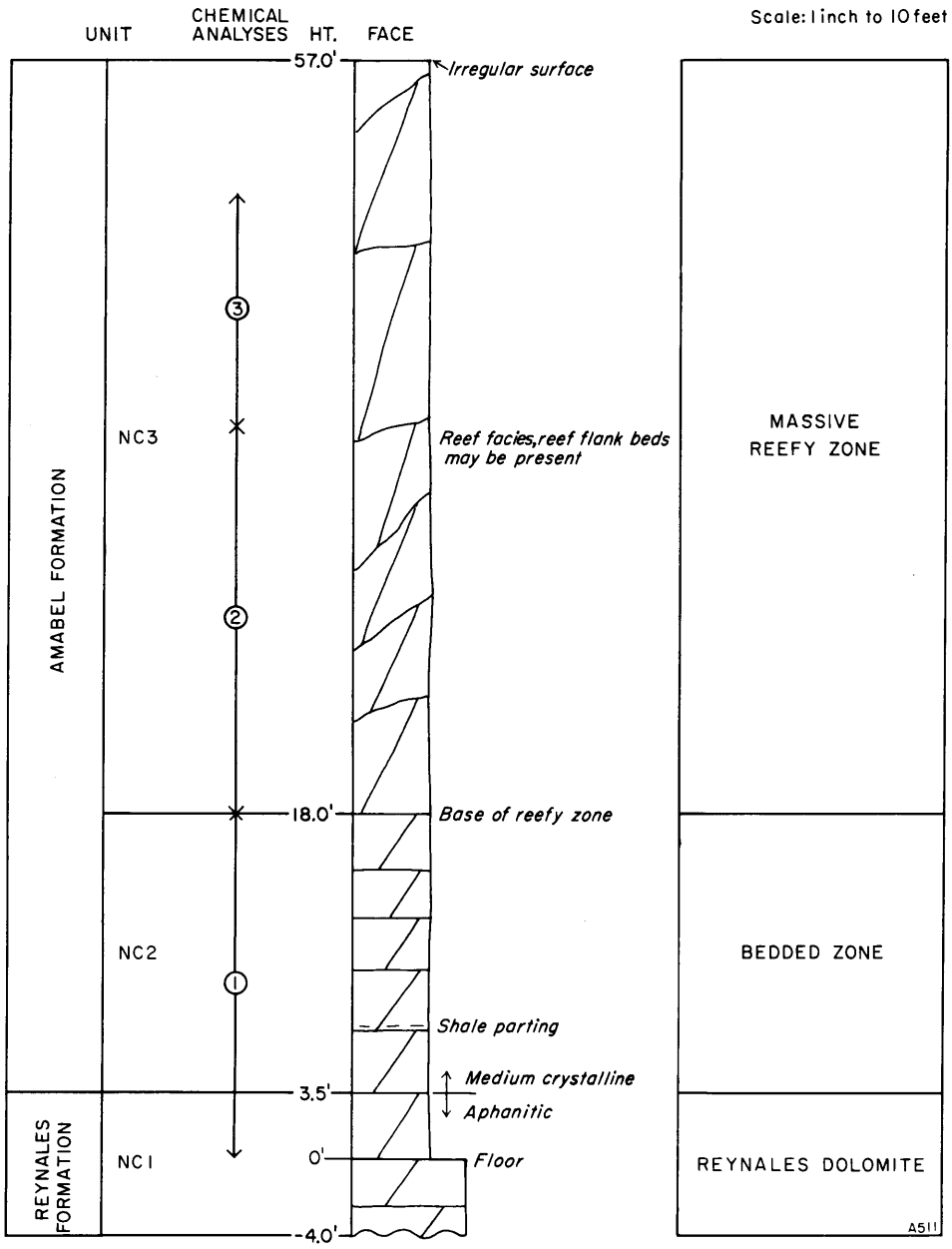
(99) QUARRY SECTION—OLD NELSON QUARRY

FORMATION	DESCRIPTION	THICKNESS Feet
Amabel	Dolomite: light grey to buff; medium crystalline; medium to thick bedded; in places poorly or irregularly bedded reefy facies appearing; porous; fossiliferous.....	30 +
Rochester	Dolomite and Shale: grey; black shale zone 6–12 inches thick with white gypsum spots marks last vestiges of the Rochester shale.....	2.8
Irondequoit	Dolomite: light-grey to buff, mottled; massive 4-foot bed; marked shale parting and sharp textural and colour break at base.....	4.0
Reynales	Dolomite: light-brownish grey; aphanitic; medium bedded; common shaly partings.	6.0
	Quarry Floor	
Thorold	Buff-weathering sandy and silty aphanitic dolomite and grey-green shale, sulphides.	5.0+

QUARRY SECTION—NELSON CRUSHED STONE LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
AMABEL FORMATION		
NC3	Dolomite: light grey, buff weathering; medium crystalline; massive bedded to reefy; bedding absent, inclined, or present depending on position with respect to biohermal facies; porous; hard; fossiliferous	39.0
NC2	Dolomite: light-grey, buff weathering; medium crystalline; medium bedded; vuggy, in part fossiliferous	14.5
REYNALES FORMATION		
NC1	Dolomite: medium buff to grey mottled, buff weathering; aphanitic; medium bedded; green shaly partings	7.5

Geology

The 50- to 70-foot quarry face, with the exception of the lowermost 3.5 feet of Reynales dolomite, consists entirely of light-buff, medium-crystalline, Amabel dolomite, which is the northern reefy facies equivalent to the Lockport dolomite of the Niagara–Dundas area. The section exposed is illustrated and described in (100).

The lowermost 3.5 feet, together with a 4-foot section exposed in the ditches, is medium-buff-to-grey mottled, buff-weathering, aphanitic dolomite typical of the Reynales formation. This unit, 5–10 feet thick, marks the base of the commercial quarriable stone in the Nelson-Georgetown area, and is underlain by sandstone and shale of the Clinton and Cataract (Medina) groups: (the Thorold and Grimsby sandstone and shale and the Cabot Head shale).

Some 50–70 feet of Amabel dolomite are exposed in the quarry face above the Reynales formation. The lower 14.5 feet is well-bedded, light-grey, buff-weathering, medium-crystalline dolomite. Above this is 30–50 feet of massive reefy to irregularly-bedded dolomite, which represents a more reefy facies of the Amabel. Massive porous reefstone, inclined beds dipping off the reef flanks, and flat inter-reef beds are present. The reef mounds or bioherms exposed in this quarry are 100–300 feet wide and 20–50 feet high. The base of the reefy zone is 18 feet above the quarry floor. The uneven quarry surface reflects the structures of buried reef mounds in the underlying beds.

Chemical analyses of chip samples taken up the quarry face as indicated on the section are given in (101). The analyses indicate that the Amabel formation here exposed may be classed as a high-purity dolomite with over 97 percent total carbonates and over 20 percent magnesia.

Quarry Operation

Overburden, consisting of sand, clay, and glacial boulder till, ranges from 5 to as much as 20 feet in thickness. Due to the initial dips over reef structures in the quarriable stone, the rock surface is quite irregular and presents difficulties in stripping. Initial stripping is done by a 1½-cubic-yard, Dominion 450, diesel shovel. Final stripping of the last few feet over the irregular rock surface is done by two Bucyrus-Erie backhoes, Models 30B and 22B. Haulage of overburden is done by three 15-ton, rear-dump, Euclid trucks and two 20-ton, Euclid, belly-dump carriers. A D-8 Caterpillar bulldozer assists clean-up and makes roads for moving the rotary drill. Crushed stone is hauled by two Mack tandem trucks to fill surface irregularities for movement of the rotary drill.

Drilling of 6¾-inch holes on an 18- by 22-foot pattern is done by a Joy Heavyweight Champion rotary drill. Forcite and prilled ammonium nitrate are the blasting agents. In the quarry, stone is loaded on four 22-ton Euclid rear-dump trucks by a 4-cubic-yard Marion electric shovel for haulage to the primary crusher located on a bench at the south end of the quarry.

CRUSHING PLANT

The plant layout is indicated in (102). The primary crusher is a 42-inch Traylor gyratory crusher serviced by 50-ton and 2½-ton electric hoist. The minus 6-inch crusher product discharges to an equalizer bin, which feeds a 36-inch conveyor carrying the stone to a 10,000-ton live surge pile south of the quarry.

SECONDARY CRUSHING AND SCREENING

Two Syntron feeders discharge stone from the surge pile on a 36-inch reclaiming conveyor (No. 1) in a reclaiming tunnel under the surge pile. This stone goes to the secondary-crusher building, which houses a 6- by 14-foot, 2-deck, F900 scalping screen, a pair of 5- by 14-foot, 2-deck, F600 secondary screens, a 5½-foot, Symons standard, secondary cone-crusher, a 4¼-foot, Symons standard tertiary cone-crusher, and two Symons 3-foot shorthead tertiary cone-crushers.

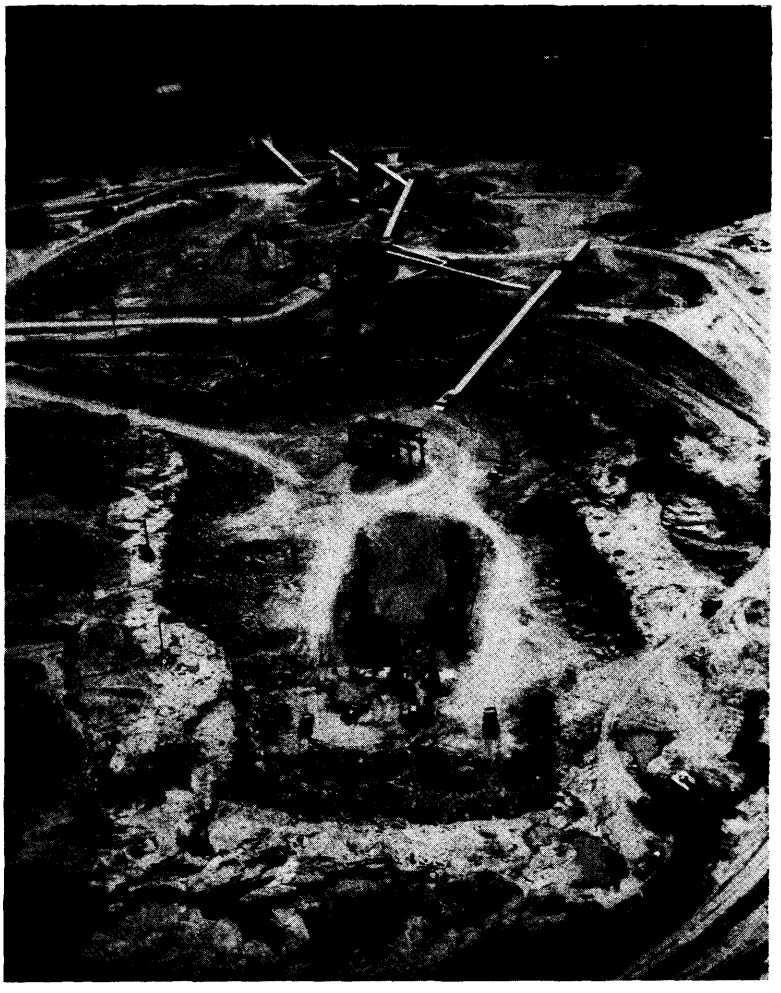
The 36-inch No. 1 conveyor discharges on the 6- by 14-foot, 2-deck scalping screen with 2½- and ⅞-inch openings. The oversize goes either to the

(101) CHEMICAL ANALYSES—NELSON CRUSHED STONE LIMITED

(Analyses by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent	percent
1	0–18	0.88	0.21	0.82	21.15	30.30	46.33	0.10	0.42	100.21
2	18–38	1.58	0.25	0.47	21.13	29.30	45.30	0.13	0.20	98.36
3	38–50	1.74	0.20	0.37	21.11	30.00	45.83	0.09	0.05	99.39

Courtesy of Nelson Crushed Stone Ltd.



An air view of the quarry and plant layout at Nelson Crushed Stone quarry in Nelson township near Waterdown. This is one of the largest quarries in Ontario. Changes in the plant, indicated in (102), are not shown in this photo, which was taken in 1955.

secondary crusher (5½-foot Symons standard cone) or is conveyed to a small screen tower housing a Tyler F600, 4- by 10-foot screen producing 6-inch stone.

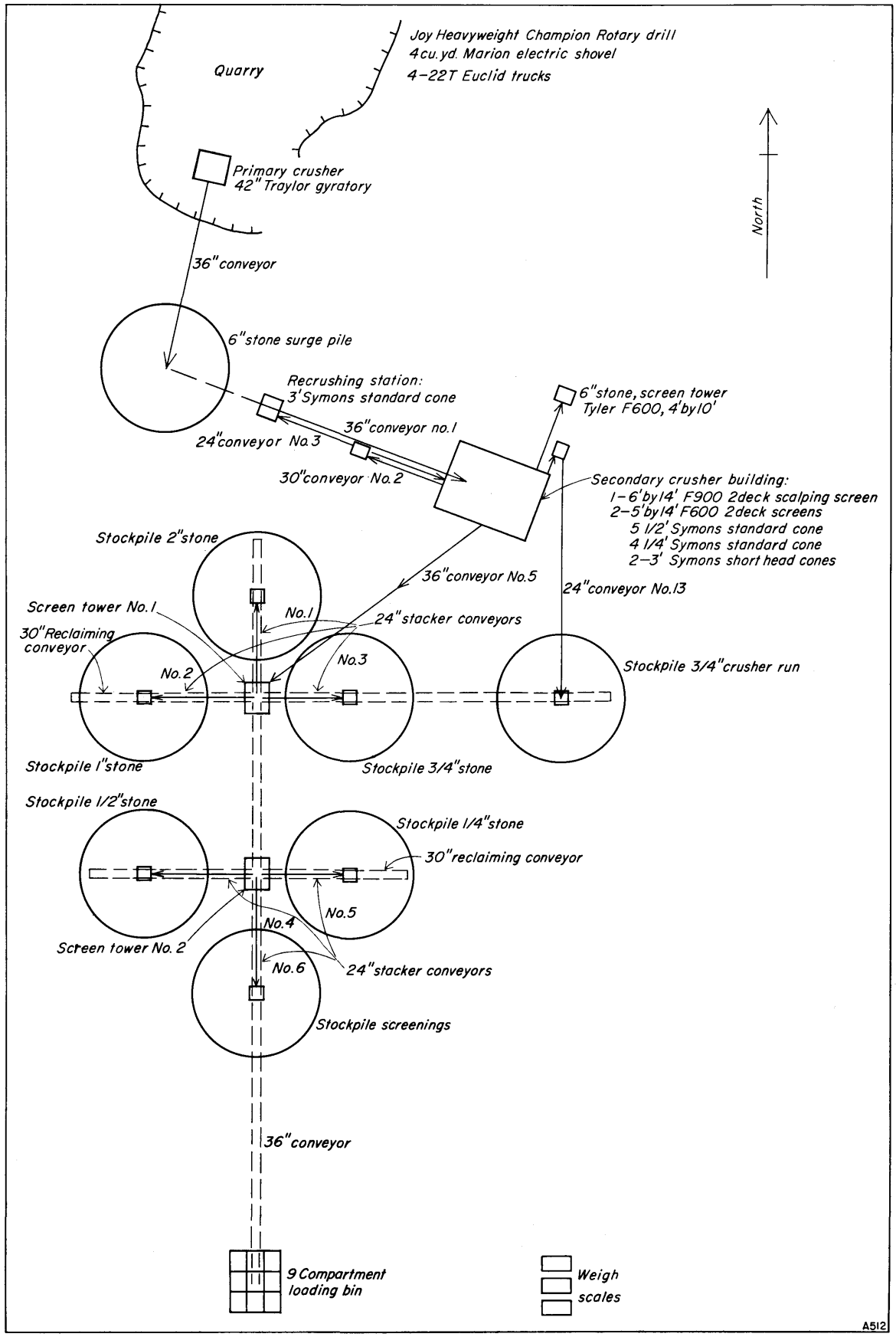
The product from the secondary crusher is returned to the secondary screens by a 30-inch, two-stage conveyor (No. 2). This flow may be diverted by a 24-inch conveyor (No. 3) to a recrushing station over the 36-inch No. 1 conveyor. This recrushing station houses a 3-foot, Symons standard cone-crusher, which discharges on No. 1 conveyor.

The 2½- by ⅞-inch stone from the bottom deck of the scalping screen can either join the secondary-crusher product going to the secondary screens or can proceed directly via the 36-inch No. 5 conveyor to No. 1 screen tower.

The minus ⅞-inch stone from the scalping screen may also go via No. 5 conveyor to No. 1 screen tower or may go via the 24-inch, No. 13 stacker conveyor to the ¾-inch crusher-run stockpile.

The pair of 5- by 14-foot, 2-deck, secondary screens have 2¾-inch openings on the top decks and 1- and 1¾-inch openings on the bottom decks.

The plus 2¾-inch stone from the top decks goes to the 4¼-foot, Symons standard cone-crusher. The 2¾- by 1-inch stone goes either to the 4¼-foot cone-crusher or to one of the 3-foot shorthead cones when a larger percentage of fines is required. The other 3-foot shorthead cone recrushes minus 1¾-inch stone, but these shortheads may be by-passed if desired. The screen throughs, if any, and the crusher products are all conveyed via No. 5 conveyor to No. 1 screen tower.


Joy Heavyweight Champion Rotary drill
4 cu. yd. Marion electric shovel
4–22T Euclid trucks
Quarry
Primary crusher
42" Traylor gyratory
North
36" conveyor
6" stone surge pile
Recrushing station:
3' Symons standard cone
6" stone, screen tower
Tyler F600, 4' by 10'
36" conveyor no. 1
24" conveyor No. 3
30" conveyor No. 2
Secondary crusher building:
1–6' by 14' F900 2 deck scalping screen
2–5' by 14' F600 2 deck screens
5 1/2' Symons standard cone
4 1/4' Symons standard cone
2–3' Symons short head cones
Stockpile 2" stone
36" conveyor No. 5
24" conveyor No. 13
Screen tower No. 1
No. 1
24" stacker conveyors
30" Reclaiming conveyor
No. 2
No. 3
Stockpile 3/4" crusher run
Stockpile 1" stone
Stockpile 3/4" stone
Stockpile 1/2" stone
Stockpile 1/4" stone
30" reclaiming conveyor
No. 5
No. 4
Screen tower No. 2
No. 6
24" stacker conveyors
Stockpile screenings
36" conveyor
9 Compartment loading bin
Weigh scales
A512

NO. 1 SCREEN TOWER

Production of three basic sizes of stone, 2-inch, 1-inch and ¾-inch stone, is accomplished by a pair of 5- by 14-foot Dillon, 3-deck screens at screen tower No. 1. The screens have 1¾-inch, 1-inch, and ⅝-inch deck openings. The top deck supplies 2-inch stone to the 24-inch No. 1 stacker conveyor, which stockpiles the 2-inch stone north of the No. 1 screen tower. The middle deck supplies 1-inch stone to the 24-inch, No. 2 stacker conveyor, which stockpiles this stone to the west of No. 1 screen tower. The lower deck supplies ¾-inch stone to the 24-inch No. 3 stacker conveyor, which stockpiles this stone to the east of No. 1 screen tower. The minus ⅝-inch throughs are conveyed south by the 30-inch No. 6 conveyor to No. 2 screen tower.

NO. 2 SCREEN TOWER

Production of three more basic sizes, ½-inch stone, ¼-inch stone, and screenings, is carried out at No. 2 screen tower by a pair of 5- by 14-foot, 2-deck, Dillon screens with ⅜- and 3/16-inch openings. The ½-inch stone from the top deck is stockpiled west of the screen tower by 24-inch stacker conveyor No. 4. The ¼-inch stone from the bottom deck is stockpiled east of the screen tower by 24-inch stacker conveyor No. 5. The screenings passing through the 3/16-inch bottom-deck screens are stock-piled by 24-inch stacker conveyor No. 6 south of the screen tower.

RECLAIMING, BLENDING, AND LOADING

Thirty-inch reclaiming conveyors are located in east-west tunnels under the stockpiles east and west of the screen towers. These feed on to a 36-inch main blending conveyor running north-south under the 2-inch stone stockpile, the two screen towers and the screenings stockpile to a 9-compartment 900-ton loading bin.

Any size of stone, or stone blended to the customer's requirements from the basic sizes, may be produced and loaded with great rapidity. Haulage is entirely by truck.

The plant has a capacity of 500 tons per hour and operates one or two shifts as required by stone sales.

LOWVILLE QUARRIES LIMITED, MOUNT NEMO

The quarry of Lowville Quarries Limited is located on the top of the escarpment at Mount Nemo, two miles southeast of Lowville and 3½ miles northwest of Nelson, which is on highway No. 5. The quarry, which is in lot 2, concession IV, Nelson township, Halton county, opened during the summer of 1958.

Geology

The 70-foot quarry face consists entirely of Amabel dolomite; this is light-buff to medium-grey in colour, light-buff- to light-grey-weathering; medium- to coarse-crystalline; irregular massive-bedded and reefy to thick-bedded; fossiliferous; crinoidal, coralline; porous in places.

The quarry is worked on an upper 50-foot lift and a lower 20-foot lift. The south face of the 50-foot lift discloses massive reef-rock with west-dipping reef flank beds. The east wall is mainly porous reef rock. The north wall is thick to massive bedded and non-reefy to partly reefy. There are a few clay seams. The lower lift appears to be massive to thick-bedded and lacks reef rock. Thin colour lamination may be present.

Quarry Operation

Overburden is thin, but the irregular surface is difficult to strip owing to reefy hummocks. The upper few feet of weathered stone is quarried separately. Drilling is done on contract, with 6-inch holes drilled on a 12- by 12-foot pattern. The blasting agents are dynamite and prilled ammonium nitrate.

Stone is loaded by a 2½-cubic-yard, Lima, diesel shovel. Haulage is by three 22-ton, rear-dump, Euclid trucks. The primary crusher is a 48- by 60-inch, Traylor jaw-crusher. The crusher product is carried by the 36-inch, No. 1 conveyor to the screening and secondary-crushing tower. The feed is split into two lines, each consisting of a 4- by 12-foot scalping screen, two 4- by 12-foot, 2-deck Dillon screens and one 4- by 12-foot, triple-deck Dillon screen.

The oversize from the 2-inch scalping screens goes to a Traylor 15-inch gyratory crusher. A 6-inch Allis-Chalmers Superior McCully gyratory crusher is used for recrushing. Sizes made are 2-inch, 1-inch, ¾-inch, ⅝-inch, and ⅜-inch stone, screenings, and 2-inch and ¾-inch crusher run. The products from the various screens go to steel bins below the screens and are stockpiled by truck. A blending belt conveyor runs under feeders from the various bins to allow blending to customers' specifications.

Plant capacity is about 350–400 tons per hour. The stone is used mainly for road construction and concrete aggregate. Transportation is entirely by truck.

MILTON QUARRIES LIMITED, MILTON

The quarry of Milton Quarries Limited is located on the brow of the escarpment 1 mile west of Milton, in lot 1, concession VII, Nassagaweya township, Halton county. The quarry was opened during the summer of 1958.

Geology

The 35- to 38-foot quarry face consists mainly of light-buff to light-grey, medium-crystalline Amabel dolomite; 4 feet of mottled blue-grey, aphanitic, medium-bedded Reynales dolomite is exposed at the base of the quarry section, and this formation forms the quarry floor.

The section is described in (103). The Reynales dolomite makes the quarry floor and is the lowermost quarriable dolomite horizon throughout the area. It ranges in thickness from 7 to 10 feet.

In the lower 6 feet of the quarry face, the typical buff, medium-crystalline, crinoidal dolomite of the Amabel formation is streaked and mottled with tones of grey. This zone of colour mottling may represent the Gasport equivalent. Rare reef-mound structures were observed in the southwest face of the quarry.

A second small quarry face, opened at the top of the hill 500 feet northwest of the main quarry, exposes up to 20 feet of thick-bedded, buff, Amabel dolomite with reef-mound structures.

Quarry Operation

Overburden is thin, ranging from 0 to 5 feet in thickness. The quarry surface is fairly regular. The 35- to 38-foot quarry face is operated in a single lift, except where it is desirable to strip off 6–8 feet of more weathered surface rock. Drilling is done by a Joy Junior Challenger drill equipped with 3-inch bits, drilling on a 6- by 6-foot pattern. Blasting agents are 40 percent Forcite and prilled ammonium nitrate. Stone is loaded by a Northwest Model 6, 1½-cubic-yard, diesel shovel. A Dominion 400 shovel is on standby duty and is equipped with a 1-cubic-yard bucket. Haulage is done by two 22-ton, rear-dump, Euclid trucks.

CRUSHING PLANT

Stone is dumped on a 5- by 8-foot Jeffrey feeder feeding the primary crusher, a 40- by 48-inch, Rogers jaw-crusher. A two-stage interchange conveyor carries the crusher product to a Symons vibrating bar grizzly with 2$\frac{1}{16}$-inch openings. The oversize feeds to a B21 Babbitless, 21-inch, gyratory crusher set at 2¼ inches. The grizzly throughs and the secondary-crusher product go via the 30-inch No. 1 conveyor to the 9,000-ton 2-inch-stone surge pile.

A 30-inch conveyor in a reclaiming tunnel carries the stone to a splitter. From the splitter, 2-inch crusher run may be conveyed to a storage bin. All or part of the flow may proceed via another 30-inch conveyor to the secondary-crusher building for scalping and crushing.

SECONDARY-CRUSHER BUILDING

The stone discharges on a 5- by 12-foot, Babbitless, 2-deck screen with 1½- and ⅝-inch openings. The ⅝-inch throughs are conveyed either to the ⅝-inch crusher-run bin or to the screen tower. The plus 1½-inch stone and the 1½- by ⅝-inch stone go into bins that feed the three tertiary crushers.

The three tertiary crushers are Model 504 Babbitless, 4-inch, gyratory crushers set at 1 inch. The product of these crushers is conveyed to the screen tower.

SCREEN TOWER

Screening is carried out by two 2-deck, 5- by 12-foot, Babbitless screens, which produce the following sizes:

1-inch, ¾-inch, ½-inch, ⅜-inch stone, and screenings. Five bins are provided for these five sizes. Feeders on the south side of the bins feed conveyors to 5 concrete silos, each of 400-ton capacity, standing south of the screen tower. Feeders on the north side of the bins feed a 24-inch collecting conveyor, which transfers to a 24-inch radial stacker conveyor, which stockpiles stone to the north of the screen tower.

The plant was designed in France. Operation of all equipment is controlled from a central control panel. The plant capacity is about 300 tons per hour.

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(103) QUARRY SECTION—MILTON QUARRIES LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
AMABEL FORMATION	Dolomite: light grey to buff, buff weathering; medium to coarsely crystalline; massive to medium bedded; regular bedded with rare reef facies; crinoidal.....	31.0
REYNALES FORMATION	Dolomite: mottled light and medium grey, blue grey tones; buff weathering; aphanitic; medium bedded; streaky shale partings.....	4.2

GYPSUM, LIME & ALABASTINE LIMITED (MILTON QUARRY AND LIME PLANT, MILTON)

(A Division of Dominion Tar & Chemical Co. Ltd.)

The Milton quarry and lime plant of Gypsum Lime & Alabastine Limited are located on the edge of the escarpment 3 miles from Milton, south of the Canadian Pacific railway line in lot 3, concessions VI and VII, Nassagaweya township, Halton county.

Geology

The 60- to 90-foot quarry face exposed along the north-facing scarp consists of light-buff to medium-light grey, medium-crystalline, thick- to massive-bedded, crinoidal dolomite of the Amabel formation. It is in part irregularly-bedded, vuggy reef facies. The lower 8 feet of this formation is bluish-grey in colour, but otherwise very similar in lithology to the overlying dolomite. Bolton (p. 95, section 31) suggests this may possibly be Irondequoit equivalent. The floor of the quarry exposes 6 feet of medium-grey mottled, aphanitic, thin- to medium-bedded Reynales dolomite in sharp contact with the overlying Amabel formation.

A chemical analysis representing the 80-foot quarry face at the property is given by Goudge (p. 242) in (104).

Quarry Operation

The quarry is operated in a single lift. Overburden is thin, ranging from 1 to 5 feet in thickness. Drilling is done by churn-drill. A considerable abount of secondary blasting is carried out. Kiln stone, in man-sized blocks 5 inches to 12 inches in diameter, is hand-loaded into skips or boxes, which are hauled by truck to the kilns. Secondary breaking to man-sized blocks is done by hand-sledging.

Lime Plant

The lime plant consists of three coal-fired vertical kilns having a total capacity of 50 tons per 24 hours.

HALTON CRUSHED STONE LIMITED, MILTON

The quarry of Halton Crushed Stone Limited is located on the brow of the Niagara escarpment, 4 miles west of Milton, in lot 8, concession VI, Nassagaweya township, Halton county. This quarry began operation in the summer of 1959.

Geology

The quarry face exposes up to 40 feet of Amabel dolomite. The dolomite is buff to light-grey in colour, buff-weathering, medium crystalline, crinoidal, medium to thick and irregularly bedded, reefy, stylolitic, and fossiliferous. Due to the reefy character of the section, bedding is irregular or poorly developed. Massive-bedded units may form large blocks during blasting operations. Both the quarry floor and the quarry surface tend to be irregular and humpy owing to the reef mounds. Dark-grey coloration patches and sulphides are rare.

Quarry Operation

Overburden in the quarry area ranges in thickness from a few inches up to over 20 feet. A 40-foot face is operated, but plans are to increase the face to 60 feet. Drilling was being done at the time of the author's visit in November, 1959, by a Joy Challenger drill equipped with 4-inch bits. Air was supplied by a 600-cubic-feet-per-minute Chicago Pneumatic compressor. However a Joy Heavy-weight Champion drill has been purchased and is expected to go into operation shortly. Stone is loaded by a Lima 3½-cubic-yard diesel shovel. Five 22-ton Euclid rear-dump trucks haul the stone to the primary crusher and stockpile the products.

The stone is dumped on a 43-inch by 14-foot feeder, which feeds a double vibrating grizzly, which removes minus 2-inch fines and any dirt from the quarry stone. The oversize from the grizzly feeds a 40- by 50-inch, Cedarapids impact mill. The product from the impact mill goes via 36-inch conveyor to a surge pile. Stone from the

(104) CHEMICAL ANALYSIS—GYPSUM, LIME & ALABASTINE LIMITED

(Analysis from Goudge, p. 242)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	CaO	MgO	S	Total
289.....	percent 0.38	percent 0.48	percent trace	percent 0.04	percent 55.11	percent 43.25	percent 30.88	percent 20.68	percent 0.04	percent 99.26

surge pile is conveyed to the screen and bin tower where it passes over a Tyler 5- by 10-foot, 2-deck scalping screen with 2¼- and 1¾-inch openings. The oversize goes to a 4¼-foot Symons standard cone for secondary crushing, and the crusher product is returned to the scalping screen by transfer conveyor. The discharge from the scalping screen is split and goes to two screen lines, each consisting of one 4- by 12-foot, 2-deck screen and one 4- by 14-foot, 2-deck screen. The sized products from these two sets of screens go to seven steel bins below the screens. Provision will be made for blending and recrushing from the bins.

Plant capacity is expected to be about 500 tons per hour.

ARMSTRONG BROTHERS COMPANY LIMITED (GEORGETOWN QUARRY), GEORGETOWN

The Georgetown quarry of Armstrong Brothers Company Limited, opened during the summer of 1958, is located 3 miles west of Georgetown and ½ mile west of highway No. 7 in lot 24, concession VII, Esquesing township, Halton county.

Geology

The quarry is worked in two lifts. The upper lift, 24–39 feet in height, consists entirely of light-grey to light-buff, medium-crystalline to aphanitic, medium- to thick-bedded, crinoidal, Amabel dolomite. It is in part porous and fossiliferous, but reefs are rare and of minor size and extent. Two small reefs, 5–6 feet in height and 20 feet across, were noted in the north quarry face.

The lower lift was flooded at the time of the author's visit, but conversation with the quarry superintendent and examination of stone from the lower lift, indicated that the lower 15-foot lift consists of 10 feet of Amabel dolomite, underlain by about 5 feet of medium-grey aphanitic Reynales dolomite. This formation forms the lower limit of quarriable dolomite and is underlain by shale and sandstone of the Clinton and Cataract groups.

A chemical analysis of a composite chip sample of the upper 20 feet of the upper lift exposed at the time of the author's first visit to the property is given in (105).

Quarry Operation

Drilling is done by three wagon drills drilling 1½-inch holes on a 4- by 5-foot pattern and one Chicago Pneumatic drill drilling 2¾-inch holes on a 7- by 6-foot pattern. The blasting agent is Dupont 50-percent gelatin. Air is supplied by two 600-cubic-foot-per-minute Jaeger compressors. Stone is loaded by a Link-Belt 1½-cubic-yard diesel shovel onto four 15-ton rear-dump Euclid trucks, which haul to the Cedarapids portable crushing plant. Three 15-ton Euclid trucks are used on stockpiling.

This crushing plant, with a capacity of 240 tons per hour, produces 3,000–3,500 tons per day. It consists of a 32- by 42-inch Cedarapids jaw-crusher, a 4- by 12-foot, 2-deck scalping screen, a 4¼-foot Symons secondary cone-crusher, a 4- by 14-foot triple-deck screen and 5 bins, each feeding a truck-loading conveyor. A vibrating grizzly in advance of the jaw-crusher removes dirt and fines from the quarry-run stone. The stone is mainly used for road construction and aggregate.

LIMEHOUSE CRUSHED STONE AND GRAVEL LIMITED, GEORGETOWN

The quarry of Limehouse Crushed Stone and Gravel Limited is located north of Georgetown on the east side of highway No. 7 at Silver Creek, in lot 27, concession VIII, Esquesing township, Halton county.

The 15-foot quarry face consists of light-buff to light-grey, medium-crystalline, medium- to thick-bedded, crinoidal dolomite of the Amabel formation. The face is in part composed of irregular massive reefstone with off-reef flank beds showing initial dips up to 5°–10°, and in part, of even-bedded interreef beds.

At the time of the author's visit the quarry was inactive. A portable crushing plant was used during quarry operation.

(105) CHEMICAL ANALYSIS—ARMSTRONG BROTHERS COMPANY LIMITED

(Analysis by the Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Depth Below Surface	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent	percent
1.....	0–20	0.64	0.39	0.76	21.20	30.00	46.42	0.19	0.02	99.62

(106) CHEMICAL ANALYSIS—INDUSTRIAL SAND AND GRAVEL COMPANY LIMITED

(Analysis by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	percent	percent	percent	percent	percent	percent	percent	percent	percent
1	0.54	0.38	0.73	21.00	31.20	47.02	0.13	trace	101.00

INDUSTRIAL SAND AND GRAVEL COMPANY LIMITED (GLEN WILLIAMS QUARRY), GEORGETOWN

The Glen Williams quarry of Industrial Sand and Gravel Company Limited is located 2 miles northwest of Glen Williams, on an outlier of the escarpment in lot 26 or 27, concession IX, Esquesing township, Halton county.

Geology

The 35-foot quarry face consists of 30 feet of white to light-buff, white-weathering, medium-crystalline, massive irregularly bedded, crinoidal dolomite of the Amabel formation, underlain by 5 feet of light-grey to dark-grey streaked, aphanitic, medium-bedded, shaly Reynales dolomite. Some of the Amabel dolomite is porous and reefy, medium-dark-grey dolomite.

A chemical analysis of a composite chip sample of the 35-foot quarry face is given in (106).

Quarry Operation

The quarry surface is irregular and difficult to strip by bulldozer. However overburden is generally light, 1–14 feet thick. The 35-foot quarry face is drilled on contract by rotary drill. Stone is loaded on two 15-ton, rear-dump Euclid trucks by a 1½-cubic-yard Northwest shovel for haulage to the crushing plant.

The Cedarapids aggregate plant used at this quarry consists of a feeder, jaw-crusher, conveyor, impact crusher, conveyor, screens, and bins. Sizes produced are 2-inch stone, ¾-inch stone, screenings, and ¾-inch crusher run. The plant capacity is about 100 tons per hour, and the production is mainly used for road construction. Haulage is entirely by truck. A front-end loader is employed to load trucks from the stockpiles. The operation is seasonal.

ROCKWOOD LIME COMPANY LIMITED, ROCKWOOD

The quarries and lime plant of Rockwood Lime Company Limited are located ½ mile northeast of Rockwood village in concession V, Eramosa township, Wellington county.

Geology

Two small quarries have been opened up in hillsides on the property. At the quarry at present in operation the face has a maximum height of 30 feet and is worked in irregular 10-foot benches. The quarry rock is light-buff to medium-grey, irregularly-bedded, reefy, fine- to coarsely-crystalline, crinoidal dolomite of the Amabel formation. The section is quite reefy and therefore somewhat variable; in part the stone is porous and fossiliferous; in places shaly, dark-grey patches and irregular impure sections of dolomite occur. Reef flank beds with dips of 10°–15° may be seen in several places in the quarry faces.

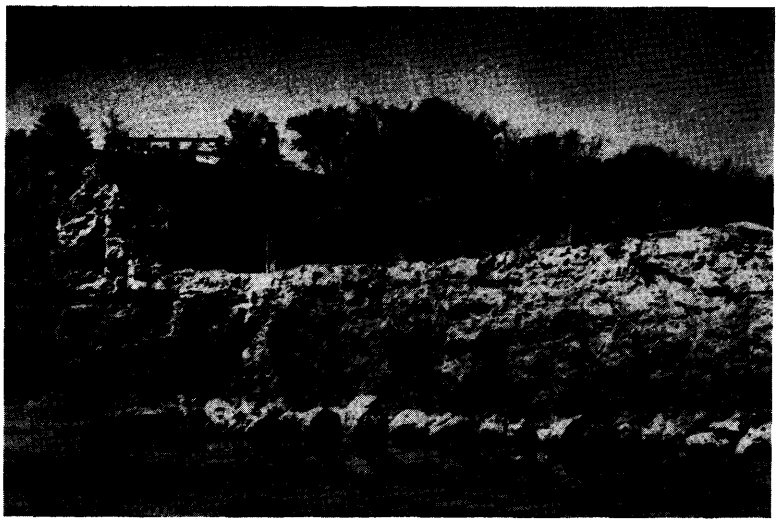
Quarry Operation

The 30-foot quarry face is drilled off in 10-foot benches by a wagon drill with a 1½-inch bit drilling holes on an irregular 4- by 4-foot pattern as required. A 105-cubic-foot-per-minute Schram compressor supplies air for the drill. After secondary drilling is done, the oversized is hand broken and loaded on two 5-ton dump trucks by an Allis-Chalmers 1½-cubic-yard front-end shovel and hauled from the quarry to a screening plant.

The screening plant consists of a 12-inch bar grizzly, which feeds via a hopper into a 42-inch by 8-foot trommel screen with 3-inch openings. The 12- by 3-inch stone from the trommel is kiln feed, which goes to a bin. The minus 3-inch stone goes to a second bin and is sold for road construction or fill.

Lime Plant

The kiln feed from the bin is trucked to the lime plant where it is charged at the top of two 6- by 9-foot by 46-foot, vertical draw kilns. The two kilns have a total capacity of 35 tons per 24 hours. The grey dolomitic lime is used as mason's lime in the building trade, and for brick and block.



A 50-foot quarry face of reefy Guelph dolomite is quarried at Glen Christie by Gypsum Lime & Alabastine for the manufacture of lime.

GYPSUM, LIME & ALABASTINE LIMITED (GLEN CHRISTIE QUARRY AND LIME PLANT, HESPELER)

(A Division of Dominion Tar & Chemical Co. Ltd.)

The Glen Christie quarry and lime plant operated by Gypsum Lime & Alabastine Limited is located 3 miles north of Hespeler at Glen Christie on the Speed River, in lots 1–4, concession IV, Puslinch township, Wellington county. The quarry is served by truck and rail transportation, being located on highway No. 24 and the Canadian National railway line.

Geology

The 78-foot section, exposed east of the railway line along the west quarry face, consists entirely of Guelph dolomite, and may be divided into two members, an upper 26 feet of well-bedded, light-creamy-buff, light-buff-weathering, aphanitic to fine-crystalline, thick-bedded, vuggy dolomite, and a lower 52-foot unit of massive to reefy, irregularly-bedded dolomite, light-creamy-buff, light-buff-weathering, aphanitic to fine-crystalline, vuggy, in part rusty, porous, and fossiliferous. The lower unit is typical Guelph reef facies, with some reef flank beds with initial dips of 10°–15°. Coquinoid coralline areas are common; in some places the reef facies is thin bedded, with abundant white fucoids.

Texture and porosity vary somewhat from the massive reefy facies to the even-bedded facies, although the entire section is of high purity.

Chemical analyses of diamond-drill hole No. 1, located at the northwest corner of the quarry face, were kindly supplied by Gypsum, Lime and Alabastine Company and are given in (107).

The upper 25 feet comprises the upper unit of the quarry section already described. From 25–110 feet the dolomite is buff to grey-green and of high purity. From 110–54 feet the blue-grey, porous, reefy dolomite shows a somewhat higher iron oxide content.

Quarry Operation

Although there is a maximum section 78 feet in height along the quarry floor along the west wall adjacent to the railway line, the average quarry face being advanced to the northeast has a height of 47–50 feet above the quarry floor, and consists entirely of the massive, irregularly-bedded, Guelph dolomite reef facies. Overburden within the Speed River valley, where the quarry is located, is thin. The 50-foot quarry face is drilled by an electric churn-drill boring 6-inch holes on a 12- by 14-foot pattern. The blasting agents are 40-percent and 70-percent Dynamex. Secondary breaking is done by a drop-ball attachment on the shovel. A diesel, 1½-cubic-yard shovel loads two trucks with 8-ton rear-dump bodies, which haul the stone to the primary crusher.

Crushing Plant and Lime Plant

The primary crusher is a 30-inch gyratory. The product is conveyed to a 2-deck, 4- by 8-foot, scalping screen with 5-inch and 2½-inch square openings. The minus 2½-inch stone is not used for lime and goes to a secondary impact crusher to yield crushed stone and agricultural lime.

The plus 5-inch stone from the scalping screen forms kiln feed for eight vertical, coal-fired, stack kilns. The 5- by 2½-inch stone from the scalping

(107) CHEMICAL ANALYSES—GYPSUM, LIME AND ALABASTINE LIMITED

(Analyses of Drill Hole No. 1 supplied by the company)

Depth	CaO	MgO	Fe_2O_3	SiO_2 plus Insolubles
feet	percent	percent	percent	percent
2 – 10	31.10	21.25	0.10	0.02
10 – 20	31.00	21.55	0.10	0.02
20 – 25	31.00	21.40	0.10	0.10
25 – 31.5	31.00	21.25	0.09	0.04
31.5– 41.2	31.05	21.18	0.09	0.03
41.2– 50.0	31.05	21.19	0.10	0.09
50.0– 60.0	31.05	21.40	0.11	0.14
60.0– 72.0	31.25	21.15	0.13	0.16
72.0– 82.4	31.10	21.40	0.09	0.05
82.4– 90.0	31.10	21.17	0.12	0.21
90.0–100.0	31.05	21.52	0.12	0.13
100.0–110.0	30.90	21.22	0.12	0.20
110.0–115.0	30.95	21.35	0.17	0.45
115.0–123.0	31.00	21.33	0.17	0.40
123.0–130.0	31.05	21.28	0.17	0.36
130.0–141.0	30.65	21.52	0.17	0.51
141.0–153.0	30.50	20.95	0.30	1.85
153.0–154.0	30.90	21.14	0.20	0.79

screen forms kiln feed for two gas-fired, vertical stack kilns. The plant has a rated capacity of about 220 tons of lime per 24 hours.

The quarry and crushing plant is rated at about 100 tons per hour. High-quality white hydrated lime and quick lime are produced.

CANADIAN GYPSUM COMPANY LIMITED (GUELPH QUARRY AND LIME PLANT, GUELPH)

The Guelph quarry and lime plant of Canadian Gypsum Company Limited is located on highway No. 24, on the southwest outskirts of the city of Guelph, on the east side of the Speed River, in Guelph township, Wellington county.

Geology

The 42-foot quarry face, operated in two 21-foot lifts, consists of light-buff Guelph dolomite. The upper lift is light-creamy-buff, fine-crystalline, massive- to medium-bedded dolomite. The lower lift is white, aphanitic, medium- to irregularly-bedded dolomite. The quarry floor is medium-brownish, aphanitic dolomite with some bituminous material. This is assigned to the Eramosa beds of the Amabel (Lockport) formation.

The quarry surface is irregular and rolling, but there is a good quarry floor.

A chemical analysis of the light-buff dolomite quarried by Canadian Gypsum Company, as given by Goudge (p. 296), is shown in (108).

Quarry Operation

Overburden is thick, ranging from 25–27 feet in depth. The two 21-foot lifts are drilled on a 9- by 9-foot pattern by an Ingersoll-Rand wagon drill equipped with 2½-inch bits. Dynamite and prilled ammonium nitrate are the blasting agents. Stone is loaded on a 10-ton Euclid and a 15-ton Euclid truck by a 1½-cubic-yard, Bucyrus-Erie diesel shovel.

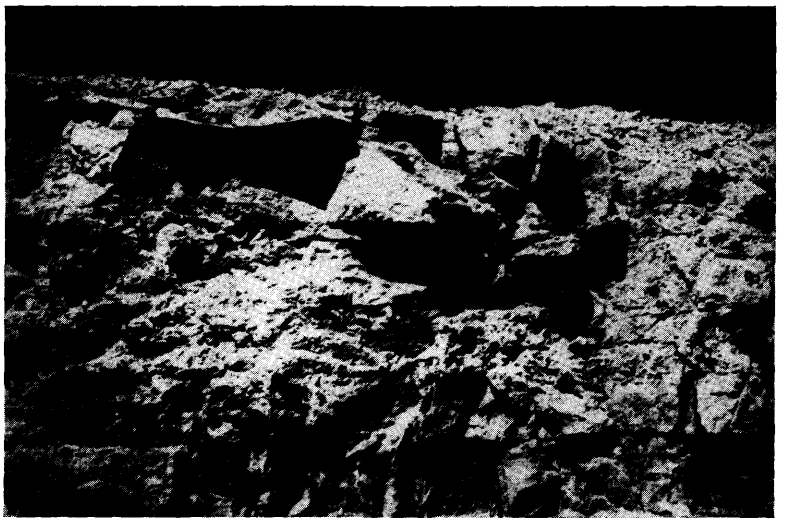
The stone goes through the primary crusher and by 30-inch conveyor to the rock surge pile. From the surge pile it is conveyed to a 2-deck scalping screen with 3½- and 1½-inch openings. The plus 3½-inch stone (3½- to 12-inch) forms kiln feed for the 13 vertical stack kilns. These kilns are coal fired and have a total capacity of 225–50 tons per 24 hours.

The minus 3½-inch stone is used for crushed stone. The quarry produces about 100 tons of stone per hour.

(108) CHEMICAL ANALYSIS—CANADIAN GYPSUM COMPANY LIMITED

(Analysis from Goudge, p. 296)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
	percent	percent	percent	percent	percent	percent	percent	percent	percent
283	0.28	0.17	0.07	56.07	43.10	99.69	0.01	31.42	20.61



The quarry face of the Canadian Gypsum Company quarry at Guelph shows massive irregularly bedded reef rock of the Guelph dolomite formation.

PUSLINCH DRILLING

In 1957 diamond-drilling was carried out on a dolomite property in lots 27 and 28, gore of Puslinch township, Wellington county. The property is on the Canadian Pacific railway line, 2½ miles west of Puslinch and is served by rail and road transportation. The property is just west of the old Christie Henderson Company lime kiln in lot 29. Overburden is light.

Two diamond-drill holes were drilled, No. 1 located north of the railway, and No. 2 south of the railway. J. D. Campbell of Ingersoll kindly allowed the author to examine the drill core (see section (109)) and furnished chemical analyses of drill hole No. 1 (110).

The chemical analyses indicate that the Guelph dolomite and upper few feet of Eramosa dolomite to a depth of about 60 feet are of high purity and suitable for chemical and flux stone. The content of organic matter rises at the Eramosa contact at 42 feet.

The Guelph dolomite is somewhat softer than the underlying Eramosa dolomite, as indicated by the following results of the Los Angeles abrasion tests on the core: Guelph dolomite, 35.2 percent loss L.A.; Eramosa dolomite, 20.1 percent loss L.A. Magnesium sulphate soundness tests; five cycles, indicated 4.2 percent loss for the Guelph dolomite, 2.6 percent loss for the Eramosa beds.

OWEN SOUND–WIARTON AREA

In the Owen Sound–Wiarton area the only commercial quarry operations are four small building-stone quarries producing ashlar, sills, flagstone, and random flagstone from the thin-bedded Eramosa member of the Amabel (Lockport) dolomite.

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(109) SECTION—PUSLINCH DRILLING

DESCRIPTION	DEPTH Feet
DIAMOND-DRILL HOLE NO. 1	
Overburden and loose boulders	0–5
Guelph Dolomite: light buff to creamy; fine crystalline to aphanitic; massive bedded; in part porous and vuggy	5–42
Eramosa Dolomite: medium-brown to medium dark brown; fine-crystalline to aphanitic; fine laminations with black shaly and bituminous partings	42–90
	Feet
DIAMOND-DRILL HOLE NO. 2	
Guelph Dolomite: light buff to creamy buff; medium to fine crystalline; massive bedded; porous to vuggy in part	0–42
Eramosa Dolomite: medium brown, black banding; aphanitic; medium to thin bedded; black shaly and bituminous partings	42–90

Thin-bedded Eramosa dolomite is quarried for ashlar, flagstone, and sills in several small quarries near Wiarton. Note the stone saw in the foreground. Near the top of the quarry face a 12-inch-thick biostrome or bed of reef rock can be seen.

The quarry of Owen Sound Ledgerock Company is located west of highway No. 6, north of Owen Sound.

The quarry face consists of 5–6 feet of thin-bedded, brown, aphanitic dolomite in 1- to 2-inch beds. The stone is quarried by hand and trimmed in a guillotine.

The quarries of J. S. Cook, Bruce Peninsula Stone Quarries, and Ebel Quarry are located on the Oliphant road west of Wiarton.

The quarry faces are 4–8 feet in height. The thin-bedded, brown, aphanitic Eramosa dolomite is in beds 1½–8 inches thick. The stone is generally quarried by hand using an electric circular stone saw to cut the stone in the beds. Plugs and feathers and crowbars are also used to divide and move the beds of stone.

Summary

As indicated in (111) the Guelph and Amabel formations and parts of the Lockport formation are high-purity dolomite. Shaly facies of the Eramosa member of the Lockport, and cherty facies of the Goat Island member of the Lockport, may be quite impure. Dolomite of unusually high purity is available in parts of the Guelph formation.

For use as crushed stone, cherty and shaly facies of the Lockport are undesirable, but shale-free Eramosa dolomite and chert-free Goat Island dolomite make a good aggregate. Parts of the Gasport dolomite may be somewhat soft. The Amabel dolomite, due to its reefy character in places, may be somewhat soft, with the losses in the Los Angeles abrasion test ranging from 21 to 35 percent.

(110) CHEMICAL ANALYSES—PUSLINCH DRILLING

(Analyses by the Warnock Hersey Company Limited, by permission of J. D. Campbell)

Depth	SiO_2	Fe_2O_3 + Al_2O_3	$CaCO_3$	$MgCO_3$	S	Organic Matter
feet	percent	percent	percent	percent	percent	percent
5–10	0.42	0.23	54.05	44.85	0.03	0.01
10–20	0.58	0.41	55.55	43.26	0.03	0.03
20–30	0.48	0.37	54.55	44.33	0.02	0.08
30–40	0.11	0.19	54.38	44.82	0.02	0.07
40–50	0.42	0.33	54.19	44.56	0.04	0.25
50–60	0.76	0.39	54.21	44.07	0.09	0.31
60–70	3.64	0.55	51.15	41.72	0.27	1.51
70–80	8.39	1.16	48.58	39.08	0.31	1.16
80–90	5.79	0.90	51.75	39.64	0.27	0.50

(111) CHEMICAL ANALYSES—GUELPH-LOCKPORT-AMABEL FORMATIONS IN ONTARIO

Location	Stratigraphic Unit	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO
		percent	percent	percent	percent	percent
Queenston	Gasport member (25 ft.)	1.92	1.28	0.97	36.75	13.56
Thorold	Gasport member (24 ft.)	1.91	1.23	1.12	34.50	16.22
Vineland	Gasport and Goat Island members (35 ft.)	3.02	0.78	1.76	29.95	20.09
Stoney Creek	Eramosa dolomite (20 ft.)	4.27	0.79	1.71	29.40	19.83
Dundas	Eramosa dolomite (40 ft.)	0.65	0.80		30.01	20.7
Nelson Crushed Stone	Amabel dolomite (50 ft.)	1.40	0.55	0.22	29.87	21.13
Milton (Gypsum, Lime and Alabastine)	Amabel dolomite (80 ft.)	0.38	0.48	trace	30.88	20.68
Georgetown	Amabel dolomite (20 ft.)	0.64	0.76	0.39	30.00	21.20
Glen Williams	Amabel dolomite (35 ft.)	0.54	0.73	0.38	31.20	21.00
Glen Christie	Guelph dolomite (90 ft.)	*0.09	0.10	.....	31.07	21.29
Guelph	Guelph dolomite	0.28	0.17	0.07	31.42	20.61

*Includes insolubles.

5. BOIS BLANC LIMESTONE AND BERTIE–AKRON DOLOMITE

The Devonian Bois Blanc cherty limestone and the underlying Silurian Bertie-Akron dolomite are quarried commercially by ten operators in the Fort Erie–Port Colborne–Hagersville area. Four of the quarries, Ridgemount Quarries, Canada Cement Company (Port Colborne), Canada Crushed and Cut Stone (Hagersville), and Hagersville Quarries Limited, quarry only the Bois Blanc cherty limestone. However the other six operators, Geo. C. Campbell Limited, Niagara Crushed Stone (Humberstone) Limited, R. E. Law Crushed Stone Limited, Dunnville Quarries Limited, Cayuga Quarries Limited, and Haldimand Quarries Limited, quarry both the Bois Blanc cherty limestone and the underlying Bertie-Akron dolomite. These formations are therefore dealt with together. The largest quarry centre is at Hagersville where Hagersville Quarries, Canada Crushed and Cut Stone, and Haldimand Quarries are located.

The Bertie-Akron dolomite and overlying Bois Blanc limestone form a south- and southwest-dipping band of bedrock outcrop, 4–12 miles wide, extending from Fort Erie through Port Colborne, Hagersville, Woodstock, Listowel, Palmerston, and Walkerton to Port Elgin on Lake Huron. There are at present no commercial quarry operations northwest of Hagersville in these formations. The outcrop area of the Bertie-Akron and Bois Blanc formations are shown on Map No. 1062A, Geological Map of Southwestern Ontario, published by the Geological Survey of Canada in 1958.

For the ten quarries examined by the author, see Bois Blanc and Bertie-Akron Sections in map case.

Bertie–Akron Dolomite (Bass Island Equivalent)

The Bertie-Akron dolomite is the uppermost formation of the Silurian system in the Niagara Peninsula, and rests on the underlying Salina shale and shaly dolomite. The lower contact is not exposed in any quarries visited. There is an erosional unconformity between the Bertie-Akron dolomite and the overlying Middle Devonian Bois Blanc cherty limestone, and a complete Bertie-Akron section is not generally present. The upper contact is exposed in several quarries. The Bertie-Akron formation has a thickness of 35–60 feet. The thickest Bertie-Akron section exposed in the quarries is 54 feet, at Cayuga Quarries. The dolomite forms a band, 1–2 miles wide, extending from Fort Erie west through Dunnville and Hagersville to Southampton on Lake Huron. It dips to the south or southwest.

As indicated on the accompanying series of sections (map case), the Bertie-Akron formation can be divided into four units: the lowermost unit is medium-brown, massive- to medium-bedded, aphanitic dolomite, up to 20 feet thick; above this there is a dark-greyish brown, thin-bedded, shaly dolomite unit 6–12 feet thick. This shaly unit is persistent and can be seen in every quarry section except at Niagara Crushed Stone (Humberstone) where the section is not deep enough to uncover this unit. Above the shaly unit in the Fort Erie–Port Colborne area, the upper 12–18 feet consists of a lower massive-to-laminated, brown dolomite and an upper buff mottled, aphanitic dolomite. To

the west, at Dunnville, Cayuga, and Hagersville, the two upper units consist of massive to mottled or laminated brown dolomite, overlain by light-buff to laminated, buff, aphanitic dolomite.

The upper 10–20 feet of Bertie-Akron light-buff dolomite frequently contains thin sandy interbeds, possibly indicating a change from chemical to clastic sedimentation in a shallowing sea before the advent of the epoch during which the Lower Devonian Oriskany beach sand was laid down. The Oriskany and Springvale sandstones may represent weathering and reworking of the sandy facies in the upper Bertie-Akron in this area.

Bois Blanc Limestone[1]

The Bois Blanc formation is of Middle Devonian age and rests unconformably on the Upper Silurian Bertie-Akron dolomite. The Lower Devonian Oriskany sandstone is absent through most of the area, being present only in Oneida and North Cayuga townships near Nelles Corners. The Bois Blanc formation extends in a band, 3–10 miles wide, extending from Fort Erie, through Hagersville and Woodstock to Port Elgin on Lake Huron. The thickness of the formation is 90–100 feet at Selkirk (south of Cayuga), 102 feet at Norwich, 125 feet at Ingersoll, 195 feet at St. Marys, and 240 feet at Teeswater, to 220 feet at Inverhuron.[2] It thickens to the northwest.

The Bois Blanc formation is present in all ten quarries examined in the Fort Erie–Hagersville area, the maximum exposed thickness is 39 feet at Ridgemount Quarries Limited.

The Bois Blanc formation consists mainly of medium-brownish grey to greenish-grey, light-grey-weathering, medium-crystalline, medium- to irregularly thin-bedded, highly fossiliferous, cherty limestone. The limestone may be silty, argillaceous, or sandy in places.

[1]For a complete detailed description of the Bois Blanc formation, see E. W. Best, *Pre-Hamilton Devonian Stratigraphy of Southwestern Ontario*, unpublished Ph.D. thesis, University of Wisconsin, 1953.

[2]E. W. Best, *op. cit.*

The basal member of the Bois Blanc formation is frequently a greenish, glauconitic, sandy unit. The sandstone, known as the Springvale sandstone member, is not always present as a distinct unit, but frequently the lower few feet of Bois Blanc cherty silty limestone contains sandy, greenish, glauconitic beds. Sometimes the glauconitic sandstone layers occur several feet above the lower Bois Blanc contact.

The Bois Blanc limestone is extremely fossiliferous, with cup corals being unusually abundant. At the Canada Cement Company quarry at Port Colborne, the variable lithology of the Bois Blanc limestone may be readily seen. Here, greyish-green, silty to shaly, magnesian limestone appears on the southwest side of the quarry. This gives way to the normal cherty, thin to medium irregularly bedded, Bois Blanc limestone. Coral biostromes, 6–8 feet thick and flatly lenticular in shape, form lenses of high-purity limestone in the quarry face.

At Hagersville four units are recognizable in the Bois Blanc formation: a lower sandy, shaly, glauconitic, cherty, silty limestone, up to 6 feet thick; a lower cherty limestone member, 12–14 feet thick; a middle limestone member relatively chert-free, 6–12 feet thick; and an upper cherty limestone member, of which 12–13 feet is exposed in the quarries.

Some of the lower Bois Blanc formation is nominally a limestone, but consists of chert beds 3–5 inches thick. At the Niagara Crushed Stone (Humberstone) quarry the silica content of the 9 feet of Bois Blanc formation sampled by the author is 67.82 percent. Chert occurs both in layers and nodules and frequently replaces fossils.

Quarries and Geological Sections

GEORGE C. CAMPBELL COMPANY LIMITED, RIDGEMOUNT

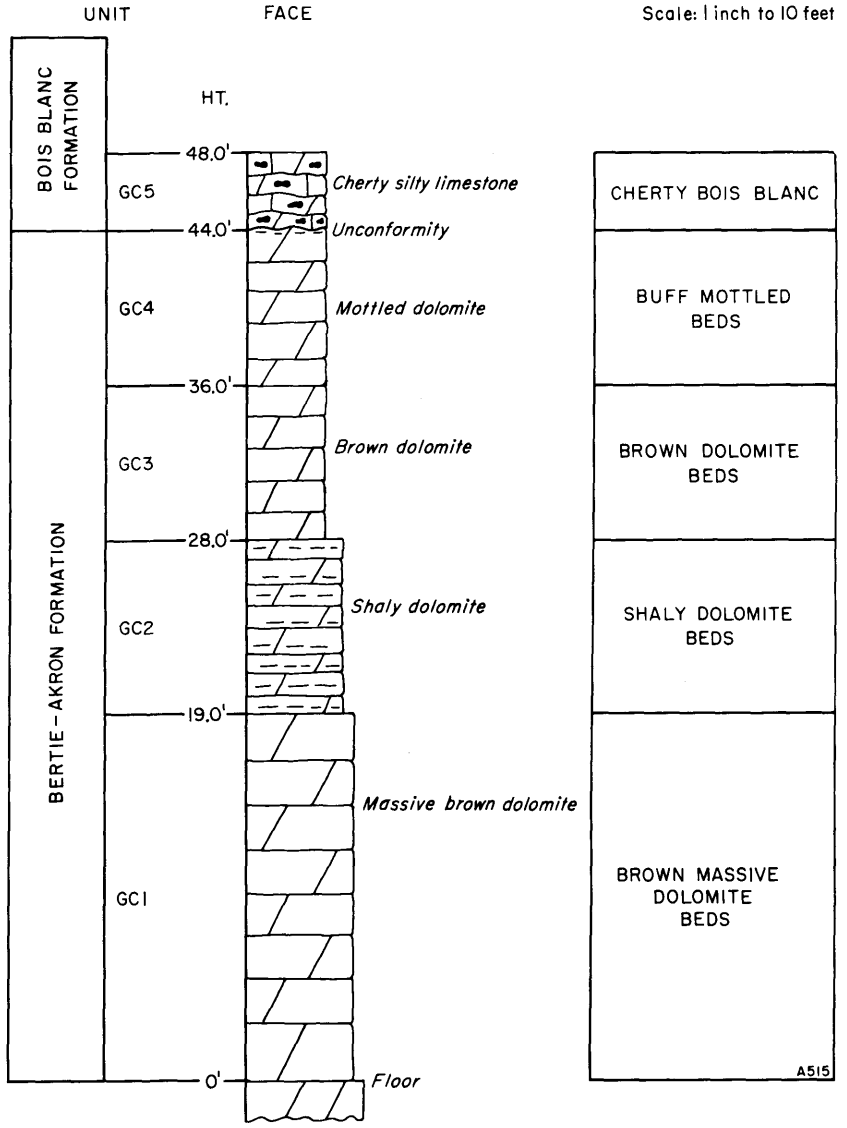
The quarry of George C. Campbell Company Limited is located at Ridgemount, 2½ miles east of Stevensville, in lot 8, concession VIII, Bertie township, Welland county. Haulage is by truck.

(112) CHEMICAL ANALYSES—GEORGE C. CAMPBELL COMPANY LIMITED

(Analyses supplied by the company)

	SiO_2 + Insolubles	Fe_2O_3 + FeO	$CaCO_3$	$MgCO_3$
	percent	percent	percent	percent
Upper lift	8.00	0.84	49.75	39.35
Lower lift	20.58	1.18	42.40	32.60

(113) QUARRY SECTION—GEORGE C. CAMPBELL COMPANY LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
Bois Blanc Formation		
GC5	Limestone: cherty, silty, magnesian; medium light grey, light grey weathering; aphanitic to medium-crystalline; thin irregular bedded; mottled chert nodules; some green glauconitic sand; black shale parting prominent at unconformity	4.0
	Unconformity	
Bertie-Akron Formation		
GC4	Dolomite: mottled, light and medium brown, buff weathering; aphanitic; medium bedded	8.0
GC3	Dolomite: medium brown, buff weathering; aphanitic; medium bedded	8.0
GC2	Dolomite: shaly; medium brown with dark grey shaly streaks; aphanitic; thin to medium bedded; laminated	9.0
GC1	Dolomite: medium brown, medium brownish weathering; aphanitic; medium bedded	19.0
	Total	48.0

Geology

The 48-foot quarry face consists of 4 feet of Bois Blanc cherty limestone underlain by 44 feet of Bertie-Akron dolomite. The quarry section is illustrated and described in (113). The thin veneer of Bois Blanc cherty limestone carries some glauconitic sandy beds and rests with unconformity on the Bertie-Akron. This underlying formation can be divided into four units, as follows: an upper 8-foot section of buff mottled dolomite; 8 feet of medium-brown, medium-bedded dolomite; 9 feet of dark-greyish brown, shaly dolomite; and 19 feet of brown, massive, medium-bedded dolomite. The quarry is worked in three lifts; the lower lift of 19 feet, the middle lift of 9 feet consisting wholly of the shaly dolomite unit, and the upper 20-foot lift comprising the remaining section above the shaly member.

The company kindly supplied the partial chemical analysis (112) of the upper and lower lifts, no analyses being available for the shaly member in the middle lift.

Quarry Operation

The three lifts are drilled on a 5- by 6-foot pattern by two wagon drills equipped with 1⅝-inch bits. A 500-cubic-foot-per-minute Gardner Denver compressor supplies air. The blasting agents are 40-percent Forcite and prilled ammonium nitrate. Some secondary blasting is required. The stone is loaded by a 1¼-cubic-yard, P & H gasoline shovel on two 5-ton Ford dump trucks for haulage to the primary crusher, a 15- by 36-inch jaw-crusher. The product of the jaw-crusher goes via a 24-inch conveyor to the screening plant, consisting of a 3-deck, 4- by 12-foot Niagara screen and a 5- by 10-foot Niagara screen. The oversize from the top deck of the first screen is recrushed in a 3-foot, Symons, standard cone. The main sizes of stone produced are 2-inch, 1-inch, ¾-inch, ½-inch, ⅜-inch chips, and dust. Crusher run may also be produced for road construction. The plant has a rated capacity of about 80 tons per hour. The stone is used mainly for road construction. An asphalt plant was operating in the quarry at the time of the author's visit.

A 40-ton-per-hour, Cedarapids, tandem, junior portable crushing plant was also operating in the quarry to give additional capacity. The operation is seasonal.

RIDGEMOUNT QUARRIES LIMITED (STEVENSVILLE)

The quarry of Ridgemount Quarries Limited is located ¾ mile north of highway No. 3, 4 miles west of Fort Erie, in lot 3, concession VIII, Bertie township, Welland county.

Geology

The main quarry face has a height of 27 feet, but a 12-foot lift taken in the quarry floor exposes the section for a total thickness of 39 feet. The section is entirely Bois Blanc cherty limestone of Middle Devonian age. There is a marked southerly dip. The section is described as follows: Limestone, cherty, medium-grey, light-grey-weathering; medium-crystalline coquinoid to aphanitic; medium to thin irregularly bedded; very cherty with black, grey, blue and white chert nodules and flats; black shaly partings; silty magnesian facies more common toward the base of section; very fossiliferous with abundant cup corals. The upper 13.5 feet of the section is somewhat more thin bedded than the lower part of the section.

Quarry Operation

Overburden consists of 6–10 feet of clay, with boulders. The 27-foot quarry face is drilled by a Bucyrus-Erie, 20T electric churn-drill, drilling 5¾-inch holes on a 10- by 12-foot pattern. A Joy wagon drill, drilling 1¾-inch holes on a 5- by 5-foot pattern, is also used. This drill is run on air supplied by a 300-cubic-foot-per-minute Schram compressor. The blasting agents are 40- and 60-percent Forcite and prilled ammonium nitrate (in churn-drill holes). Stone is loaded by a 1-cubic-yard Koehring Model 405 diesel shovel onto two 5-ton dump trucks hauling to the primary crusher, a Cedarapids 25- by 40-inch jaw-crusher. The crusher product is carried by a 24-inch conveyor to a 3-deck Niagara 4- by 10-foot screen with 2⅛-inch, 1¼-inch, and ¾-inch openings. Three bins are provided for the products; 2-inch stone, ¾-inch stone, and ¾-inch crusher run (traffic-bound, granular base course).

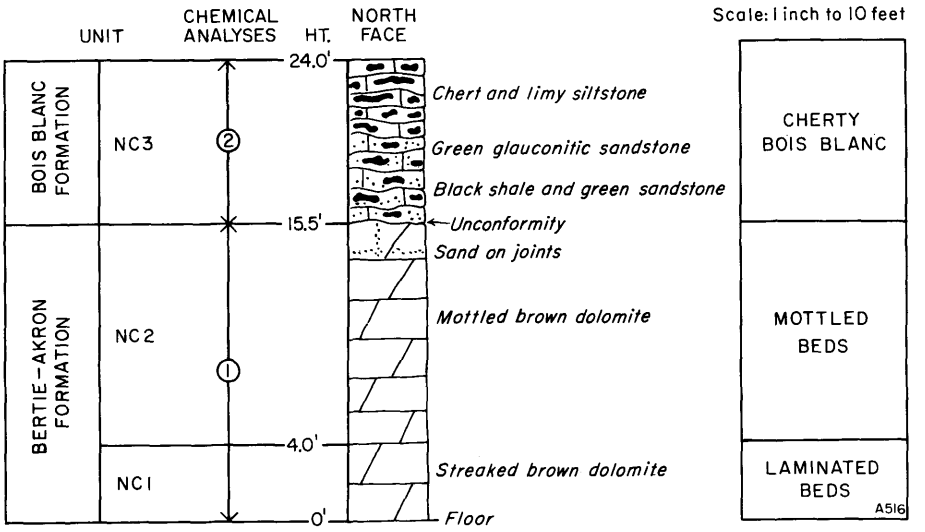
The oversize from the upper screen goes to the secondary crusher, a 3-foot Symons standard cone. The product is carried by a 24-inch conveyor to a second screenhouse where it discharges on a scalping screen followed by a 3-deck Niagara 3- by 8-foot screen. Screen openings are 1½-inch, ⅞-inch, ½-inch and ¼-inch, and the products are 2-inch stone, 1-inch stone, ½-inch stone, ⅜-inch stone, and screenings.

Most of the stone is used for road construction, but concrete aggregate, rubble, and riprap are also sold.

NIAGARA CRUSHED STONE (HUMBERSTONE) LIMITED, PORT COLBORNE

The quarry of Niagara Crushed Stone (Humberstone) Limited is located on a 150-acre property on Chippewa road, east of the Welland Canal, 1 mile northeast of Port Colborne, in lot 24, concession II, Humberstone township, Welland county. Rail and water transportation are available nearby.

(114) QUARRY SECTION—NIAGARA CRUSHED STONE (HUMBERSTONE) LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
	Bois Blanc Formation	
NC3	Chert, Sandy Siltstone, and Cherty Limestone. Limestone: cherty; light medium grey; medium-crystalline to aphanitic; medium- to thin irregular bedded; rubbly weathering; abundant white chert; highly fossiliferous, coralline. Sandy Siltstone: grey to green; glauconitic; aphanitic	8.5
	Unconformity *(Irregular, 2- to 3-foot relief, marked by black shale and green glauconitic sandstone.)*	
	Bertie-Akron Formation	
NC2	Dolomite: mottled, medium to brownish grey and light brown, buff weathering; aphanitic; medium-bedded; shale partings; upper few feet show some sand, mainly as joint fillings	11.5
NC1	Dolomite: same as NC2, but streaked dark grey to black; laminated rather than mottled	4.0
	Total	24.0

(115) CHEMICAL ANALYSES—NIAGARA CRUSHED STONE (HUMBERSTONE) LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	Stratigraphic Unit	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet		percent	percent	percent	percent	percent	percent	percent	percent
1	0 –15.5	Bertie-Akron	7.06	0.85	1.29	19.19	28.00	42.09	0.05	98.53
2	15.5–24.0	Bois Blanc	67.82	3.64	1.86	4.77	9.52	11.70	0.04	99.35

The Bois Blanc—Bertie-Akron unconformity is exposed in the quarry face at Niagara Crushed Stone (Humberstone) Limited, Port Colborne.

Geology

The 24-foot quarry face consists of 8.5 feet of cherty Bois Blanc limestone and chert beds, underlain by 15.5 feet of Bertie-Akron dolomite (later deepened to 20 feet). The section is illustrated and described in (114). The Bois Blanc formation, as here exposed, consists of chert beds, sandy glauconitic siltstone and cherty, grey, coralline limestone. The unconformity between the Middle Devonian Bois Blanc formation and the underlying Upper Silurian Bertie-Akron dolomite is marked and shows 2–3 feet of relief. The contact is marked by green, glauconitic sandstone and black shale. The underlying Bertie-Akron dolomite consists of an upper mottled, medium brownish grey and light-brown aphanitic unit, and a lower brown laminated dolomite unit.

Chemical analyses of composite chip samples, taken by the author from the north quarry face, are given in (115).

Quarry Operation

At the time of the author's visit in July, 1958, the plant was being re-designed. Drilling was being done on the 24-foot quarry face by two wagon drills drilling 2-inch holes on a 4- by 5-foot pattern or by a modified Ingersoll-Rand Quarrymaster drilling 4½-inch holes on an 8- by 10- to 10- by 12-foot pattern. A Joy 315-cubic-foot-per-minute compressor supplied air for the wagon drills. The blasting agents are 40-percent Dynamex and prilled ammonium nitrate.

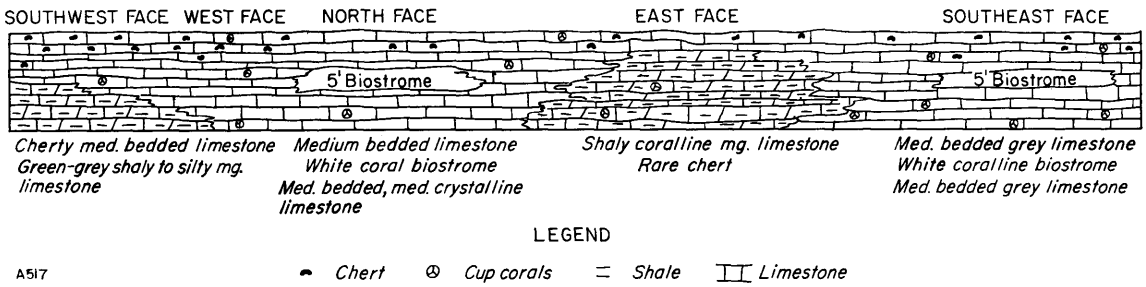
The quarry operation was later modified, and two lifts were operated. The upper cherty beds are stripped off on one lift; the lower lift consists of 20 feet of Bertie-Akron dolomite. A Joy Junior Challenger drill and a 500-cubic-foot-per-minute compressor were added to the equipment in use.

Stone is loaded by a 2½-cubic-yard, Northwest Model 80D, diesel shovel and a 2½-cubic-yard, Link-Belt Speeder, diesel shovel. Haulage is done by three 15-ton and three 22-ton Euclid rear-dump trucks. The crushing-plant feed is split between two primary crushers, a 25- by 40-inch and a 22- by 36-inch Cedarapids jaw-crusher. The crusher products go via a 36-inch conveyor to a 5- by 14-foot, 2-deck, scalping screen with 2-inch and ¾-inch openings. The oversize goes to a 4¼-foot Symons standard cone-crusher. The screened product and the secondary-crusher product go via a 42-inch conveyor to a screen tower with two lines of two, 5- by 14-foot, triple-deck screens. Recrushing is done by a 4-foot Symons shorthead cone-crusher. The main sizes produced are ¾-inch, ½-inch, ⅜-inch stone, and screenings. Plant capacity is 300–400 tons per hour. The stone is used for road construction and concrete aggregate.

CANADA CEMENT COMPANY LIMITED (PORT COLBORNE PLANT, PORT COLBORNE)

The Port Colborne plant of Canada Cement Company Limited is located on the western outskirts of Port Colborne. The quarry being operated at present is located 1¾ miles west of the plant in lot 6, concession I, Wainfleet township, Welland county. The quarry is south of the C.N. railway and highway No. 3. The cement plant is a wet-process plant with one kiln having a capacity of 525 tons (3,000 barrels) per 24 hours.

(116) QUARRY SECTION—CANADA CEMENT COMPANY LIMITED



Geology

The 20- to 27-foot quarry face consists entirely of Bois Blanc limestone. This quarry displays minor facies changes in the lower Bois Blanc formation. The accompanying sketch (116) shows the disposition of the various facies present in the quarry. The west face exposes a 25-foot section of medium-grey, medium-bedded, medium- to fine-crystalline, cherty, coralline limestone with shaly partings. The east and southwest faces show an influx of silty, shaly, magnesian material; chert is common, especially in the upper beds. The north and southeast faces show light-grey to white coral biostromes, 5–8 feet thick and 200 feet long, midway up the quarry section. These massive-bedded, medium-crystalline, fossiliferous biostromes are high-purity limestone and are a desirable source of stone for the cement plant owing to their low magnesia content. However this rapid facies change from biostrome to medium-bedded limestone to shaly magnesian limestone makes chemical control more difficult. The coral biostromes occasionally contain pockets of petroleum.

A chemical analysis of 15 feet of the quarry section as given by Goudge (p. 287) is given in (117).

This relatively high purity stone is now largely gone, and the average stone quarried at Port Colborne in December, 1958, has the chemical analysis given in (118). The range of composition in quarry rock is also indicated.

At the south end of the quarry the magnesia content is low, but the silica content is high. The reverse is true in the northern part of the quarry, depending on the relative percentages of chert and silt.

Quarry Operation

Clay overburden is up to 5 feet in thickness. Two Bucyrus-Erie electric churn-drills drill 6-inch holes on a 13- by 14-foot pattern in the 25-foot quarry section. Dynamite and prilled ammonium nitrate are the blasting agents. Stone is loaded on two, 15-ton Euclid rear-dump trucks by a Bucyrus-Erie 2½-cubic-yard model 54B electric shovel. The

(117) CHEMICAL ANALYSIS—CANADA CEMENT COMPANY LIMITED

(Analysis from Goudge, p. 287)

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
	percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
331	4.32	0.43	0.43	0.02	91.70	1.89	98.79	0.07	51.36	0.90

(118) CHEMICAL ANALYSES—CANADA CEMENT COMPANY LIMITED

(Analyses supplied by the company)

	Average Composition, December, 1958	Range in Composition of Stone Previously Quarried
	percent	percent
SiO_2	15.36	9 –17
Al_2O_3	2.90	2 – 3.5
Fe_2O_3	1.02	0.5– 1.3
CaO	40.92	30 –50
MgO	3.82	2 – 5
Loss on ignition	34.94	.....

Euclids haul the stone to a loading station in the quarry where a 10-car train, hauled by a diesel engine, transports the stone to the cement plant, 2 miles to the east. The 10-car train has a capacity of about 100 tons. Quarry production averages 700–800 tons per day, with 7–8 train-loads going to the plant during one shift.

Cement Plant

About 50 percent of the stone used by the cement plant is shipped in by rail from Beachville. This high-purity calcium limestone is blended with the stone from the Port Colborne quarry to give a suitable silica and magnesia content. Gypsum, coal, and iron oxide are shipped into the plant.

The primary crusher is a No. 11 McCully, 27-inch, gyratory crusher, followed by a 42- by 48-inch, type "B" Jeffrey, Swing Hammer Mill in open circuit to produce a minus ¾-inch feed for the raw-grinding mills.

Raw grinding is done in two Unidan, three-compartment, 7- by 39-foot, ball mills. The 412-foot, coal-fired, F. L. Smidth kiln has the following dimensions; 11 feet 3 inches by 10 feet by 11 feet 3 inches in the preheat, calcining, and burning zones. It has a capacity of about 3,000 barrels per day or 1,000,000 barrels per year.

Finish grinding is done in open circuit in four 5- by 8-foot, F. L. Smidth ball mills followed by six 6.5- by 20-foot, Smidth tube mills.

R. E. LAW CRUSHED STONE LIMITED PORT COLBORNE

The quarry of R. E. Law Crushed Stone Limited is located 2 miles west of Port Colborne, on the north side of highway No. 3, in lot 5, concession II, Humberstone township, Welland county.

Geology

The total quarry section of 71 feet in height consists of 28 feet of cherty Bois Blanc limestone resting unconformably on 43 feet of Bertie-Akron dolomite. The quarry section is illustrated and described in (119). The Bois Blanc formation here consists of a lower 12.6-foot unit consisting of basal sandy, cherty, glauconitic siltstone, cherty limestone, and shaly cherty limestone; a middle 10-foot chert-free limestone unit; and an upper 5.6-foot cherty, grey, irregularly bedded limestone unit.

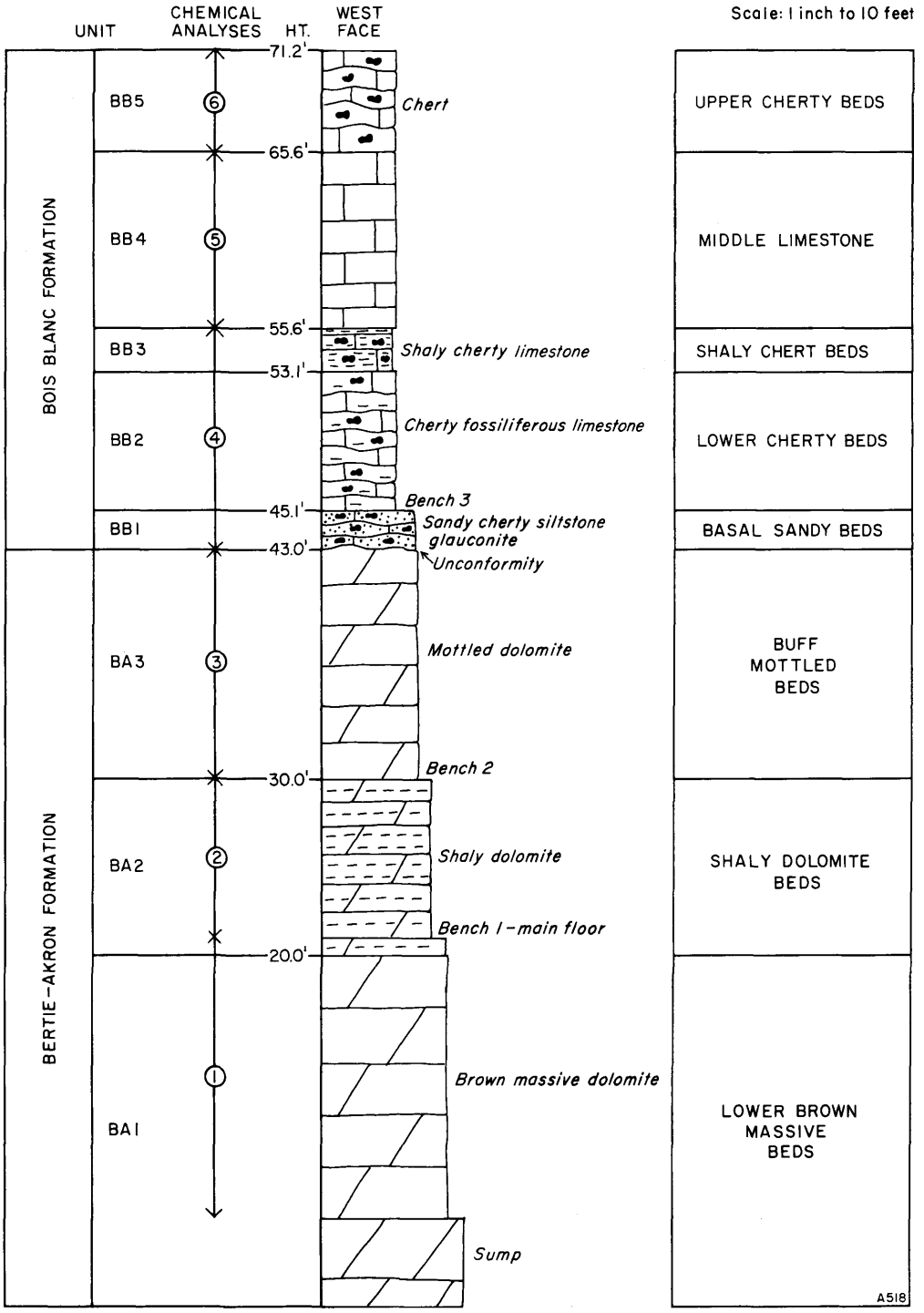
The Bertie-Akron formation consists of 20 feet of lower brown, massive, aphanitic dolomite, overlain by a 10-foot shaly dolomite unit and a 13-foot unit of buff-mottled, aphanitic, medium-bedded dolomite.

Due to the regional southwest dip, the thickness of Bois Blanc formation is a maximum at the southwest corner of the quarry, and thins to the north and east. Along the east face of the quarry the buff-mottled upper unit of the Bertie-Akron contains fracture-fillings and breccia consisting of pure white Oriskany (?) sandstone.

(119) QUARRY SECTION—R. E. LAW CRUSHED STONE LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
Bois Blanc Formation		
BB5	Limestone: cherty; medium brownish grey, medium grey weathering; fine crystalline; medium to thin irregularly bedded; black shaly partings; brown and tan chert in nodules and layers; fossiliferous, abundant corals	5.6
BB4	Limestone: medium brownish grey, medium grey weathering; medium to fine crystalline; medium to thick bedded; in part shaly, shaly partings; coralline	10.0
BB3	Limestone: shaly, silty, cherty; medium dark grey, medium dark grey weathering; medium-bedded; shaly and rubbly weathering; aphanitic; 0.6 feet shale top, 0.3 feet shale base	2.5
BB2	Limestone: cherty, silty; medium light grey, light grey weathering; medium crystalline to aphanitic; medium to thin irregularly bedded; white and grey chert nodules and layers; fossiliferous, corals; abundant shaly partings	8.0
BB1	Siltstone: cherty, sandy, glauconitic; medium-grey, buff-grey to dark-grey weathering; thin irregular bedding; shaly; black chert; green glauconitic sand	2.1
	Unconformity	
Bertie-Akron Formation		
BA3	Dolomite: mottled, medium and light brown; buff to brown weathering; aphanitic; medium bedded; thin shaly partings; lower 3 feet more shaly, upper 10 feet strikingly mottled	13.0
BA2	Dolomite: shaly; medium to medium light-brown, light to medium brown weathering; aphanitic; thin to medium bedded; thin shale laminations, dark grey	10.0
BA1	Dolomite: medium brown, cclour lamination dark-brownish grey to medium brown, brown-weathering; aphanitic; thick- to massive-bedded; thin-laminated; rare white chert	20.0
	Total	71.2

(119) QUARRY SECTION—R. E. LAW CRUSHED STONE LIMITED



(120) CHEMICAL ANALYSES—R. E. LAW CRUSHED STONE LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Stratigraphic Unit	Footage on Section (See (119))	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	P_2O_5	Total
			percent	percent	percent	percent	percent	percent	percent	percent	percent
1.....	BA1	5 –21	2.76	0.94	1.24	19.50	29.60	45.53	0.12	0.20	99.89
2.....	BA2	21 –30	21.80	6.94	0.70	14.75	20.56	33.25	0.25	.....	98.25
3.....	BA3	30 –43	4.14	0.84	1.06	19.90	29.20	44.83	0.13	.....	100.12
4.....	BB1, BB2, BB3	43 –55.6	54.60	5.23	0.35	5.10	15.82	17.74	0.13	.....	98.97
5.....	BB4	55.6–65.6	11.04	1.61	0.73	2.62	44.80	39.07	0.12	.....	99.99
6.....	BB5	65.6–71.2	19.24	2.27	0.73	1.17	41.80	35.17	0.10	.....	100.48

Chemical analyses of composite chip samples representative of the various stratigraphic units in the quarry section taken by the author are given in (119).

The chemical analyses indicate the shaly character of unit BA2 (sample 2) of the Bertie-Akron, and the highly siliceous character of the Bois Blanc formation, especially its lower 12 feet (sample 4). The lower parts of this formation (samples 4 and 5) are over 2 percent in magnesia, a feature undesirable for manufacture of portland cement.

Quarry Operation

The main quarry floor is at the base of the shaly dolomite beds of the Bertie-Akron formation, and throughout most of the quarry the section is worked in an upper 35-foot and a lower 17-foot lift. Overburden is up to 5 feet in thickness, and a flat glaciated rock surface allows easy stripping. Drilling is done by two Bucyrus-Erie, and one Clipper electric churn-drills boring 6-inch holes on a 15- by 15-foot pattern on the upper 35-foot lift and on a 10- by 10-foot pattern on the lower 17-foot lift. The blasting agents are dynamite and prilled ammonium nitrate.

Stone is loaded by a 1½-cubic-yard, Northwest, diesel shovel on three 15-ton Mack, and one 15-ton International trucks for haulage to the primary crusher, a 24-inch Telsmith gyratory crusher. The crusher product is carried by a 30-inch conveyor to a scalping screen, which scalps plus 3-inch stone, which is sent to a 4½-foot Symons standard cone. The minus 3-inch stone goes to a 4¼-foot Symons shorthead cone. The product from the 4½-foot standard cone is conveyed to the screen house, where it is sized by one 3-deck, 4- by 8-foot and one 2-deck, 4- by 6-foot, Tyler screens in series. Sizes produced are 2-inch, 1-inch, ¾-inch, ½-inch, and ⅜-inch stone, and screenings. The 2-inch, 1-inch, and ¾-inch stone may be recrushed in a 3-foot, Symons standard cone.

The product from the 4¼-foot Symons shorthead tertiary crusher is conveyed to a 3-deck, 4- by 12-foot screen for screening. Screenings and ⅜-inch stone are the main products.

The plant has a rated capacity of about 200 tons per hour. The stone is mainly used for road construction and concrete aggregate. An asphalt plant and ready-mix concrete batching plant are located at the quarry.

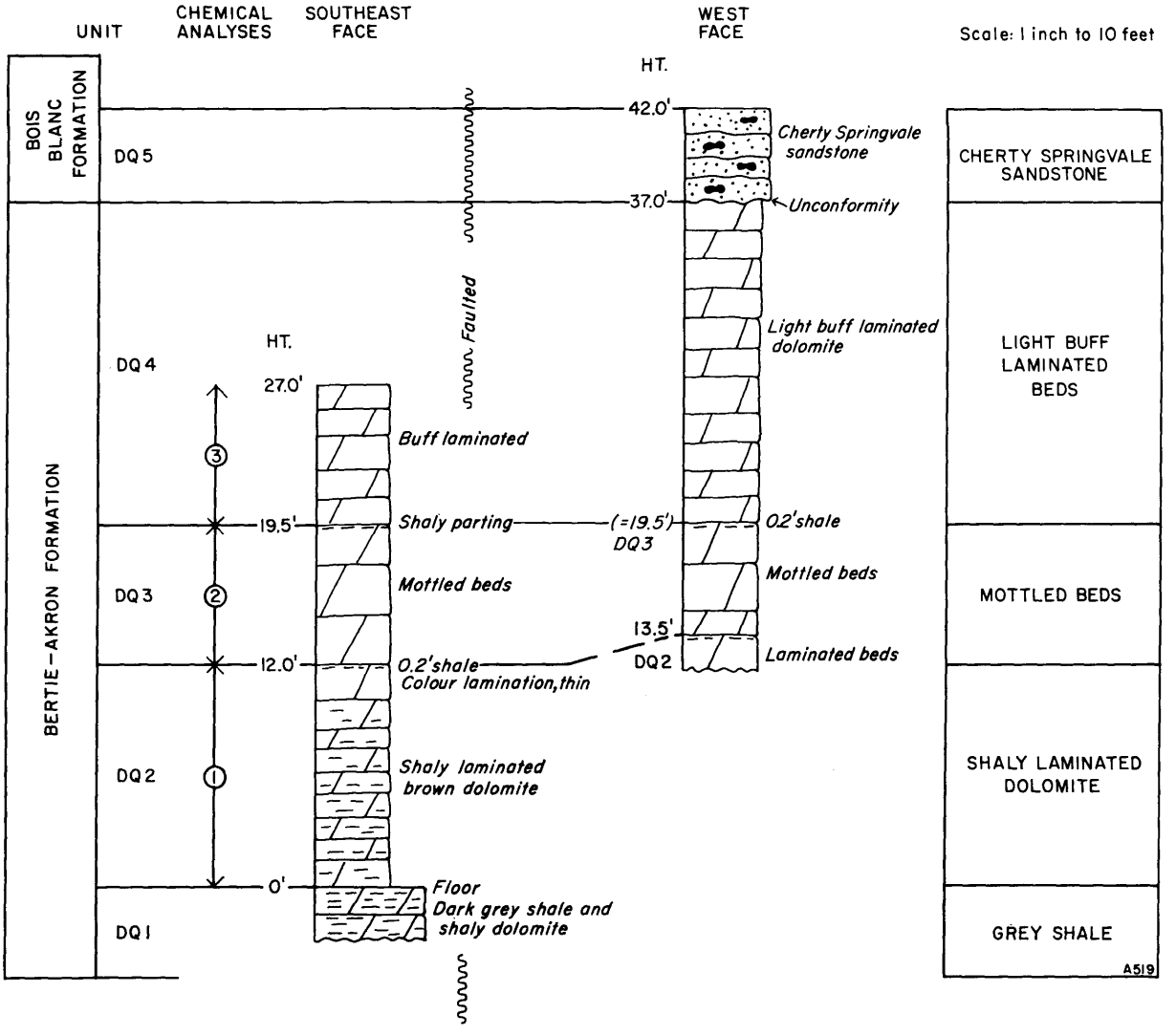
DUNNVILLE QUARRIES LIMITED, DUNNVILLE

The quarry operated by Dunnville Quarries Limited is located ½ mile south of Byng, in lot 17, concession I, Dunn township, Haldimand county.

Geology

Although the quarry face is 28–30 feet in height, due to northeast-trending vertical faulting in which the northwest side is down-thrown 15 feet, a total section of 42 feet of Bertie-Akron dolomite and Bois Blanc (Springvale) cherty sandstone is exposed. The southeast quarry face exposes 27 feet of Bertie-Akron dolomite consisting of a lower 12-foot unit of shaly dolomite, overlain by 7.5 feet of mottled, aphanitic dolomite and 7.5 feet of buff, laminated dolomite. The west quarry face on the other side of the fault exposes 24 feet of Bertie-Akron dolomite consisting of 6.5 feet of the mottled unit and 17.5 feet of the light-buff laminated dolomite unit. Overlying this dolomite unconformably, there is a thin 5-foot veneer of cherty grey sand-

(121) QUARRY SECTION—DUNNVILLE QUARRIES LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
	BOIS BLANC FORMATION (Springvale sandstone member)	
DQ5	Sandstone: cherty; medium light grey; medium grained; medium bedded; glauconitic in part...	5.0
	Unconformity	
	BERTIE-AKRON FORMATION	
DQ4	Dolomite: light buff laminated; medium to light brown, light buff weathering; aphanitic; medium bedded; hard and dense; thin colour laminations; dark grey shale partings.....	17.5
DQ3	Dolomite: mottled, light brown and medium brown, buff weathering; aphanitic; massive bedded; lower part mottled to laminated; hard and dense.....	7.5
DQ2	Dolomite: shaly laminated; medium brownish grey to medium dark grey, dark grey to buff weathering; colour lamination; aphanitic; medium to thin bedded; shaly partings.....	12.0
DQ1	Shale: medium dark grey; aphanitic; fissile; in part dolomitic.....	2.0
	Total (Bois Blanc plus Bertie-Akron)	44.0

(122) CHEMICAL ANALYSES—DUNNVILLE QUARRIES LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Stratigraphic Unit	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
		feet	percent	percent	percent	percent	percent	percent	percent	percent	percent
1.....	DQ2	0 –12	14.18	2.50	1.14	16.31	28.30	37.21	.....	0.65	100.29
2.....	DQ3	12 –19.5	3.12	0.89	0.44	20.05	30.63	46.08	0.12	0.10	101.43
3.....	DQ4	19.5–27.0	5.28	0.84	0.85	19.70	29.58	42.03	.....	0.11	98.39

stone belonging to the Springvale sandstone member of the basal Bois Blanc formation. This is only present on the west side of the quarry.

The section exposed is illustrated and described in (121). Brecciation and faulting is very apparent in the north, northeast, and southwest walls of the quarry. Some peculiar low-angle thrust faulting appears to have occurred along the north quarry wall in the lower beds without disturbing the overlying section.

Chemical analyses of composite chip samples of 27 feet of Bertie-Akron dolomite taken up the southeast face of the quarry are given in (122).

The analyses show the shaly character of the shaly unit of the Bertie-Akron, and the general relative impurity of the formation compared, for example, with the Guelph dolomite.

Quarry Operation

Overburden is up to 10 feet in thickness. A Koehring diesel, ¾-cubic-yard shovel is used on stripping. The 30-foot face is drilled by two Armstrong churn-drills operating on natural gas, drilling 6-inch holes on a 14- by 14-foot pattern. The blasting agents are dynamite and prilled ammonium nitrate. Stone is loaded by a 1¼-cubic-yard Koehring diesel shovel. Haulage is done by two 11-ton tandem trucks.

The primary crusher is a 20-inch Traylor gyratory crusher. The product is carried by 30-inch conveyor to a 3-deck 5- by 12-foot set of screens producing 1½-inch stone, 1-inch stone, and ¾-inch crusher run. The oversize plus 3-inch stone goes to the secondary crusher, a No. 37 K.V.S. gyratory. The product goes to a 2-deck 4- by 10-foot Niagara screen producing screenings, ⅜-inch stone, and ¾-inch stone. The plant has a capacity of about 100 tons per hour, and the product is mainly used for road construction and concrete aggregate.

CAYUGA QUARRIES LIMITED, CAYUGA

The property of Cayuga Quarries Limited is located on the north side of highway No. 3, 3½ miles west of Cayuga, in lots 45 and 46, concession I North, North Cayuga township, Haldimand county.

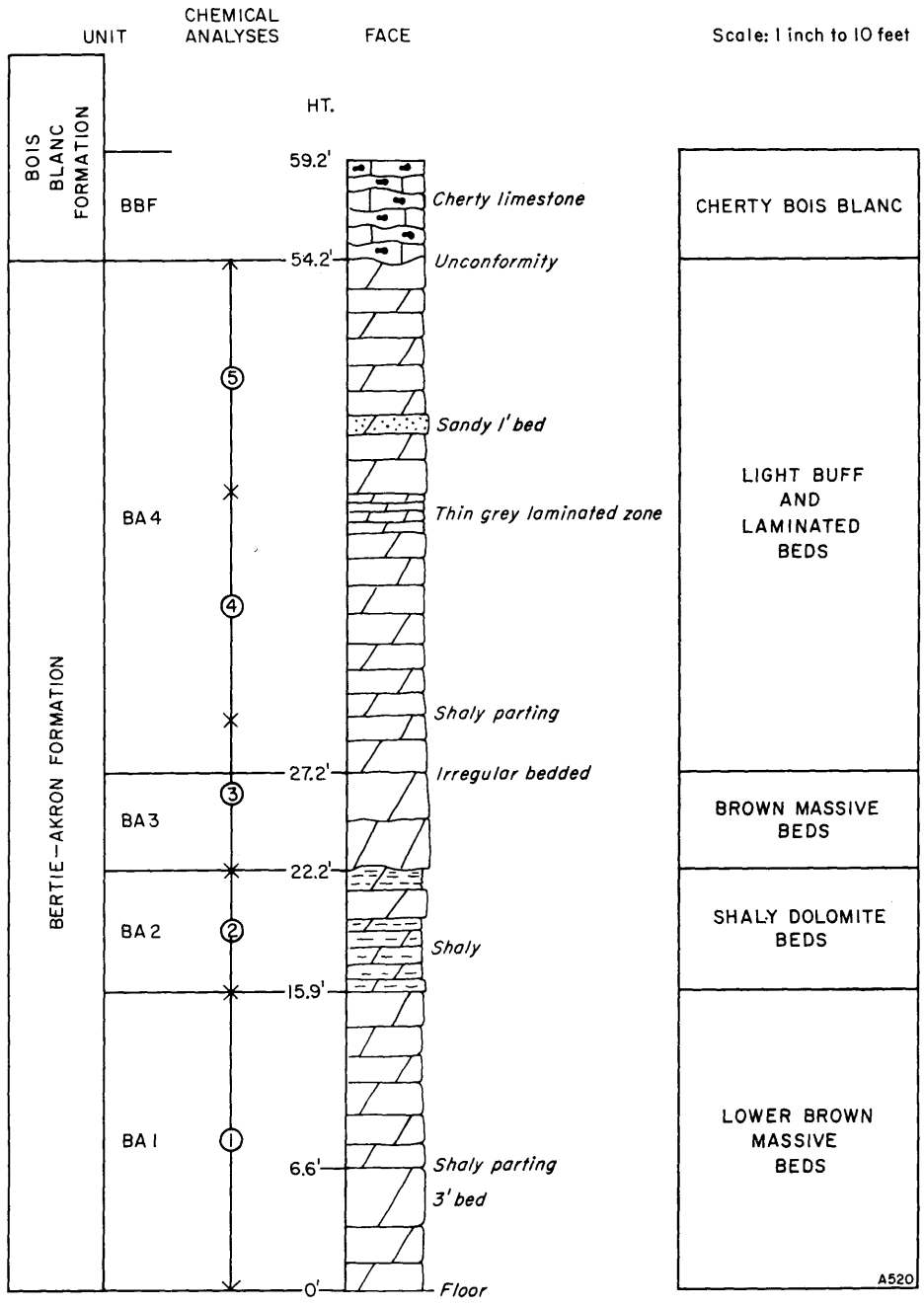
Geology

The quarry face at Cayuga Quarries exposes a section of 54 feet of Bertie-Akron dolomite of Silurian age. At the east end of the quarry 5 feet of cherty Bois Blanc limestone rest unconformably on the underlying Bertie-Akron dolomite. The quarry section is illustrated and described in (123). The four units here recognized in the 54-foot Bertie-Akron section consist of a lower 16-foot of brown, massive, medium-bedded dolomite, 6 feet

(123) QUARRY SECTION—CAYUGA QUARRIES LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
Bois Blanc Formation		
BBF	Limestone and Chert: medium grey, medium light grey weathering; medium crystalline to aphanitic; thin irregularly bedded; shaly partings; white and grey chert.....	5.0
	Unconformity	
Bertie-Akron Formation		
BA4	Dolomite: medium light brown to medium brown laminated, light buff to buff weathering; aphanitic to fine crystalline; medium to thin bedded; in part thin laminated, shaly; sandy beds at 45.0–46.0 feet.....	27.0
BA3	Dolomite: medium brown; massive irregular bedded; fine crystalline to aphanitic.....	5.0
BA2	Dolomite: shaly; medium brownish grey; aphanitic; medium to thin bedded; laminated.....	6.3
BA1	Dolomite: medium brown, buff weathering; fine crystalline to aphanitic; medium bedded, one 3-foot massive bed near base; laminated in part; shaly partings.....	15.9
	Total (Bertie-Akron)	54.2

(123) QUARRY SECTION—CAYUGA QUARRIES LIMITED



(124) CHEMICAL ANALYSES—CAYUGA QUARRIES

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Height Above Floor	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	S	Total
	feet	percent	percent	percent	percent	percent	percent	percent	percent
5	42 –54	4.78	0.57	0.87	19.30	30.40	44.08	0.02	100.02
4	30 –42	3.12	0.73	0.93	19.90	30.00	45.33	0.04	100.05
3	22 –30	5.94	1.40	0.74	18.18	28.32	42.78	0.87	98.13
2	15.7–22	24.28	6.78	1.72	13.42	19.42	30.04	0.38	96.04
1	0 –15.7	1.66	0.22	1.14	19.61	30.10	45.80	0.07	98.60

of shaly dolomite, an upper 5 feet of brown, massive dolomite, and 27 feet of light-buff and laminated dolomite. Sandy beds occur in this upper unit below the Devonian contact.

The west quarry wall is faulted.

Chemical analyses of composite chip samples representative of the 54-foot section of Bertie-Akron dolomite are given in (124).

The shaly dolomite unit BA2, shown on (123), has a silica content of 24 percent and an alumina content of 7 percent. The rest of the section is dolomite but cannot be classed as high-purity dolomite for chemical or metallurgical purposes.

Quarry Operation

Overburden is thin. The 50-foot face is drilled on a 12- by 15-foot pattern by a Bucyrus-Erie 27T, gasoline churn-drill drilling 6-inch holes. The blasting agents are 60-percent Forcite and prilled ammonium nitrate. Stone is loaded by a 1½-cubic-yard, Manitowoc diesel shovel onto two 15-ton, rear-dump, Euclid trucks for haulage to the plant.

The stone goes over a 2½-inch vibrating grizzly. The oversize goes to a 32- by 40-inch Cedarapids, impact breaker. The minus 2½-inch stone goes to the screen house or to a stacker conveyor. The product from the impact crusher goes via a 30-inch conveyor to the screen house where there are three sets of Dillon, 2-deck, 4- by 12-foot screens in series. These produce 2-inch, ¾-inch, ½-inch, ⅜-inch screenings, and ¼-inch agricultural limestone. The oversize from No. 1 screen goes to a 3-foot Symons standard cone in closed circuit with the screen house. Bins are provided for 2-inch stone, ¾-inch stone, ½-inch stone, ¾-inch crusher run, ⅜-inch screenings, and ¼-inch agricultural limestone. A blending belt-conveyor passes below the bin chutes to a stacker. The larger sizes may be recrushed, if desired. Stone is stockpiled by truck. Stone is loaded by overhead loader. The quarry is on the C.N. railway line and is served by rail and road haulage.

The plant has a rated capacity of 240 tons per hour, and a production of 2,400 tons per 10-hour shift is attained. The stone is used principally for road construction and concrete aggregate. This modern plant went into operation in 1957.

HALDIMAND QUARRIES AND CONSTRUCTION LIMITED, HAGERSVILLE

The quarry of Haldimand Quarries and Construction Limited is located on the eastern outskirts of Hagersville, in lots 27 and 28, concession I, Oneida township, Haldimand county. The old quarry is north of the Michigan Central Railway line, but the new quarry at present in operation is on the south side of the railway line and is connected to the old quarry and crushing plant by a tunnel under the railway.

(125) CHEMICAL ANALYSES—HALDIMAND QUARRIES AND CONSTRUCTION LIMITED

(Analyses by Provincial Assay Office, Ont. Dept. Mines, 1959)

Sample No.	Interval Above Floor	Stratigraphic Unit (See (125))	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	P_2O_5	S	Total
	feet		percent	percent	percent	percent	percent	percent	percent	percent	percent
1	–8 to –3	H1	1.90	0.30	0.76	20.50	31.10	44.27	0.13	0.18	99.14
2	–3 to +5	H2	19.74	3.05	1.44	14.33	28.05	30.73	.....	0.79	98.13
3	+5 to +15	H3, H4	5.44	1.14	0.88	18.42	29.06	41.47	.....	0.93	97.34
4	+15 to +28	H4, H5	3.46	0.84	0.76	20.20	29.80	44.60	0.14	0.08	99.88

Geology

The Haldimand quarry is worked in two lifts of 28–30 feet in height. The upper lift consists entirely of cherty Bois Blanc limestone of Middle Devonian age. The lower lift consists entirely of Bertie-Akron dolomite of Upper Silurian age. The 58-foot section measured on the south face of the north quarry is illustrated and described in (126).

The Bois Blanc formation is cherty, coralline medium-grey, medium-crystalline to aphanitic, thin irregularly bedded limestone with about 4 feet of glauconitic, sandy and cherty siltstone (Springvale member) at the base. The underlying Bertie-Akron is divided into five recognizable lithologic units, as indicated, including the easily recognizable shaly dolomite unit, which occurs throughout the formation.

Chemical analyses of chip samples of the 36-foot Bertie-Akron dolomite section are given in (125).

Quarry Operation

Overburden is thin, ranging from 1 to 4 feet in thickness. Drilling on the two 28- to 30-foot lifts is done by three churn-drills, one electric and two diesel, drilling 6-inch holes on a 15- by 15-foot pattern. Dynamite and prilled ammonium nitrate are the blasting agents. Stone is loaded by a 1½-cubic-yard Dominion diesel shovel onto three 15-ton, Euclid, rear-dump trucks for haulage to the crushing plant.

The primary crusher is a 20-inch Superior McCully gyratory crusher. A 30-inch conveyor carries the stone to a surge bin. The stone from the surge bin feeds a 5- by 10-foot, 2-deck, scalping screen. The plus 2-inch stone goes to a 4-foot, Symons standard cone-crusher, the product of which goes on to a 24-inch conveyor to the screen house. The 2-inch stone and minus 1½-inch stone from the scalping screen go to two bins. The 2-inch stone may be sent to the 4-foot cone-crusher for recrushing or may be fed with the minus 1½-inch stone to the 24-inch conveyor to the screen house. At the screen house sizing is carried out by a 4- by 8-foot Niagara 3-deck screen, a 3- by 8-foot Niagara 2-deck screen, and a 4- by 8-foot, 2-deck Dillon screen in series. The oversize goes to a 3-foot Symons standard cone or a 6-inch, Superior McCully, gyratory crusher for recrushing.

Sizes produced are 2-inch, 1½-inch, 1-inch, ¾-inch, ⅝-inch, ½-inch, ⅜-inch stone, screenings, and ¾-inch crusher run. Stockpiling is by truck. Screenings are stacked by conveyor. Three cranes and an overhead loader load rail and truck transportation. The stone is mainly used for road construction and concrete aggregate. Plant capacity is about 150 tons per hour.

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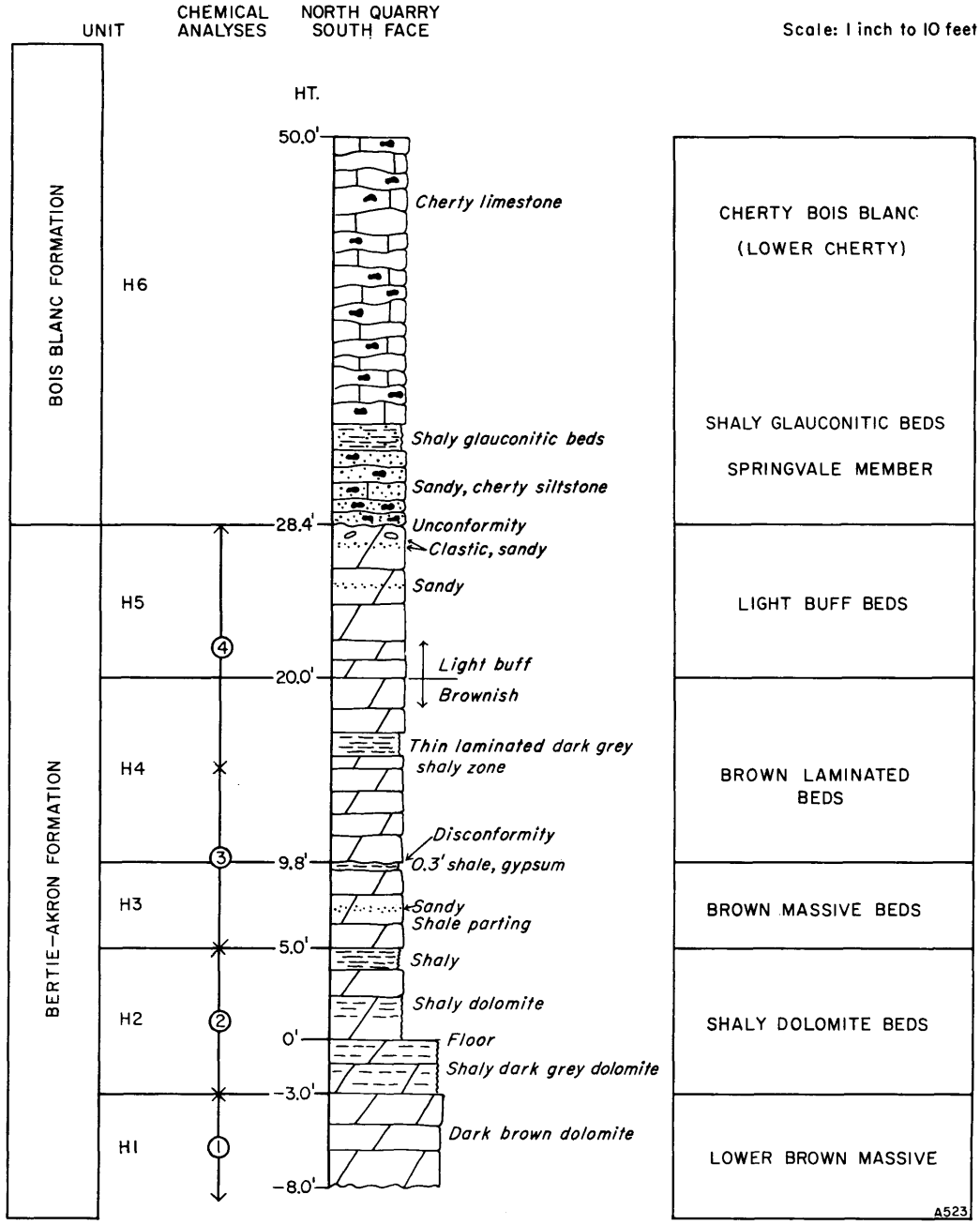
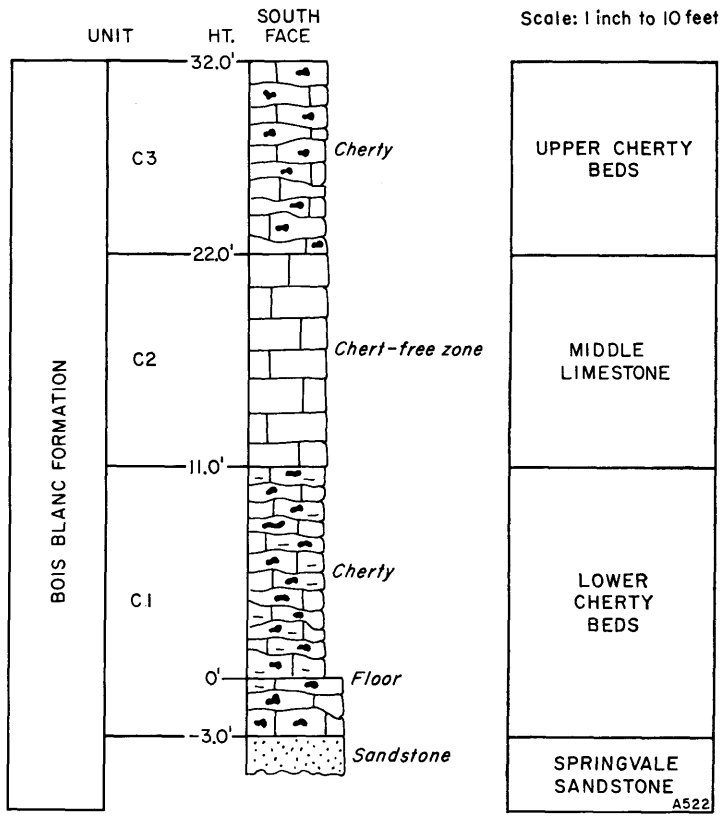
(126) QUARRY SECTION—HALDIMAND QUARRIES AND CONSTRUCTION LIMITED, HAGERSVILLE

UNIT	DESCRIPTION	THICKNESS Feet
	BOIS BLANC FORMATION	
H6	Limestone: cherty, coralline; medium grey, light grey weathering; medium crystalline to aphanitic; thin irregularly bedded; fossiliferous, silicified cup corals predominant; grey and white chert. Shaly glauconitic beds: 1–2 feet of greenish glauconitic sandy shale near base above Springvale member. Springvale member: lower 4 feet sandy cherty siltstone; greenish grey, light grey weathering; fossiliferous	21.6
	Unconformity	
	BERTIE-AKRON FORMATION	
H5	Dolomite: light brown, light buff weathering; aphanitic to fine crystalline; massive- to thick-bedded, lower 2 feet medium-bedded; in part sandy, in part clastic calcirudite	8.4
H4	Dolomite: medium brown to medium light brown, buff weathering; aphanitic; medium-bedded; thin dark grey colour lamination; shaly partings; thin 1.6-foot dark grey shaly zone at 15.4–17.0 feet	10.2
H3	Dolomite: medium-brown, brown-weathering; fine-crystalline to aphanitic; medium- to thick-bedded with irregular bedding; shaly partings; sandy; mottled; clastic calcarenite with ½-inch fragments; gypsum—white efflorescence	4.8
H2	Dolomite: shaly; medium brown to medium grey; dark grey shaly partings; aphanitic; medium to thin bedded	8.0
H1	Dolomite: medium brown; medium bedded; aphanitic; dark grey shale partings; thin colour laminations	5.0
	Total	58.0

(126) QUARRY SECTION—HALDIMAND QUARRIES AND CONSTRUCTION LIMITED



(127) QUARRY SECTION—CANADA CRUSHED AND CUT STONE LIMITED, HAGERSVILLE



UNIT	DESCRIPTION	THICKNESS Feet
C3	Limestone: cherty; medium grey, grey weathering; medium crystalline to aphanitic; thin irregularly bedded; fossiliferous, coralline; grey and white chert nodules	10.0
C2	Limestone: medium grey; medium crystalline to aphanitic; medium bedded; rare chert; shaly partings; fossiliferous, abundant corals	11.0
C1	Limestone: cherty, shaly; medium grey, grey weathering; medium crystalline to aphanitic; medium bedded; shaly partings; fossiliferous, abundant corals, in part silicified, white and grey chert	14.0
	Total	35.0

CANADA CRUSHED & CUT STONE LIMITED (HAGERSVILLE QUARRY), HAGERSVILLE

The Hagersville quarry and crushed stone plant of Canada Crushed & Cut Stone Limited is located on the north side of the Michigan Central Railway line on the western outskirts of Hagersville, in lots 13 and 14, concession XIII, Walpole township, Haldimand county, directly north of Hagersville Quarries Limited.

Geology

The 32-foot quarry face consists entirely of cherty limestone of the Bois Blanc formation of Middle Devonian age. The section is illustrated and described in (127), and can be divided into an upper and lower cherty member, with an 11-foot-thick relatively chert-free limestone between. In the northwestern part of the quarry the Springvale sandstone, the basal member of the Bois Blanc formation, is exposed 3 feet below the main quarry floor.

The chemical analysis of the stone is assumed to be similar to that of Hagersville Quarries Limited south of the railway tracks.

Quarry Operation

The 25- to 30-foot quarry face is drilled by an electric churn-drill, drilling 6-inch holes on a 12- by 15-foot pattern. The blasting agents are 70-percent Dynamex and prilled ammonium nitrate. Stone is loaded by a 2½-cubic-yard Bucyrus-Erie 54B electric shovel. Haulage is done by one 11-ton Mack truck and two 9-ton Koehring Dumpsters. A Ford tractor with scraper blade is used on clean-up.

The primary crusher is a No. 12K Gates gyratory crusher. A 30-inch conveyor carries the stone to the scalping screen, a 4- by 10-foot, 2-deck, Dillon screen. The oversize goes to a 3-foot Symons standard cone. The crusher product and the undersize from the screen is carried by a 24-inch conveyor to the screen house, where there are one 4- by 12-foot, 2-deck, and two 4- by 14-foot, 2-deck screens in series. These produce 2-inch, 1½-inch, ¾-inch, ⅜-inch stone, and screenings. Granular base course (¾-inch crusher run) is also produced.

The plant has a capacity of 120 tons per hour and the average production is 1,100 tons per day. Transportation is by rail or truck haulage. The stone is mainly used for road construction, concrete aggregate, and railway ballast.

HAGERSVILLE QUARRIES LIMITED, HAGERSVILLE

The crushing plant of Hagersville Quarries Limited is located west of the junction of the Michigan Central and Canadian National railway lines on the western outskirts of Hagersville, in lot 13, concession XIII, Walpole township, Haldimand county. Large quarries were formerly operated in lots 12 and 13 adjacent to the crushing plant, but the present quarry is located ¼ mile south of the crushing plant in lot 13, concession XII, Walpole township. Hagersville Quarries Limited is a subsidiary of Associated Quarries and Construction Limited, of Toronto.

Geology

The 27-foot quarry face is composed entirely of cherty Bois Blanc limestone of Middle Devonian age. The sections in the northwest and south quarries are illustrated and described in (128). The quarry section can be divided into an upper and lower cherty unit, separated by a 6- to 7-foot section of relatively chert-free limestone. The limestone is medium-brownish grey, light-grey-weathering; medium to thin irregularly bedded; medium-crystalline with shaly partings and abundant grey and black mottled chert nodules and chert beds The limestone is very fossiliferous, and cup corals are abundant.

Chemical analyses of two 15-foot churn-drill samples representing the 30-foot quarry face in the northeast quarry, as given by Goudge (p. 236), are shown in (129).

The silica content gives a good indication of the percentage of chert present.

Quarry Operation

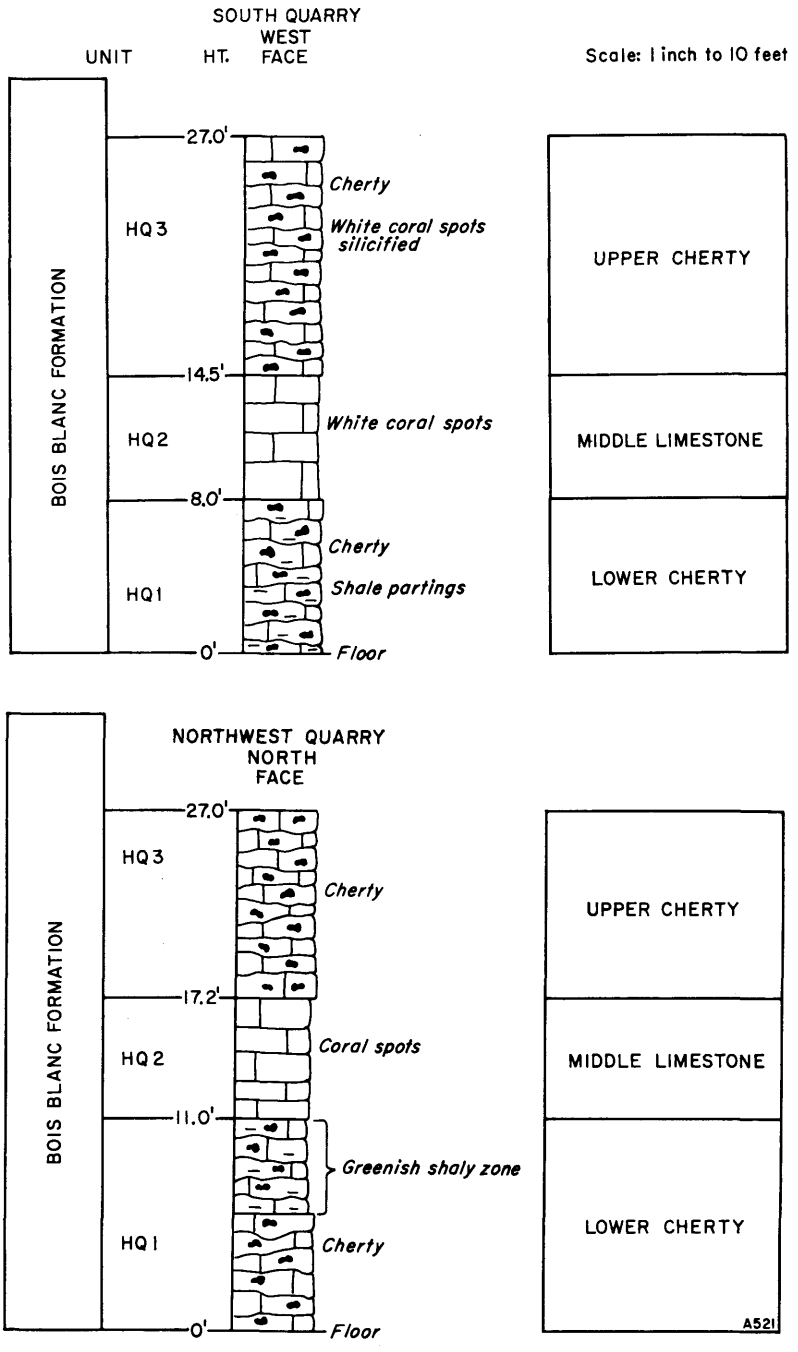
Overburden is light, ranging from 0 to 6 feet in thickness. The 28-foot quarry face is drilled by a Joy Champion drill boring 4½-inch holes on a 12- by 13-foot pattern. The blasting agents are dyna-

(128) QUARRY SECTION—HAGERSVILLE QUARRIES, HAGERSVILLE

UNIT	DESCRIPTION (WEST FACE)	THICKNESS Feet
HQ3	Limestone: cherty; medium brownish grey, light grey weathering; medium to thin irregularly bedded; medium crystalline; shaly partings; grey- and black-mottled chert; fossiliferous—cup corals prominent, often silicified	12.5
HQ2	Limestone: medium brownish grey, light grey weathering; medium to fine crystalline; medium to thick bedded; shaly partings; chert rare or absent; coralline, cup corals prominent	6.5
HQ1	Limestone: cherty; medium brownish grey, light grey weathering; medium-crystalline; medium- to thin irregularly bedded; irregular shaly partings; black and grey chert nodules not abundant	8.0
	Total	27.0

UNIT	DESCRIPTION (NORTH FACE)	Feet
HQ3	Limestone: same as HQ3 above	9.8
HQ2	Limestone: same as HQ2 above	6.2
HQ1	Limestone: cherty, in part shaly; coralline; medium brownish grey, grey-green shaly facies, weathers grey; medium to irregularly bedded; medium crystalline; grey chert nodules; fossiliferous with prominent brown and white coral spots	11.0
	Total	27.0

(128) QUARRY SECTION—HAGERSVILLE QUARRIES



(129) CHEMICAL ANALYSES—HAGERSVILLE QUARRIES LIMITED

(Analyses from Goudge, p. 236)

Sample No.	Interval	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	CaO	MgO	S
		percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
353.....	Top 15 feet	29.46	1.79	1.95	0.42	63.95	1.47	99.04	36.04	0.70	0.32
353A.....	Lower 15 feet	32.00	1.74	1.00	0.13	63.38	1.85	100.10	35.56	0.88	0.32

mite and prilled ammonium nitrate. Stone is loaded by a 2½-cubic-yard Lima diesel shovel and a 2-cubic-yard Bucyrus-Erie diesel shovel. Haulage to the plant is done by eight 8½-ton, White and Mack, side-dump tandem trucks. A bulldozer and grader are employed in the quarry on clean-up and road maintenance.

The primary crusher is a 30-inch McCully gyratory crusher. The product is carried by a 30-inch conveyor to No. 1 scalping screen, a 4- by 12-foot F600 Tyroc, 2-deck screen, with 2½-inch and ⅞-inch openings. The plus 2½-inch and plus ⅞-inch stone goes to a 10-inch McCully gyratory crusher; the crusher product goes to No. 2 scalping screen, an F600, 3-deck, 4- by 12-foot screen with 2-inch openings. The plus 2-inch stone goes to a 4-foot Symons standard cone-crusher. The crusher product and throughs from the scalping screens go to the screen house. Here screening is done by three sets of two 2-deck screens; the first set, with 1¼-inch and 1-inch openings, produces 2-inch and 1-inch stone, which goes to bins. The minus ¾-inch stone is sized on the second series of screens with ¾- and ½-inch openings producing ¾-inch and ½-inch stone, which goes to bins. The throughs go to two 4- by 10-foot, F300 2-deck screens with 5/16- and 3/16-inch openings. These produce ⅜-inch stone, ¼-inch chips, and screenings.

Provision is made to blend stone to the customers' requirements. Recrushing of the 2-inch and 1-inch stone is done by a 3-foot, Symons, standard cone-crusher. Products are 2-inch, 1-inch, ¾-inch, ½-inch, ⅜-inch, ¼-inch stone, screenings, 2-inch crusher run, and ¾-inch crusher run. The plant has a rated capacity of 300 tons per hour and produces an average of 2,800 tons per day. The stone is used mainly for crushed stone, concrete aggregate, and railway ballast.

6. DETROIT RIVER AND DELAWARE LIMESTONES

High-calcium limestone of the Detroit River group is quarried at Beachville near Woodstock by Chemical Lime Limited, Cyanamid of Canada Limited, and Gypsum Lime and Alabastine Limited and at Zorra Station, north of Beachville, by Canada Cement Company. Limestone of the Delaware formation is quarried at St. Marys by St. Marys Cement Company. Detroit River limestone and the overlying Delaware dolomitic limestone are quarried at Amherstburg by Brunner Mond Canada Limited.

General Description

The stratigraphic succession for Middle Devonian limestone and dolomite formations in southwestern Ontario is shown in (130).

The areal distribution of bedrock outcrops of these formations in southwestern Ontario is indicated on map No. 1062A, *Geological Map of Southwestern Ontario*, published in 1958 by the Geological Survey of Canada.

The Detroit River and overlying Delaware limestone and dolomite form the bedrock surface in a band 30–50 miles wide extending northwest from Lake Erie through London and Woodstock to Lake Huron. These formations dip southwest and outcrop again on the west side of the broad Chatham syncline in Essex county. Throughout most of southwestern Ontario overburden is thick, and outcrops of these formations are scarce.

(130) STRATIGRAPHIC SUCCESSION—MIDDLE DEVONIAN LIMESTONE AND DOLOMITE FORMATIONS, SOUTHWESTERN ONTARIO

Formation or Group		Description	Thickness
Delaware Formation		Brown and buff limestone or dolomitic limestone.	feet 85–160
Columbus Formation*		Grey and buff sandy limestone, limestone, and dolomite.	20– 40
Detroit River Group	Anderdon Limestone*	Limestone.	100–350
	Lucas Formation	Limestone or dolomite.	
	Amherstburg Limestone	Limestone or dolomite.	
	Sylvania Sandstone*	Sandstone.	
Bois Blanc Formation		Cherty magnesian limestone, limestone, and dolomite, sandstone at base	90–220

*Not always present.

Detroit River Group

In southwestern Ontario the Detroit River group, consisting of limestone and dolomite, forms a northwest-trending band extending from Norwich through Beachville, Stratford, and Wingham to Kincardine on Lake Huron. The formations dip southwest. Southeast of Norwich the Detroit River group pinches out, and in Norfolk county between Norwich and Lake Erie, the overlying Delaware limestone rests directly on the underlying Bois Blanc formation. The Detroit River outcrop belt widens to 3½ miles at Beachville and from 12–18 miles or more, to the northwest in the Seaforth and Kincardine areas. In this part of Ontario the Sylvania sandstone and Anderdon limestone are not present. For the purposes of this report the Lucas and Amherstburg formations are not separated as they are lithologically similar, and the distinction between them is made on faunal grounds.

In this belt the rocks of the Detroit River group are divided into two facies: to the southeast of Embro and St. Marys the Detroit River is composed of limestone; to the north of St. Marys it is mainly dolomite; in the St. Marys area the dolomite and limestone facies interfinger.

The southern facies, as exposed at Beachville, consists of 100–10 feet of high-purity calcium limestone, medium-brownish grey to tan in colour, medium-crystalline to micro-crystalline in texture, medium- to thick-bedded, with abundant corals and stromatoporoids. The northern facies is described as follows:[1]

To the north the high calcium facies changes to dolomitic facies. At St. Marys the two lithologies interfinger. In the northern part of the area where the Detroit River group is dominantly dolomite several types of lithologies are developed. The normal dolomites of the northern facies are soft, evenly bedded, uniform, light to medium brown and fine-grained. Bituminious laminae are common, and there may be a petroliferous odour. In some areas the dolomite is fine-grained, thin-bedded, cream-coloured, and contains numerous small lath-like pieces of calcite which likely are replacements of gypsum crystals. Interbedded are thick algal biostromes of medium grained, medium brown, crystalline dolomite in massive hummocky irregular beds.

Also in the northern facies, massive, fossiliferous, high-purity calcium limestone reefs occur in the Detroit River. These reefs are called "Formosa reef limestone" by E. W. Best and are a reef facies of the Detroit River. They were formerly correlated with the Alpena limestone of Michigan but have since been re-correlated by Best with the older Detroit River group. High-purity Formosa reef limestone is exposed near Formosa, Bruce county. (See Goudge, pp. 210, 211, for descriptions.)

The thickness of the Detroit River group increases from 0 feet southeast of Norwich to 110 feet at Beachville, to 197 feet at St. Marys, and to 350 feet at Clinton.[2] Throughout central-southwestern Ontario the Detroit River limestone and dolomite rest on the Bois Blanc cherty limestone (the Sylvania sandstone is absent). In the Beachville area the Detroit River limestone is overlain by up to 30 feet of Columbus buff, sandy, dolomitic limestone. The Columbus formation is absent throughout the rest of the belt, and the Delaware limestone overlies the Detroit River unconformably.

In the Windsor-Amherstburg area of Essex county, where the Detroit River group outcrops again on the west side of the Chatham syncline it is divided into four formations as follows:

Formation	Thickness Feet
Anderdon limestone	32
Lucas dolomite	200 ±
Amherstburg dolomite	
Sylvania sandstone	70–100

[1]Abstracted after E. W. Best, 1953, *op. cit.*

[2]E. W. Best, *op. cit.*

The complete section of Anderdon limestone, a high-purity calcium limestone 32 feet thick, is exposed in the Brunner Mond quarry at Amherstburg, where it is overlain by 52 feet of Delaware buff dolomitic limestone and underlain by Lucas dolomite. The Sylvania sandstone, a fine-grained, grey to white, high-purity sandstone, has been intersected in drilling and shaft-sinking but does not outcrop. It is thin and pinches out to the east. In the Canadian Rock Salt Company's shaft at Ojibway, this sandstone was intersected between 370 and 440 feet.

Delaware Formation (Dundee Equivalent)

The Delaware limestone rests on Columbus sandy limestone, or where this is absent, directly on the underlying Detroit River group. The formation has a thickness of 85–160 feet.

Fifty feet of Delaware limestone is exposed in the St. Marys Cement Company quarry at St. Marys. Here the formation consists of medium-brownish grey to medium-light grey, medium-crystalline coquinoid to fine-crystalline, thick- to medium-bedded limestone with shaly partings and some colour laminations.

Fifty-two feet of Delaware limestone is exposed in the upper lift at the Brunner Mond quarry in Amherstburg, where it consists of medium-brownish grey, buff- to light-brown-weathering, aphanitic, massive-bedded, fossiliferous, dolomitic limestone with some mottling and colour laminations. Chert is rarely present.

Beachville Area

The Detroit River limestone is exposed in the valley of the Thames River for a distance of 3½ miles between Ingersoll and Woodstock. Here the Detroit River limestone has a thickness of 100–10 feet and dips southwest. It is underlain in the vicinity of Woodstock by the cherty, somewhat higher magnesia-bearing limestone of the Bois Blanc formation, and overlain by 20–30 feet of sandy, buff-coloured, Columbus limestone, which forms the cap rock at the Chemical Lime Limited quarry near Ingersoll.

The 110 feet of Detroit River limestone is characterized by its high-purity and averages less than 1 percent combined silica, iron, and alumina, and less than 1–1.5 percent magnesia. This limestone is the thickest, most uniform, and purest high-calcium chemical limestone available in Ontario and is an important stone source for the production of chemical lime. It should be regarded as a wasting asset. Although other deposits of high-calcium limestone are available, none have the thickness, uniformity, and purity of this deposit.

Drift is thin in the Thames River valley, and the entire exposed length of Detroit River limestone is occupied by quarry operators. At the Ingersoll end of the 3½-mile section, Chemical Lime Limited has a complete 100-foot section of limestone available. However, the southwest-dipping, siliceous, buff Columbus limestone cap rock covers the deposit to the southwest of the present quarry, rendering expansion of open-pit quarrying uneconomic in that direction. Cyanamid of Canada operates a large quarry to the northeast of the Chemical Lime property, and adjoining on the east is the quarry of Gypsum, Lime & Alabastine Limited. Since the formations dip southwest, a complete 110-foot section of Detroit River limestone is not available on the Gypsum, Lime & Alabastine property. The west quarry face exposes the lower 73 feet of the high-purity Detroit River limestone. Eastward in the quarry the thickness of high-purity stone diminishes. The lower contact of high-purity stone is placed at a well marked chemical unconformity where the magnesia content exceeds 2 percent, and the silica content exceeds 1 percent. There is no marked lithologic break, but chert generally appears in the upper part of the Bois Blanc formation, which underlies the Detroit River limestone. The limestone dips southwest at the rate of 30 feet per mile in the Thames River valley at Beachville.

The extent of the high-purity Detroit River limestone band is indicated on map No. 1960d (in map case). It extends along strike to the southeast of the Thames River valley for a distance of about 18 miles through West Oxford and North and South Norwich townships, but pinches out southeast of the town of Norwich, owing to a period of pre-Delaware erosion.

The high-purity limestone extends northwest along strike from the Beachville area, through Zorra Station, where the Canada Cement Company plant is located, and across the Middle Branch of the Thames River west of Embro. To the north of Embro, between Embro and St. Marys, the high-purity limestone facies interfingers with the dolomite facies to the north, so that a limited area of the high-purity stone is available.

Unfortunately in the territory away from the Thames River valleys, the overburden is very thick, ranging from 60 to 300 feet or more in depth. For this reason quarrying in the high-purity Detroit River limestone belt involves stripping of a considerable thickness of overburden. A large part of the desirable ground between the Thames River and the middle branch at Embro has already been taken up.

Quarries

GYPSUM, LIME & ALABASTINE LIMITED (BEACHVILLE QUARRY AND LIME PLANT, BEACHVILLE)

(A Division of Dominion Tar & Chemical Co. Ltd.)

The Beachville quarry and lime plant of Gypsum, Lime & Alabastine Limited is located in the valley of the Thames River on the north side of highway No. 2, 1 mile southwest of Beachville. The river valley is about 1,600 feet wide; the Canadian Pacific railway line follows the south side, and the Canadian National railway line follows the north side. This confines present quarry operations in the valley to a strip less than 1,000 feet wide between the C.N.R. line and the Thames River. The river flows along a diked diversion canal within this part of the valley. It is planned in 1960 to begin a tunnel under the Canadian National railway line to give access to stone reserves north of the track. It will be necessary to strip up to 60 feet of overburden in the new quarry area.

The Beachville lime plant, with six vertical stack kilns and two rotary kilns, is one of the largest and most modern in Canada, with a rated capacity of over 1,200 tons of high-quality calcium lime per day.

Geology

The 73-foot quarry section exposed at the southwest end of the quarry is illustrated and described in (133). The Detroit River limestone is medium-brownish grey to medium-brown or tan, light-brown- to grey-weathering; medium-crystalline to microcrystalline; medium- to thick-bedded, with abundant stylolites, corals, and "football-like" stromatoporoids. Black bituminous partings are present.

Chemical analyses of a representative diamond-drill hole (No. 1), drilled in 1948 on the Gypsum,

(131) DIAMOND-DRILL HOLE NO. 1—GYPSUM, LIME & ALABASTINE LIMITED, BEACHVILLE

(Company data by permission of Gypsum Lime & Alabastine Ltd.)

	Depth	L. O. I.	SiO_2, R_2O_3 + Insolubles	CaO	MgO	SO_3	Total
	feet	percent	percent	percent	percent	percent	percent
Overburden	0– 23	.....	.....	.....	.....	.....	.....
DETROIT RIVER LIMESTONE (23–73(?) ft.: total 50 ft.)	23– 26	43.66	0.41	55.20	0.32	0.04	99.63
	26– 28	43.85	0.68	54.80	0.18	0.02	99.53
	28– 35	43.77	0.37	55.00	0.32	0.03	99.49
	35– 40	43.85	0.39	55.00	0.16	0.04	99.44
	40– 45	43.44	0.88	54.30	0.83	0.06	99.51
	45– 50	43.79	0.74	54.00	0.96	0.06	99.55
	50– 55	43.79	0.48	55.00	0.30	0.04	99.61
	55– 60	43.35	0.57	55.40	0.21	0.06	99.59
	60– 65	44.01	0.48	54.80	0.25	0.04	99.58
	65– 70	44.24	0.50	54.10	1.02	0.05	99.91
	70– 75	44.00	1.11	53.20	1.61	0.07	99.99
BOIS BLANC FORMATION (73 (?) ft. to bottom of hole at 127 ft.: total, 54 ft.)	75– 80	42.12	5.25	50.65	1.81	0.09	99.92
	80– 85	42.95	3.63	50.10	3.24	0.09	100.01
	85– 90	41.97	6.64	47.00	4.41	0.08	100.10
	90– 95	42.20	6.08	47.40	4.35	0.05	100.08
	95–100	42.45	4.90	51.05	1.54	0.10	100.04
	100–105	40.22	9.66	48.50	1.63	0.05	100.06
	105–110	40.09	9.84	49.10	0.96	0.03	100.02
	110–115	38.96	12.29	47.40	1.25	0.04	99.94
	115–120	36.54	17.75	44.30	1.44	0.07	100.10
	120–125	36.55	18.16	44.30	0.94	0.06	100.01
	125–127	25.21	42.85	30.50	1.26	0.04	99.96

(132) AVERAGE CHEMICAL ANALYSES OF DIAMOND-DRILL HOLE NO. 1

	L. O. I.	SiO_2, R_2O_3 + Insolubles	CaO	MgO	SO_3	Total
	percent	percent	percent	percent	percent	percent
Detroit River (52 ft.)	43.80	0.61	54.58	0.59	0.05	99.63
Bois Blanc (52 ft.)	40.41	9.42	47.98	2.16	0.07	100.04

The Detroit River high-calcium limestone is quarried at the Beachville property of Gypsum Lime & Alabastine Limited. The lime plant is seen in the background. This is the largest and most modern plant in Canada.

Lime & Alabastine farm at the east end of the property, north of the lime plant, 200 feet north of the C.N.R. track and 200 feet east of the plant road (lot 18, concession II, N. Oxford township), were kindly supplied by the company and are reported in (131).

The average compositions of the upper 52 feet of Detroit River limestone and the lower 52 feet of Bois Blanc cherty limestones are given in (132). The lower contact of the Detroit River limestone is placed at the point where silica plus R_2O_3 increases to over 1 percent, and magnesia increases to 1.0–1.5 percent or more. The actual contact in this hole lies in the 70- to 75-foot section. This chemical unconformity is recognizable in all the drill-hole results examined by the author in the Beachville area.

Stone used for lime production at this quarry averages less than 0.8 percent MgO and less than 1 percent silica + R_2O_3.

Quarry Operation

The quarry section has its maximum height at the southwest end where the 73-foot section is quarried in an upper 55-foot and a lower 18-foot lift. Drilling is done by an electric churn-drill drilling 5¼-inch holes in a 14- by 14-foot pattern on the lower lift and a 20- by 22-foot pattern on the upper lift.

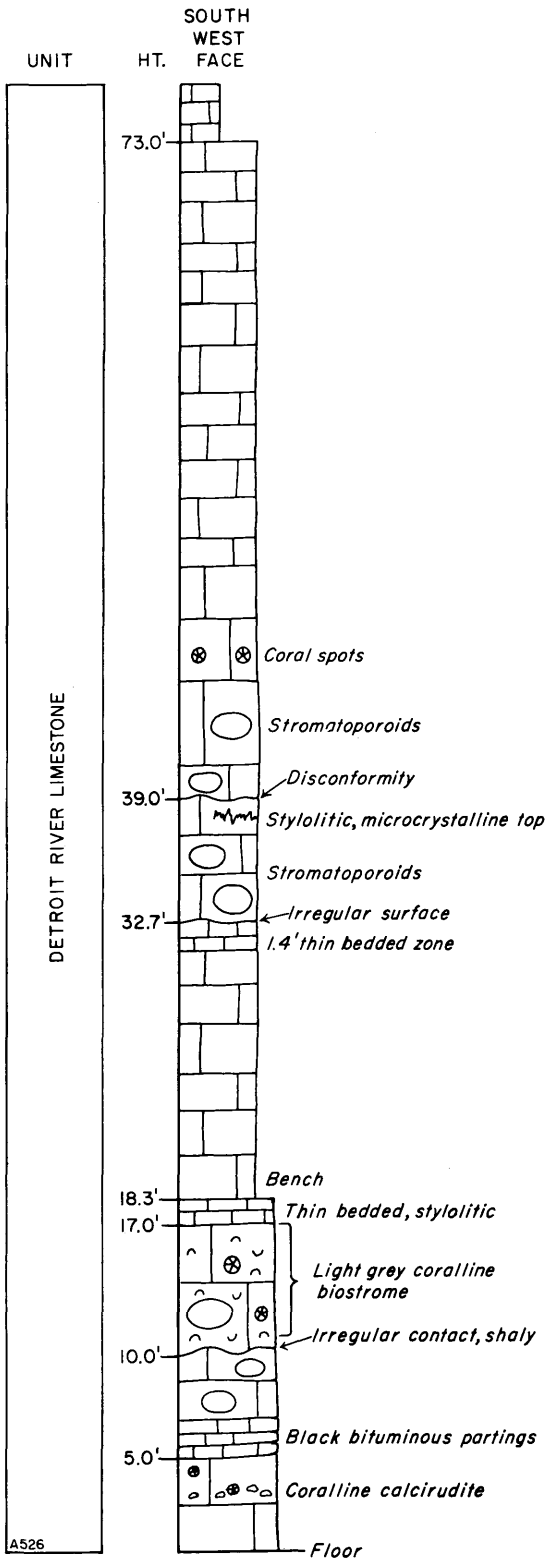
Stone is loaded by two, 2½-cubic-yard, diesel shovels onto five diesel trucks with 12-ton Easton, side-dump semi-trailers for haulage to the primary crusher, a 30-inch gyratory crusher. The crusher product is carried on a 36-inch conveyor to a variable bar grizzly set at 6 inches. The oversize goes to a 4¼-foot Symons standard cone-crusher. The grizzly throughs and the cone product go via a 36-inch conveyor to a live surge pile. Stone is reclaimed by a feeder feeding a 36-inch conveyor which carries the stone to a 6- by 14-foot, 2-deck screen with 3¼-inch and 1¾-inch openings. The 6- by 3½-inch stone from the top deck goes to the 1,000-ton storage silo No. 7 to serve as feed for the vertical shaft lime kilns Nos. 1–4. The 3½- by 1¾-inch stone from the bottom deck goes to the 1,000-ton storage silo No. 6 to serve as feed for the vertical shaft kilns Nos. 5 and 6.

The minus 1¾-inch stone from the screen is carried by conveyor to a 6- by 14-foot, 2-deck screen with 1¼- and ¾-inch openings. The 1¾- by 1¼-inch stone from the top deck goes to the 1,000-ton storage silo No. 5 as rotary-kiln feed. The ¾- by 1¼-inch stone from the bottom deck goes to the 1,000-ton storage silo No. 4 as rotary-kiln feed. The minus ¾-inch stone goes to a 6- by 14-foot, 2-deck screen with ½- and ¼-inch openings. The ¾- by ½-inch stone goes to the 750-ton storage silo No. 3 to serve as kiln feed. The ¼- by ½-inch stone goes to the 750-ton storage silo No. 2 and may be used as kiln feed for rotary kiln No. 2 in the summer. The minus ¼-inch stone is stockpiled and used for feed to the pulverized stone

(133) QUARRY SECTION—GYPSUM, LIME & ALABASTINE LIMITED, BEACHVILLE

DESCRIPTION	THICKNESS Feet
DETROIT RIVER	
Limestone: medium brownish grey to medium brown, sometimes tan, light brown to grey weathering; medium-crystalline to microcrystalline; medium to thick-bedded, rarely thin bedded; stylolites; black bituminous partings; fossiliferous—stromatoporoid "footballs" and coral spots	76.0+

(133) QUARRY SECTION—GYPSUM, LIME & ALABASTINE LIMITED, BEACHVILLE



Scale: 1 inch to 10 feet

plant. Seventy-five percent of the stone produced is plus ½-inch in size and larger. Plant capacity is about 260 tons per hour.

PULVERIZED STONE PLANT

A new pulverized stone plant came into production early in 1959. The minus ¼-inch stone goes through a rotary drier. The product is screened by 2-hummer, 2-deck screens; the oversize goes to a pulverizer in closed circuit with the screens. Fines are taken out by an air separator.

LIME PLANT

The lime plant consists of six gas-fired vertical shaft kilns and two rotary kilns. Shaft kilns Nos. 1–4 were built prior to 1950 and have a 60-square-foot cross-section and 62-foot height. They are fired by gas producers, and are charged with 6- by 3½-inch stone. They each have a capacity of 75 tons of lime per 24 hours. Vertical kilns Nos. 5 and 6, built in 1950 and 1957 respectively, are also fired by gas produced from coal, but have a 72-square-foot cross-section and have capacities of 170 tons of lime per 24 hours for each kiln. These kilns use 3½- by 1¾-inch stone.

In 1956 and 1957 two new rotary kilns were put into operation to meet the increased demand for lime especially for the Blind River uranium camp. The two 9- by 250-foot rotary kilns have a capacity of 300 tons per 24 hours each, and are fired with powdered coal supplied by a hot-air-swept Raymond mill. No. 1 rotary kiln generally uses 1¾- by 1½-inch stone, while No. 2 kiln uses ½- by ¾-inch or ¾- by 1¼-inch stone in the winter and ¼- by ½-inch to ¾- by 1¼-inch stone in the summer. The kilns have a slope of ½ inch per foot and are driven at 1 revolution per minute.

The lime produced is crushed, screened, sized, and goes to storage silos. Any size of lime can be produced to meet the customer's requirements. Lime is shipped, in bulk or in bags, by truck or rail. Hydrated lime is produced in a 10-ton continuous hydrator.

Although the quarry production is used primarily for the lime plant, some stone is also produced for flux, cement plants, and the pulverized stone market.

CYANAMID OF CANADA LIMITED (BEACHVILLE QUARRY AND LIME PLANT, BEACHVILLE)

The Beachville quarry and lime plant of Cyanamid of Canada Limited (formerly North American Cyanamid Limited) is located in the Thames River valley on the north side of highway No. 2 2 miles southwest of Beachville. The property adjoins that of Gypsum, Lime and Alabastine Limited and is southwest or down-dip from the latter property. The quarry occupies the entire width of the valley between the C.N.R. line and the Thames River diversion channel, and the face is being advanced southwest towards the Chemical Lime Limited property.

This quarry has operated for many years to supply chemical-grade limestone to the Niagara Falls lime plant of Cyanamid of Canada Limited. In 1957 a rotary-kiln lime plant was established on the Beachville property. At this time the crushing plant was re-designed, and the new crushing plant with a capacity of 350–400 tons per hour went into operation in April, 1958.

As reserves of stone in the valley are small, additional ground has been acquired north of the C.N.R. line to ensure future stone reserves.

Geology

The 70-foot quarry face at the southwest end of the quarry is composed entirely of Detroit River limestone, which is similar to that in the Gypsum, Lime and Alabastine quarry. The section is illustrated and described in (135). In a sump to the east of the primary crusher, a further 5 feet of section is exposed: below 1 foot of thin-bedded limestone there is a 4-foot-thick, massive, light-grey to white, medium-crystalline, coralline limestone. This fossiliferous horizon forms a marker that can be seen near the top of the lower 18-foot lift in the Gypsum, Lime and Alabastine quarry to the northeast. The quarry floor above this biostrome tends to be humpy.

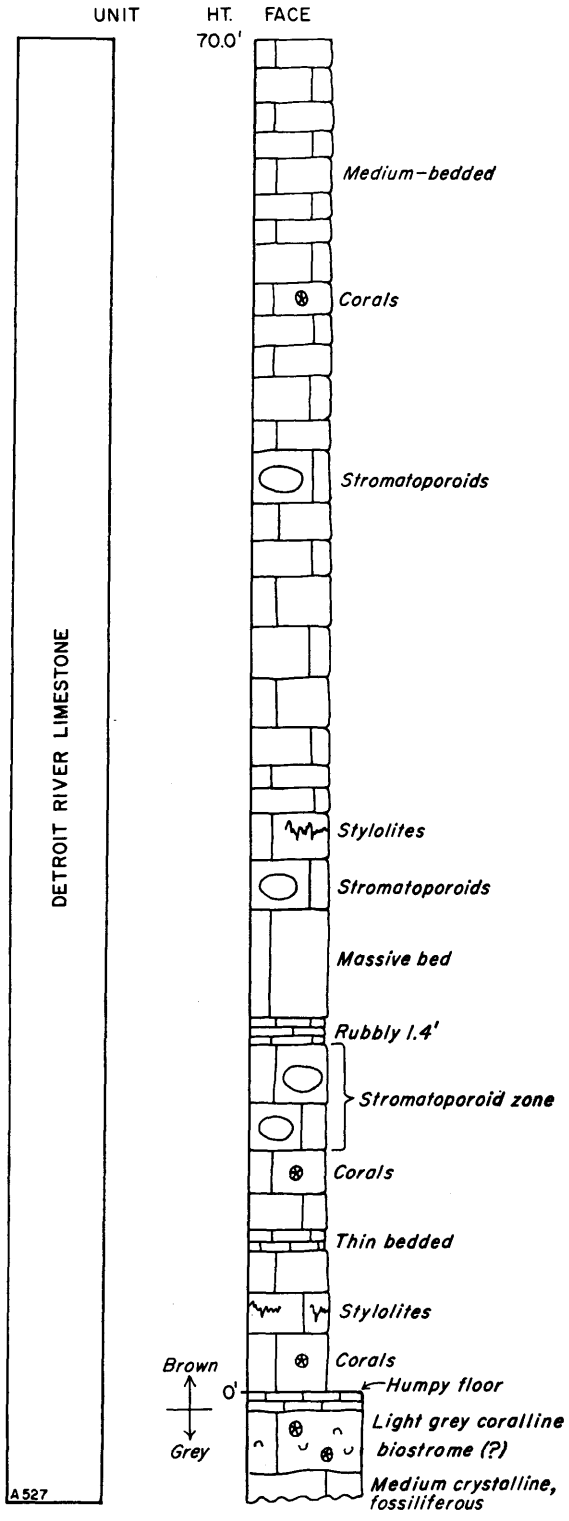
Chemical analyses of the quarry face, as given by Goudge (p. 265) are shown in (134).

(134) CHEMICAL ANALYSES—CYANAMID OF CANADA LIMITED

(Analyses from Goudge, p. 265)

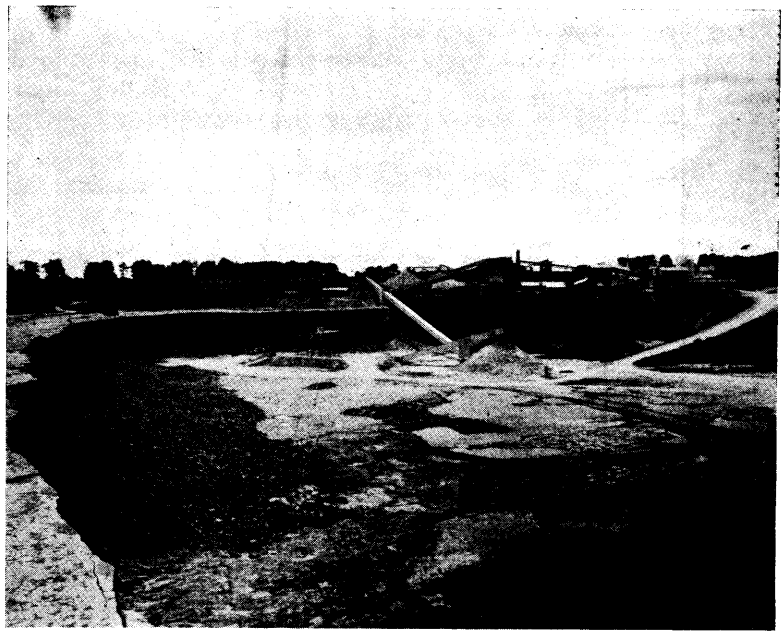
Sample No.	Height of Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
		percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
349	upper 6 ft.	0.21	0.07	0.03	0.02	98.64	0.65	99.62	0.02	55.29	0.31
349A	next 30 ft.	0.34	0.12	0.12	0.02	98.52	0.78	99.90	0.02	55.18	0.37
349B	next 23 ft.	0.48	0.06	0.25	0.02	98.45	1.20	100.46	0.04	55.14	0.57
349C	lower 11 ft.	0.58	0.08	0.27	0.02	97.71	1.51	100.17	0.05	54.73	0.72

(135) QUARRY SECTION—CYANAMID OF CANADA LIMITED, BEACHVILLE



Scale: 1 inch to 10 feet

DESCRIPTION	THICKNESS Feet
Limestone: medium-brown to light buff, buff to brownish grey weathering; fine-crystalline to aphanitic, sometimes microcrystalline; thick- to medium-bedded, sometimes massive-bedded; black bituminous partings; stylolites; fossiliferous—stromatoporoids, corals, coquinoid fossil debris in places.....	70.0



The quarry and plant of Cyanamid of Canada Limited at Beachville. The quarry face consists of over 70 feet of high-calcium Detroit River limestone.

(*Courtesy of Cyanamid of Canada Ltd.*)

Quarry Operation

Up to 20 feet of overburden is stripped by a Le Tourneau scraper and bulldozer. The 70-foot quarry face is drilled on a 21- by 23-foot pattern by one Ingersoll-Rand Drillmaster drilling 6-inch holes. Nitrone and prilled ammonium nitrate are used as blasting agents. Stone is loaded by one 4½-cubic-yard, Lima diesel shovel and one 2½-cubic-yard Northwest diesel shovel. Haulage to the primary crusher situated on the quarry floor is done by three 22-ton Euclid, and two 15-ton Mack, rear-dump trucks.

PRIMARY CRUSHER

The primary crusher is a 42-inch Traylor gyratory. A 36-inch conveyor carries the stone to a surge pile at the plant on the north side of the quarry.

SECONDARY-CRUSHER BUILDING

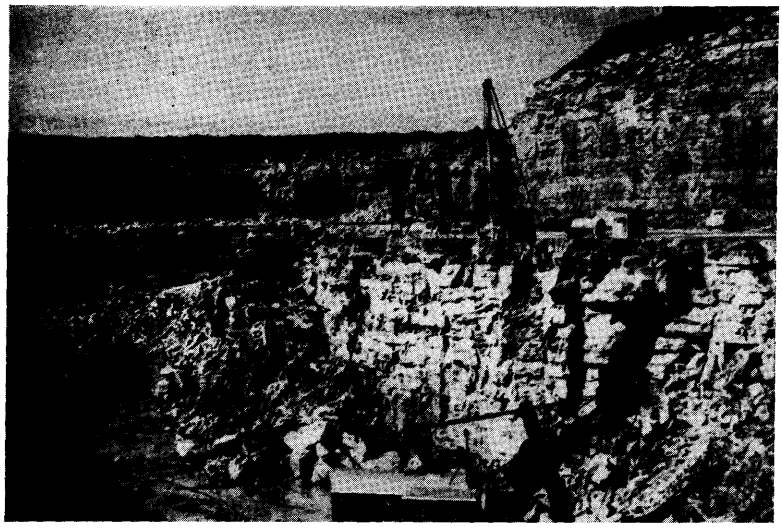
The stone from the surge pile is carried by the 36-inch conveyor in a reclaiming tunnel to the secondary-crusher building to a 2-deck, F900, 6- by 14-foot scalping screen with 9-inch and 5-inch openings. The 9- by 5-inch stone goes to No. 1 Bin for sale as open-hearth flux stone, or to the secondary crusher, a 5½-foot Symons standard cone. The plus 9-inch stone from the scalping screen also goes to the conveyor feeding the secondary crusher, which produces minus 3-inch stone. The minus 5-inch stone from the scalping screen is conveyed to an F800, 2-deck, 5- by 12-foot screen with 3-inch and 2-inch openings. The 5- by 3-inch stone from the top deck goes either to No. 2 Bin for sale as blast furnace flux stone, or to the secondary crusher. The 3- by 2-inch stone goes to the secondary crusher. The secondary-crusher product and the throughs from the F800 screen are carried by No. 3 conveyor to the new screen house and bin building.

SCREENING AND RECRUSHING

The feed from No. 3 conveyor is split between two F600, 2-deck, 5- by 12-foot screens with 1½-inch openings on the lower deck. The plus 1½-inch stone goes to a 36-inch Telsmith gyratory crusher for recrushing. This crusher is in closed circuit with the 1½-inch screens. The minus 1½-inch stone goes to two F600, 2-deck, 5- by 12-foot screens with 1-inch and ¾-inch openings. The 1½- by 1-inch stone from the top decks goes to No. 4 Bin and is shipped as kiln feed to the Niagara Falls lime plant. The 1- by ¾-inch stone goes to No. 5 Bin and is used for kiln feed at the Niagara Falls lime plant or for the rotary kiln at Beachville. The minus ¾-inch stone is carried by conveyors to the old screen building.

At this building the minus ¾-inch stone is fed to two single-deck, Symons, 4- by 15-foot screens with ⅛-inch openings; the ⅝-inch stone (¾- by ⅛-inch) goes to bins and is sold for manufacture of portland cement. The minus ⅛-inch stone is used for screenings, dust, agricultural lime, or pulverized limestone.

The quarry and crushing plant has a rated capacity of 350–400 tons per hour and operates on two 8-hour shifts to produce 5,000–6,000 tons per



Nearly 100 feet of high-calcium Detroit River limestone are quarried by Chemical Lime Limited near Ingersoll. The sandy Columbus limestone can be seen in the upper right. Note the churn drills.

day. This quarry operation, which is one of the largest in Ontario, produces over 1,000,000 tons of stone annually. Over 50 percent of the stone is used for the manufacture of chemical lime; the remainder is used for portland cement, flux stone, and pulverized stone.

The following is a summary of the sizes produced:

Size	Use
9- x 5-inch	Open hearth flux stone
5- x 3-inch	Blast furnace flux stone
1½- x 1-inch	Lime kiln feed
1- x ¾-inch	Lime kiln feed
¾- x ⅛-inch	Portland cement
minus ⅛-inch	Pulverized stone

LIME PLANT

In 1957 a rotary-kiln lime plant was built at the Beachville quarry. The 10½- by 350-foot, F. L. Smidth kiln is fired by powdered coal and has a rated capacity of 335 tons of lime per 24 hours. Kiln feed is 1- by ¾-inch or 1- by ⅝-inch stone. The lime is of high purity containing less than 1 percent silica and less than 1.5 percent magnesia. A large part of the lime is shipped to the Blind River uranium camp, where it is used in neutralization of the acid leaching solutions from the uranium mills.

Niagara Falls Lime Plant

The Beachville quarry supplies high-calcium limestone to the Niagara Falls plant where it is burned to produce lime for use in the manufacture of calcium cyanamide. The Niagara Falls lime plant has seven rotary kilns with a total capacity of 700 tons per 24 hours.

CHEMICAL LIME LIMITED (INGERSOLL QUARRY AND LIME PLANT, INGERSOLL)

The Ingersoll quarry and lime plant of Chemical Lime Limited, the third of the three lime plants between Beachville and Ingersoll, is located in the Thames River valley, on the north side of highway No. 2, 1 mile northeast of Ingersoll and 3 miles southwest of Beachville. The company is a subsidiary of the Steel Company of Canada and two-thirds of its production is flux stone. A lime plant, consisting of 6 small vertical stack kilns with a total capacity of 60 tons of lime per 24 hours, has operated for many years at the quarry. In 1959 a new plant consisting of three gas-fired vertical stack kilns, with a total capacity of 300 tons of lime per day, went into operation.

Geology

Since the Chemical Lime quarry is on the down-dip edge of the Detroit River limestone outcrop in the Thames River valley, a complete section of 100–110 feet of high-purity Detroit River limestone is available. On the southwest side of the property the overlying cap rock consisting of sandy, buff limestone of the Columbus formation is exposed. At the present quarry face, 15 feet of this sandy limestone is exposed and it thickens to the southwest. This impure cap rock limits the southwest extension of economic open-pit quarrying.

The quarry section exposed at the southwest end of the quarry consists of 98 feet of high-purity

Detroit River limestone, overlain by 15 feet of sandy Columbus limestone. The quarry is worked in three lifts: the upper 15-foot lift is cap rock, the Columbus, limestone; the middle and lower lifts are 52 and 46 feet in height, respectively.

The high-purity Detroit River limestone is similar to the sections already described, consisting of medium-brown to light-tan, medium-crystalline to microcrystalline, thick-bedded limestone with black shaly partings, some colour lamination, stylolites, abundant corals, and stromatoporoid "footballs." The quarry section is illustrated and described in (137).

Chemical analyses of diamond-drill hole No. 22, drilled in 1945 on the present quarry site 300 feet southeast of the primary crusher, were kindly supplied by the company and are reported in (136).

This diamond-drill hole cut 90 feet of Detroit River limestone and did not penetrate to the base of the high-calcium beds, which here have a thickness of about 104 feet. The average composition of the 90 feet of Detroit River limestone cut in this drill-hole is as follows: SiO_2, 0.86 percent; $Al_2O_3 + Fe_2O_3$, 0.21; CaO, 53.92; MgO, 0.84; and S, 0.037 percent.

Flux stone supplied by this quarry runs as follows: sulphur less than 0.1 percent, magnesia less than 1.0 percent, silica less than 1.0 percent.

Quarry Operation

From 15 to 20 feet of sand and up to 15 feet of sandy Columbus limestone must be stripped from the underlying high-purity limestone beds. Drilling on the 52- and 46-foot lifts of Detroit River limestone is done by two Bucyrus-Erie electric churn-drills, one model 29T and one model 22T. Six-inch holes are drilled on a 21- by 24-foot pattern on the upper lift and on a 20- by 20-foot pattern on the lower lift. Blasting agents are Nitrone and prilled ammonium nitrate. Stone is loaded by two Bucyrus-Erie Model 85B, electric, 3¼-cubic-yard shovels. Seven 15-ton Euclid rear-dump trucks are used on haulage.

CRUSHING AND SCREENING

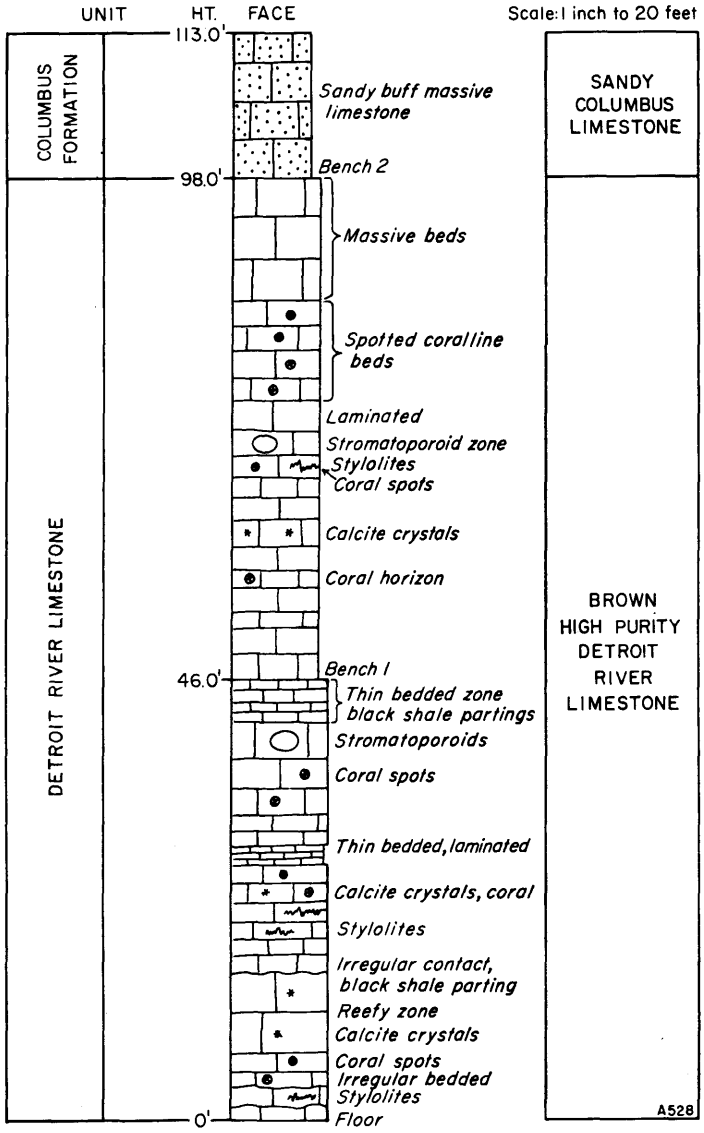
The primary crusher, a 48- by 60-inch, Traylor jaw-crusher, is located on the bench at the top of No. 1 lift in the quarry. The stone is carried from the jaw-crusher to the secondary-crusher building by a 42-inch conveyor, which discharges on a 5- by 14-foot, F800, single-deck scalping screen with a split deck having 5- and 10-inch openings. The plus 10-inch stone goes to the secondary crusher, a 24- by 36-inch, Traylor jaw-crusher set at 5 inches. The 10- by 5-inch stone is conveyed either to a bin for open-hearth flux stone or to the secondary crusher.

(136) DIAMOND-DRILL HOLE NO. 22—CHEMICAL LIME LIMITED

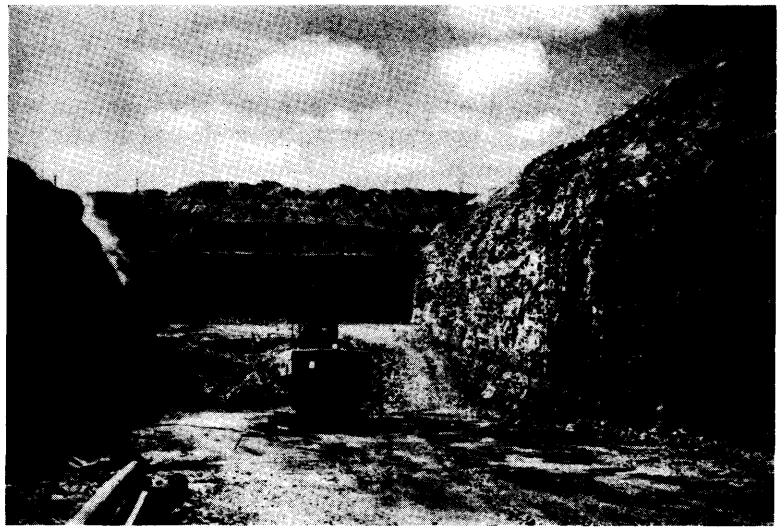
(Ground elevation, 878.90 feet)

	Depth	SiO_2	$Fe_2O_3 + Al_2O_3$	CaO	MgO	S
	feet	percent	percent	percent	percent	percent
OVERBURDEN	0– 23	.....	.....	.....	.....	.....
COLUMBUS SANDY LIMESTONE (2 ft.)	23– 25	10.00	3.30	41.23	6.02	0.035
DETROIT RIVER LIMESTONE (90 ft.)	25– 30	2.00	0.50	52.78	1.20	0.017
	30– 35	0.86	0.50	54.00	0.70	0.040
	35– 40	1.00	0.50	54.05	0.70	0.040
	40– 45	1.00	0.40	54.35	0.50	0.040
	45– 50	0.70	0.50	54.20	0.56	0.040
	50– 55	0.80	0.10	54.00	0.90	0.040
	55– 60	0.80	0.14	53.89	0.96	0.020
	60– 65	0.80	0.10	53.93	0.90	0.034
	65– 70	0.80	0.08	53.74	0.96	0.024
	70– 75	1.00	0.14	53.92	0.90	0.036
	75– 80	0.90	0.14	53.98	0.90	0.014
	80– 85	0.60	0.10	53.90	0.90	0.044
	85– 90	0.60	0.10	53.96	0.90	0.044
	90– 95	0.60	0.10	53.86	0.86	0.047
	95–100	1.00	0.12	53.80	0.94	0.065
	100–105	1.00	0.12	53.76	0.86	0.053
	105–110	0.54	0.10	53.86	0.96	0.055
	110–115	0.50	0.10	54.26	0.64	0.025

(137) QUARRY SECTION—CHEMICAL LIME LIMITED (INGERSOLL QUARRY), INGERSOLL



UNIT	DESCRIPTION	THICKNESS Feet
Columbus Formation	Limestone: sandy; light brownish buff, buff to rusty weathering; thick- to massive-bedded; fine-crystalline; fossiliferous	15.0+
Detroit River Limestone	Limestone: medium-brown to light tan, sometimes medium brownish grey, light buff to grey weathering; medium crystalline to aphanitic, sometimes microcrystalline; thick-bedded, sometimes massive or medium bedded; thin colour lamination sometimes present; black shaly and bituminous partings; calcite crystals; stylolites; fossiliferous —abundant cup corals, stromatoporoid "footballs"	98.0
	Total	113.0



Canada Cement Company Limited quarries 100 feet of high-calcium Detroit River limestone at their Woodstock plant; 70-80 feet of overburden is stripped. The photo shows the Joy Heavyweight Champion rotary drill in action.

The minus 5-inch stone goes to a 2-deck, 5- by 12-foot, F600 screen with 1½- and ½-inch openings. The 5- by 1½-inch stone and the 1½- by ½-inch stone is carried by a 36-inch conveyor to the screen house. The minus ½-inch stone goes via separate 24-inch conveyor to the screen house.

SCREEN HOUSE

The 36-inch conveyor to the screen house discharges on a 2-deck, 6- by 12-foot, F800 screen with 5-inch and 2-inch openings. The plus 5-inch stone goes to the bin for open-hearth flux. The 5- by 2-inch stone goes to a bin for blast furnace flux, and feed for the new lime plant.

The 2-inch throughs go via a 36-inch transfer conveyor to another 2-deck, split-deck screen with ¾–1 inch and 3/16–½ inch openings. The 1- by 1½-inch stone, the ½- by 1-inch, the ¼- by ½-inch, and the minus ⅛-inch stone go to separate bins. The minus ⅛-inch stone is used for sintering flux stone. The other sizes are sold for crushed stone or portland cement production. The minus ½-inch stone on the 24-inch conveyor from the secondary crusher building goes to the minus ½-inch wet fines bin.

A new pulverized stone plant is being erected to produce minus ⅛-inch sinter flux stone from the minus 2-inch stone. This plant will consist of a C38 Pennsylvania impactor in closed circuit with twin Nordberg-Rod screens.

LIME PLANT

The new lime plant, which went into production early in 1959, consists of three vertical stack kilns, each with a capacity of 100 tons of lime per 24 hours. The kilns are fired by gas from a Wellman-Gallusha gas producer. Kiln feed is 2- to 5-inch stone.

CANADA CEMENT COMPANY LIMITED (WOODSTOCK CEMENT PLANT, ZORRA STATION)

The Woodstock quarry and cement plant of Canada Cement Company Limited are located on the north side of Governors Road, 6 miles west of Woodstock, at Zorra Station on the Canadian Pacific railway line. The cement plant is in lot 1, concession IV, Zorra township, Oxford county, and the quarry, a short distance to the west, is in lot 2, concession III.

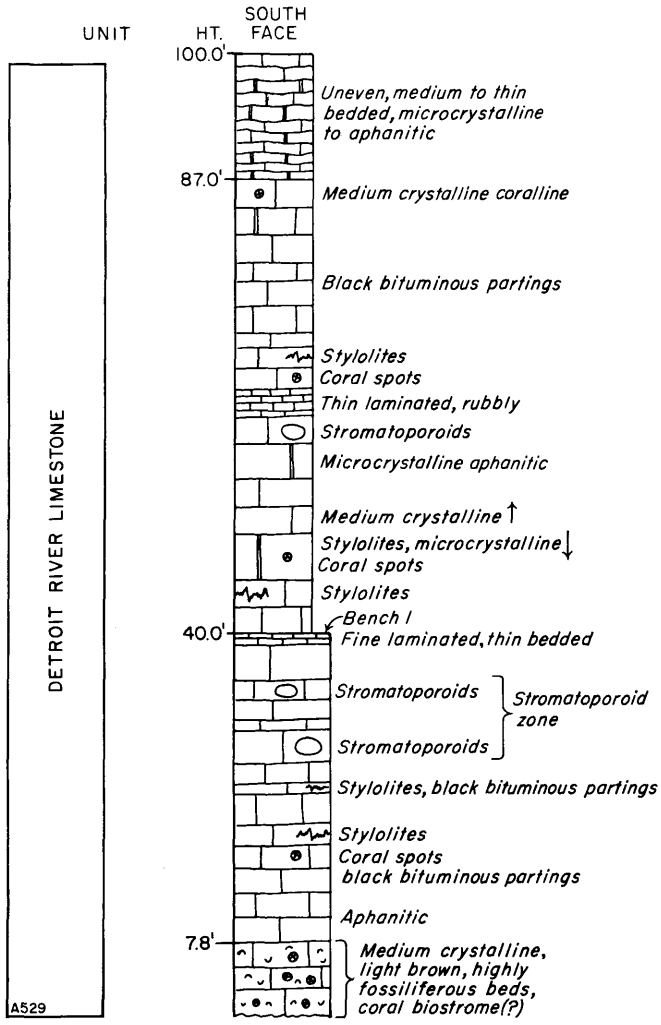
This new 3,200,000-barrel-per-year, 2-kiln, wet-process cement plant was built in 1956 and went into full production in 1957. It is designed for eventual expansion to a 5-kiln operation.

Geology

The 100-foot section exposed in the quarry consists entirely of Detroit River high-calcium limestone. The limestone is medium-brown to tan, brownish-grey-weathering; medium-crystalline to microcrystalline; medium- to thick-bedded; with black bituminous partings, abundant stylolites, corals, especially cup corals, and stromatoporoid "footballs". The section is illustrated in (138). The Detroit River limestone is rather uniform in character and has no easily distinguishable marker horizons, except for the lighter-coloured, medium-crystalline, fossiliferous 8-foot section at the base. These beds may correlate with the light-grey fossiliferous 7 feet at the top of No. 1 lift at the Gypsum, Lime & Alabastine quarry at Beachville.

Chemical analyses of a diamond-drill core from the Canada Cement property, in lot 2, concession II, Zorra township, on the north side of the C.P.R. track at the west end of the lot, are characteristic

(138) QUARRY SECTION—CANADA CEMENT COMPANY LIMITED



Scale: 1 inch to 20 feet

UNIT	DESCRIPTION	THICKNESS Feet
Detroit River	Limestone: medium brown to tan, brownish grey weathering; microcrystalline to medium-crystalline; medium to thick bedded, rarely thin bedded; black bituminous partings; calcite eyes; stylolites; fossiliferous—stromatoporoid "footballs", coral spots. Lower 7.8 feet is a light-buff, medium-crystalline, highly fossiliferous section, which may correlate with the biostrome-like beds at the base of the Beachville section (Gypsum, Lime and Alabastine, Cyanamid quarries).....	100.0+

of the Detroit River limestone and underlying Bois Blanc formation in the Zorra area. The results are reproduced in (139).

These analyses indicate the very high purity of the Detroit River limestone; weighted analyses of the two formations cut in this drill-hole are given in (140).

Quarry Operation

Overburden is very thick, averaging 70–80 feet of clay, boulder clay, and sand. The clay is used in the manufacture of portland cement. Overburden is stripped by a Bucyrus-Erie, Model 200W, electric walking-dragline with a 125-foot boom and a 6-cubic-yard bucket. Haulage is done by six 22-ton Euclid rear-dump trucks, which alternate on stone and clay production. Clay not needed for the wash mills of the cement production-line is stockpiled.

The 100-foot limestone quarry face is worked in two lifts, an upper 60-foot lift and a lower 40-foot lift. An average of 90–110 feet of high-purity Detroit River limestone is available. Drilling is done by a Joy Heavyweight Champion electric rotary drill with a 6¾-inch bit. Holes are spaced on a 26- by 22-foot burden pattern on the 60-foot lift. The blasting agent is Nitrone detonated with primacord and millisecond relay caps. Stone is loaded by a 4½-cubic-yard Bucyrus-Erie Model 110B electric shovel onto the six 22-ton Euclid trucks mentioned above. Average quarry production is 400–500 tons per hour or 3,000 tons per 8-hour shift.

(139) DIAMOND-DRILL HOLE SP3—CANADA CEMENT COMPANY

(Company data published by permission of Canada Cement Co.)

	Core Depth	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L. O. I.	Total
	feet	percent	percent	percent	percent	percent	percent	percent
Detroit River Limestone (90 ft.) (There is 96 ft. of overburden above the Detroit River limestone.)	0– 1	0.40	0.10	0.08	55.60	0.44	43.22	99.84
	1– 2	0.30	0.10	0.08	55.44	0.48	43.54	99.94
	2– 3	0.36	0.14	0.14	55.12	1.20	42.94	99.90
	3– 4	0.62	0.24	0.18	54.40	1.40	43.20	100.04
	4– 5	0.38	0.14	0.16	54.80	1.06	43.38	99.92
	5– 10	0.36	0.14	0.14	55.12	0.60	43.56	99.92
	10– 20	0.24	0.10	0.08	55.04	0.78	43.72	99.96
	20– 30	0.30	0.10	0.08	55.04	0.71	43.70	99.93
	30– 40	0.32	0.10	0.04	54.88	0.87	43.46	99.97
	40– 50	0.40	0.08	0.06	54.64	1.00	43.80	99.98
	50– 60	0.40	0.12	0.08	53.76	1.64	44.04	99.92
	60– 70	0.28	0.08	0.04	54.08	1.45	43.90	99.95
	70– 80	0.28	0.10	0.10	54.72	0.97	43.78	99.95
	80– 90	0.20	0.10	0.08	54.24	1.57	43.74	99.93
Bois Blanc Formation (98 ft.)	90–100	2.26	0.12	0.12	52.80	1.38	43.23	99.91
	100–110	2.54	0.12	0.08	51.84	2.38	42.98	99.94
	110–120	5.80	0.36	0.24	48.88	2.73	41.88	99.89
	120–125	6.72	0.22	0.18	49.36	2.07	41.32	99.87
	125–130	8.82	0.56	0.40	46.88	3.00	40.10	99.76
	130–135	12.50	0.50	0.40	45.04	3.15	38.48	100.07
	135–140	14.22	0.66	0.24	44.72	2.60	.....	100.04
	140–145	31.24	0.82	0.50	34.32	3.19	.....	100.03
	145–150	24.04	0.90	0.48	37.12	4.26	.....	100.08
	150–155	9.72	0.66	0.36	44.64	5.15	.....	100.01
	155–160	27.70	0.50	0.24	36.96	3.02	.....	100.04
	160–165	34.90	0.50	0.24	33.12	2.72	.....	100.00
	165–170	36.22	0.72	0.28	31.36	3.55	.....	100.05
	170–175	32.08	0.72	0.32	33.36	3.85	.....	100.01
	175–180	34.52	0.84	0.46	32.08	3.85	.....	99.99
	180–188	36.14	0.92	0.58	31.50	4.00	.....	99.88

(140) CHEMICAL ANALYSES—CANADA CEMENT COMPANY LIMITED

	Thickness	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L. O. I.
	feet	percent	percent	percent	percent	percent	percent
Detroit River Limestone	90	0.31	0.10	0.08	54.61	1.08	43.73
Bois Blanc Formation	98	17.37	0.51	0.29	42.50	3.02	.....

CRUSHING PLANT

The primary crusher, located ½ mile to the east of the quarry, is a 54-inch, Traylor, gyratory crusher set at 6 inches. A 42-inch conveyor carries the stone to a Pennsylvania reversible impactor in closed circuit with two 5- by 14-foot Dillon single-deck screens in parallel, with ⅝- by 5-inch slotted openings.

The minus ½-inch stone from the screens is carried by conveyors to the rock storage building at the cement plant. Provision is made for supplying stone to a 500-ton loading-bin on the C.P.R. line for shipment to other company plants when desired.

Cement Plant

CLAY SUPPLY

Clay in the slurry is supplied by two F. L. Smidth wash mills located north of the primary crusher building. Screened clay slip from the wash mills is pumped to a 110-foot-diameter clay storage basin at the cement plant. The basin is equipped with revolving mechanical and air agitation systems. The clay slip is pumped from the basin to a feed tank in the raw-grinding department, where it is charged into the raw-grinding mills with the stone.

RAW GRINDING

Stone from the rock storage building is loaded by a 5-cubic-yard, clamshell bucket on an overhead crane into three 200-ton stone bins. There are also two 200-ton, pyrite bins for addition of iron to the slurry as desired. Stone, pyrite, and clay slip are fed by automatic feeders to four, 3-compartment, Unidan ball mills, either 8- by 46-foot or 8.5- by 39.5-foot in dimension. The slurry produced averages 33 percent water with 90 percent of the slurry through 200 mesh. Each mill has a capacity of about 160 barrels per hour. The slurry goes to a sump and is then pumped to six air-agitated correcting tanks. Slurry is then pumped to a 110-foot-diameter slurry basin with a capacity of 23,000 barrels.

KILNS

The slurry is pumped to two Ferris-wheel kiln feeders supplying two 12- by 450-foot, F. L. Smidth, rotary kilns, each having a capacity of about 800 tons per 24 hours. The kilns are fired with powdered coal supplied by an air-swept, 3-compartment, coal mill in closed circuit with an air classifier. Clinker discharges into two 7- by 44-foot, Fuller, inclined-grate, clinker coolers. From the coolers the clinker discharges through a hammermill breaker to pan-conveyors. A 4-foot, Symons, standard cone-crusher set at ⅝ inches is provided for further clinker crushing if desired. The clinker is conveyed to clinker storage.

FINISH GRINDING

Clinker is loaded into three clinker feed bins supplying clinker by automatic feeder to three, 3-compartment, 8.5- by 30.5-foot, Unidan ball mills. Gypsum is automatically fed to the mills with the clinker in the proportion of about 5 percent of the feed. The ball-mill products go via Airslide, bucket elevator, and screw conveyor to three, 16-foot, Sturtevant air classifiers in closed circuit with the mills. The mills each have a capacity of 160 barrels per hour with a Blaine fineness of 2800. The finished product is pumped by air conveyor to the storage bins.

STORAGE AND PACKING

Standard portland and high early-strength cement goes to nine 40,000-barrel concrete silos. Masonry cement goes to four 19,000-barrel, concrete silos. Cement is shipped in bulk or in bags, by truck or rail.

ST. MARYS CEMENT COMPANY LIMITED, ST. MARYS

The quarry and cement plant of St. Marys Cement Company is located on the southern outskirts of St. Marys on the east side of the north branch of the Thames River, in concessions XVI and XVII, Blanchard township, Perth county. The wet-process, 4-kiln cement plant has a rated capacity of 9,600 barrels per 24 hours, or about 3,000,000 barrels per year.

Geology

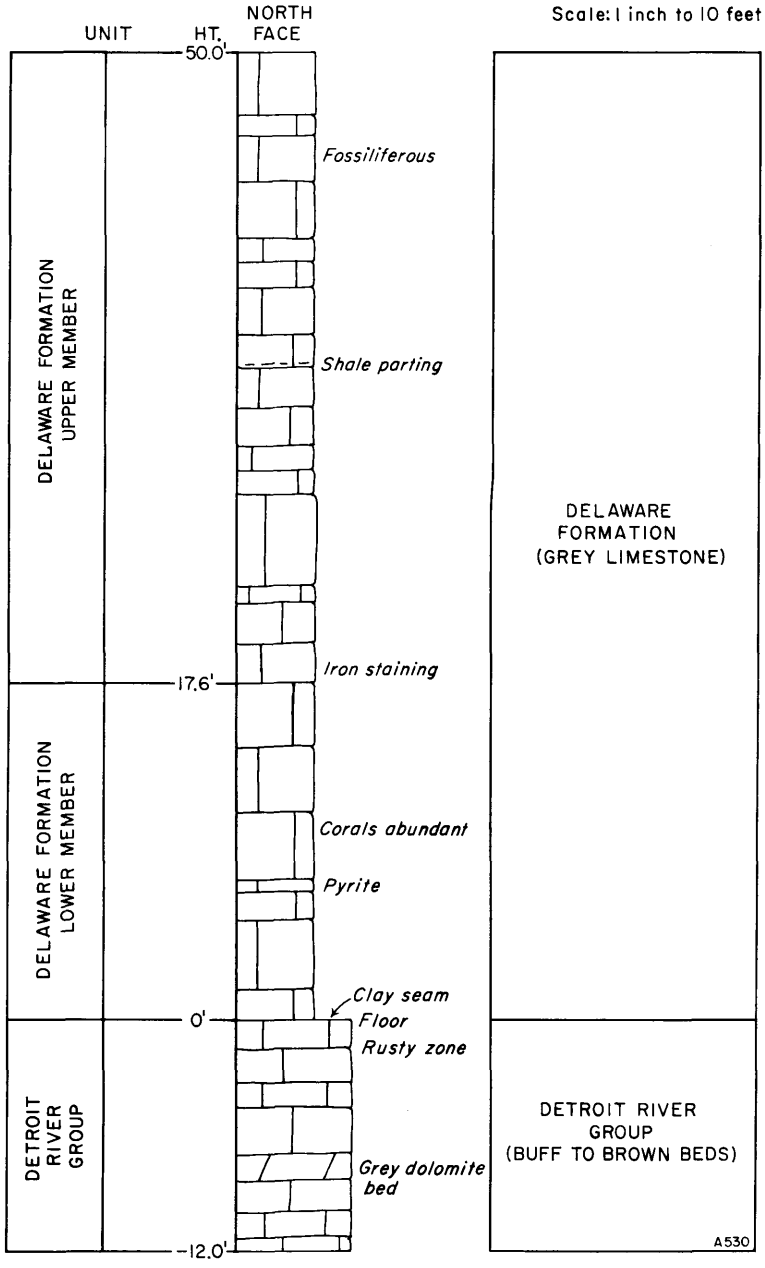
The old quarry is located on the northeast side of the plant; the present quarry is south of the plant. The 30- to 50-foot quarry face is composed entirely of Delaware limestone of Middle Devonian age. Detroit River limestone is exposed in the sump of the quarry floor and in a 12-foot cut in the quarry floor.

The quarry section exposed at the north face near the crusher is illustrated and described in (141). The underlying Detroit River beds exposed in the sump are included in the section.

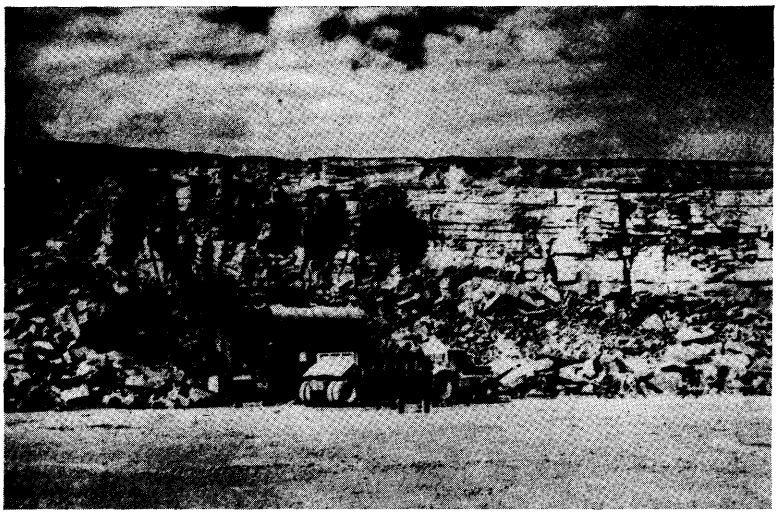
In his study of the Devonian stratigraphy of southwestern Ontario, E. W. Best[1] suggests that this section be made the type section for the Delaware formation in Ontario since a total thickness of 51 feet is exposed. He divides the Delaware formation into a 31.8-foot upper member and a 17.6-foot lower member. The Delaware limestone is medium-brownish grey to light-grey in colour;

[1]E. W. Best, *op. cit.*

(141) QUARRY SECTION—ST. MARYS CEMENT COMPANY LIMITED



UNIT	DESCRIPTION	THICKNESS Feet
Delaware Formation	Limestone: medium brownish grey to medium light grey, grey weathering; medium crystalline coquinoid to fine crystalline fossiliferous; thick or massive bedded to medium bedded; shaly partings; some colour lamination; stylolites; fossiliferous....	50.0+
Detroit River	Limestone: medium brown to tan, buff weathering; thin dark brown colour lamination; fine crystalline to aphanitic; medium to thin bedded; in part porous, rusty weathering, interbedded dolomitic limestone.....	12.0



Thick-bedded Delaware limestone is quarried by St. Marys Cement Company Limited at St. Marys.

medium-crystalline coquinoid to fine-crystalline in texture; thick- or massive-bedded to medium-bedded, with shaly partings, stylolites, and some colour lamination. It is highly fossiliferous.

The underlying Detroit River beds are medium-brown to tan in colour; there is a colour break between the two formations. The upper Detroit River beds are mostly limestone, but two dolomitic beds are exposed in the 12-foot section, and the average magnesia content is somewhat higher than in the overlying Delaware beds. Along the south wall two clay seams were observed, one being 6 inches thick. These lie along bedding planes and may represent old regoliths, the upper being at the accepted position of the Delaware–Detroit River disconformity. The Columbus limestone and the upper part of the Detroit River group is absent in this area,[1] and a considerable erosion interval is indicated.

Goudge (p. 275) gives a chemical analysis representative of the 45-foot quarry section in the south-western part of the old (No. 1) quarry. This is similar to that along the north wall of the present quarry and is given in (142).

Goudge's report also reproduces analyses of cuttings from two churn-drill holes on the property, indicating the dolomitic character of the underlying Detroit River strata. The second churn-drill hole, 595 feet deep, cut the Delaware, a complete section of Detroit River and Bois Blanc, and terminated in Bertie-Akron dolomite formation.

Partial chemical analyses of a diamond-drill hole (BB49), located just northwest of the present west quarry face, are given in (143). The Delaware beds average less than 2 percent magnesia. Analyses suggest that the beds below 50 feet in depth belong to the Detroit River group and are largely dolomite.

The company has acquired a large acreage on the west side of the Thames River. Recent drilling indicates large reserves of stone suitable for portland cement manufacture.

Quarry Operation

Overburden at the St. Marys quarry is thick, averaging over 30 feet in depth. Part of the clay overburden is used for the portland cement, but sandy overburden and clay too high in magnesia is rejected. Stripping is done by one 3-cubic-yard, and one 2½-cubic-yard, Marion electric shovel. A fleet of three 22-ton, and five 15-ton, Euclid rear-dump trucks are available on stripping as required. A Northwest, 1½-cubic-yard, diesel shovel is on standby duty.

The 30- to 50-foot quarry face is drilled by a Joy Heavyweight Champion rotary drill boring 6¾-

[1] E. W. Best, *op. cit.*

(142) CHEMICAL ANALYSIS—ST. MARYS CEMENT COMPANY LIMITED

(Analysis from Goudge, p. 275)

Sample No.	Location	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
		percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
340.....	45-foot face (No. 1 quarry)	2.70	0.47	0.81	0.15	94.50	1.81	100.44	0.13	53.00	0.86

(143) DIAMOND-DRILL HOLE BB49—ST. MARYS CEMENT COMPANY

(Company data published by permission of St. Marys Cement Co. Ltd.)

Depth (overburden 26 ft.)	CaO	MgO	L. O. I.
feet	percent	percent	percent
0 – 5	51.82	1.01	41.00
5 – 9.5	51.41	1.01	41.04
9.5– 14.5	51.68	1.09	41.76
14.5– 16.5	52.22	1.45	42.28
16.5– 19.5	53.31	0.80	42.66
19.5– 22.5	53.58	1.01	42.40
22.5– 25	52.09	1.30	42.06
25 – 28.5	52.09	1.45	41.96
28.5– 31	52.77	1.23	41.64
31 – 35	52.36	1.59	42.48
35 – 40	52.77	1.45	42.60
40 – 45	52.36	1.74	42.28
45 – 47	53.58	0.87	43.78
47 – 50	54.81	0.40	42.76
50 – 51.5	39.71	12.40	44.40
51.5– 55	51.54	3.84	44.06
55 – 60	54.40	1.16	43.54
60 – 65	51.27	3.69	43.76
65 – 67	53.18	1.74	42.72
67 – 70.5	53.72	1.52	43.44
70.5– 73	45.70	8.10	44.92
73 – 75	40.80	13.00	45.66
75 – 77	36.58	16.66	46.12
77 – 80.5	42.43	11.00	45.40
80.5– 84	48.96	5.87	44.48
84 – 87	38.35	15.10	46.40
87 – 90	46.65	7.95	44.78
90 – 93	50.50	4.56	44.10
93 – 95	35.90	17.00	45.98
95 – 98	35.09	18.50	46.24
98 –100	46.92	7.60	45.15

inch holes on a 19- by 21-foot pattern. An electric churn-drill is on standby duty. The blasting agent is Nitrone. Stone is loaded by a 4-cubic-yard Marion electric shovel. Haulage is done by four Caterpillar tractors with 15-ton, Athey, hopper-bottom trailers. These are supplemented by Euclid trucks, and conversion to Euclid haulage is planned. A D-7 Caterpillar bulldozer is used on clean-up.

Crushing and Cement Plant

The primary crusher, a 48- by 60-inch, Traylor jaw-crusher, is located in the quarry. A 32-inch conveyor carries the stone to the secondary crusher, a Pennsylvania impact mill that is in closed circuit with two 4- by 8-foot, Tyroc, 2-deck screens. The stone produced is minus ¾-inch stone. This is conveyed to a stone storage pile at the cement plant.

Raw-grinding is done in four 3-compartment, Unidan mills. The plant has four 10-foot 6-inch by 340-foot kilns each having a capacity of 2,400 barrels per day. The clinker is ground in Unidan mills.

Bulk or bagged shipments are made by truck or rail transportation. The quarry produces about 1,500 tons of stone per day in one shift operation. Magnesia content is kept at less than 2 percent in the crude rock.

BRUNNER MOND CANADA LIMITED, AMHERSTBURG

The quarry and lime plant of Brunner Mond Canada Limited is located on the northern outskirts of Amherstburg in lots 6–8, concession I, and lots 2 and 3, concession II, Anderdon township, Essex county. High-calcium limestone of the Detroit River group is used to manufacture lime, which together with salt from the nearby brine field, is used in the manufacture of soda ash.

Geology

The Brunner Mond quarry section consists of 30–52 feet of buff, dolomitic limestone of the Delaware formation, underlain by 32 feet of Anderdon limestone of the Detroit River group. The quarry section is illustrated and described in (145). The 52-foot section of Delaware dolomitic limestone is medium-brownish grey to brownish-grey, buff-weathering; aphanitic; massive-bedded, with bituminous partings and abundant fossils; and occasional chert is present. Some thin patches of sandstone at the base of the Delaware beds may represent the Columbus formation. The Delaware beds are stripped off the underlying Detroit River

The Brunner Mond quarry at Amherstburg is worked in two lifts. The upper lift is Delaware dolomitic limestone, and the lower lift is Detroit River high-calcium limestone.

beds in one lift. This dolomitic limestone is not usable in the lime plant and is sold for crushed stone.

The underlying 32 feet of Anderdon limestone of the Detroit River group can be divided into six units as indicated in the section: upper buff biostrome, grey laminated beds, brown marker bed, thin grey laminated beds, buff and grey mottled beds, and lower brown limestone. The brown marker bed is dolomitic.

The floor of the quarry consists of brown laminated dolomite of the Lucas formation of the Detroit River group. A thin veneer of grey sandstone occurs in places between the Lucas and Anderdon formations.

Goudge (p. 222) gives chemical analyses representative of the 32 feet of Delaware beds and the 24–30 feet of Anderdon limestone exposed at the time of his visit; these are reproduced in (144).

Quarry Operation

Overburden ranges in thickness from 0 to 45 feet. The dolomitic limestone cap rock (Delaware beds) ranges up to 52 feet in thickness; the cap rock plus overburden averages about 50 feet in thickness. The quarry is operated in two lifts, the upper lift is dolomitic cap rock, and the lower lift of 32 feet is high-purity calcium limestone. Drilling is done by an Ingersoll-Rand Drillmaster drilling 6-inch holes on a 15- by 15-foot pattern in the massive-bedded dolomitic cap rock, and on an 18- by 18-foot pattern in the underlying limestone. Dynamite and prilled ammonium nitrate are the blasting agents. Haulage is done by a fleet of seven 15-ton Euclid and four 22-ton Euclid rear-dump trucks. Three shovels are employed, one on each rock face and one on overburden; these are one 4½-cubic-yard, Marion Model 111M, electric shovel, and two 2½-cubic-yard Bucyrus-Erie Model 54B, shovels, one diesel and one electric. The quarry operates on two shifts. In normal quarry operation three Euclids are on limestone while four Euclids are on stripping.

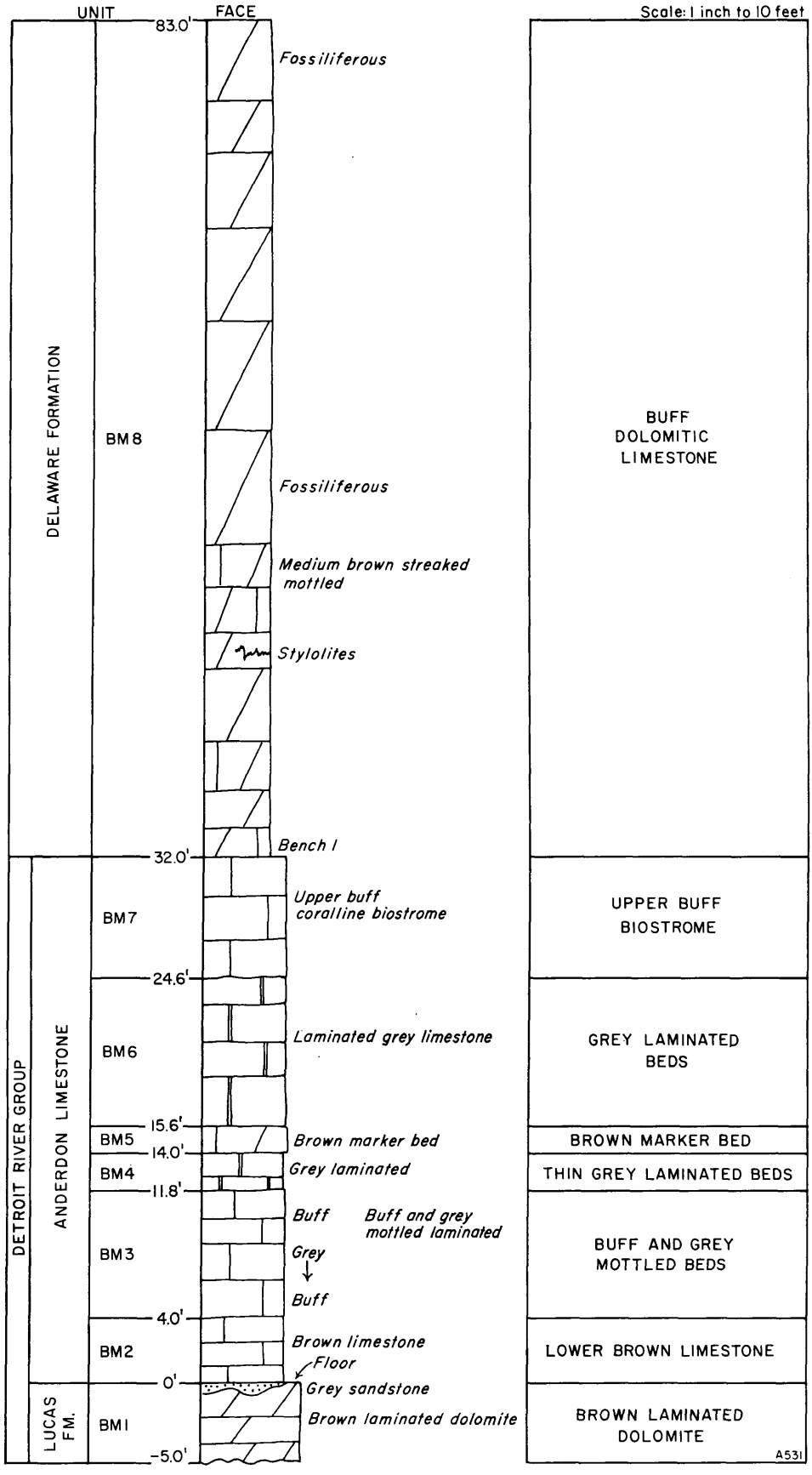
The primary crusher located in the quarry is a 42-inch Superior McCully gyratory crusher set at 6 inches. A 36-inch conveyor carries the stone to the secondary-crusher house, where it discharges on two 5- by 16-foot, double-deck, Seco scalping screens in parallel, with 3-inch top-deck openings and 1½-inch bottom-deck openings.

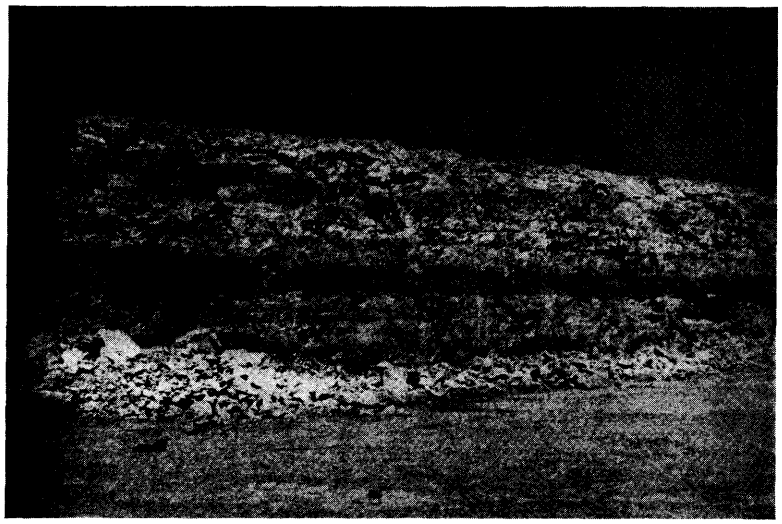
(144) CHEMICAL ANALYSES—BRUNNER MOND CANADA LIMITED

(Analyses from Goudge, p. 222)

Sample No.	Interval	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
		percent	percent	percent	percent	percent	percent	percent	percent	percent	percent
361	Top 14 ft. Delaware	1.48	0.22	0.26	0.09	79.32	18.76	100.13	0.02	44.47	8.97
361A	Next 8 ft. Delaware	1.96	0.21	0.43	0.11	60.77	36.87	100.35	0.11	34.09	17.63
361B	Lower 10 ft. Delaware	1.22	0.20	0.14	0.09	60.86	38.06	100.57	0.11	34.13	18.20
361C	22 ft. of Detroit River	1.31	0.19	0.38	0.02	97.16	0.97	100.03	0.08	54.44	0.46
361D	Brown dolomite marker	1.56	0.26	0.15	0.02	76.61	20.12	98.72	.....	42.87	9.58
361E	Lucas dolomite in floor	1.60	0.27	0.05	0.02	57.04	40.84	99.82	trace	31.95	19.53

(145) QUARRY SECTION—BRUNNER MOND CANADA LIMITED





The lower lift at the Brunner Mond quarry at Amherstburg exposes 32 feet of Anderdon limestone of the Detroit River group. The photo clearly shows the upper biostrome and the brown marker bed.

The 6- by 1½-inch limestone goes into hopper-bottom railway cars for shipment to the lime plant, which consists of five stack kilns.

The minus 1½-inch limestone goes to the screen house. The dolomitic limestone cap rock goes through the primary crusher and scalping screens. The plus 3-inch stone goes to the secondary crusher, a 7½-inch McCully gyratory crusher. The minus 1½-inch stone and the secondary-crusher product go to the screen house where the stone is sized by one 5- by 12-foot, and one 5- by 10-foot, 3-deck screen. Normally the full production of one Seco scalping screen and the minus 1½-inch rejects from the other Seco screen go to the commercial stone plant. The rest of the dolomite is stockpiled.

The commercial stone plant makes several sizes, including 6-inch stone, 3-inch crusher run, 1½-inch stone, 1-inch stone, ½-inch stone, and screenings; ¾-inch crusher run is also produced by a portable plant.

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(145) QUARRY SECTION—BRUNNER MOND CANADA LIMITED

UNIT	DESCRIPTION	THICKNESS Feet
DELAWARE FORMATION		
BM8	Dolomitic Limestone: medium brownish grey to brownish grey, buff to light brown weathering; aphanitic; massive bedded; bituminous partings; streaked and mottled in part; colour lamination; fossiliferous	51.0
DETROIT RIVER GROUP (ANDERDON LIMESTONE)		
BM7	Limestone: coquinoid calcarenite; light buff, buff weathering; medium crystalline; massive bedded biostrome; fossiliferous, coralline	7.4
BM6	Limestone: calcilutite; light and medium grey; mottled; cryptocrystalline to microcrystalline; medium to thick bedded; laminated	9.0
BM5	Dolomitic Limestone: medium brown, buff weathering; aphanitic; medium bedded	1.6
BM4	Limestone: calcilutite; medium-grey; laminated; microcrystalline; medium-bedded; hackly fracture	2.2
BM3	Limestone: calcilutite; mottled light-grey to light-brown, light-buff to grey weathering; aphanitic to microcrystalline; medium-bedded	7.8
BM2	Limestone: light-brown to medium-brown, buff-weathering; aphanitic; medium-bedded; thin colour lamination	4.0
DETROIT RIVER GROUP (LUCAS FORMATION)		
BM1	Dolomite: dark-brown to medium-brown, brown-weathering; aphanitic; medium-bedded; top few inches grey sandstone and sandy dolomite; top part of dolomite mottled medium- and light-brown	5.0+
	Total	88.0+

AMHERST QUARRIES LIMITED, MALDEN TOWNSHIP

The quarry of Amherst Quarries Limited is located in lot 22, concession III, Malden township, on the south side of Pike road, about a mile east of Amherstburg. The quarry was opened during the summer of 1959 on the site of a quarry formerly operated by Industrial Construction Company Limited. (Goudge, p. 219.)

The 10-foot quarry face with units given from top to base is given in (146).

This section of limestone and dolomite is assigned to the Upper Detroit River group.

Overburden at the quarry is 3–20 feet thick. Drilling is done by two wagon drills, drilling 2¼-inch holes on a 5- by 5-foot pattern. Air is supplied by two compressors. Stone is loaded by a Dominion, 1½-cubic-yard, diesel shovel on to three 22-ton, Euclid trucks for haulage to the crushing plant. The trucks dump into a feeder in advance of the primary crusher, a New Holland, 30- by 30-inch, impact mill. The product is conveyed to a stone surge pile. From the surge pile the stone is fed by conveyor to a Pioneer, semi-portable crushing plant consisting of two 4- by 12-foot screens, a jaw-crusher, and rolls. Production capacity is 125–150 tons per hour.

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(146) QUARRY SECTION—AMHERST QUARRIES LIMITED

DESCRIPTION	THICKNESS Feet
Limestone: calcilutite; medium grey, light grey weathering; microcrystalline; medium bedded	1.2
Limestone and Dolomite: medium brown, light buff weathering; aphanitic to fine crystalline; medium bedded; calcite crystals; fossiliferous, with abundant Stromatoporoids	6.0
Dolomite: medium brown, brownish buff weathering; brown laminated; black shaly partings; aphanitic to fine crystalline; soft	2.8

V. Utilization of Ontario Limestone Resources

Examination of the geological map (No. 1960c, in map case) showing the distribution of the limestone quarrying industry in Ontario, indicates the importance of bedrock geology and structure in the localization of quarrying in certain favourable geological horizons. There are five main stratigraphic horizons in Ontario, which furnish nearly all the limestone production:

1. The Beekmantown dolomite of Ordovician age.
2. The Trenton–Black River limestones of Ordovician age.
3. The Guelph-Lockport dolomite of Silurian age.
4. The Bois Blanc limestone and Bertie-Akron dolomite of Devonian and Silurian age.
5. The Detroit River and Delaware limestones of Devonian age.

Examination of production statistics from the 42 Ontario limestone quarries producing over 40,000 tons per year in 1957, gives data on geological distribution of limestone production as given in (147).

(147) GEOLOGICAL DISTRIBUTION OF ONTARIO LIMESTONE PRODUCTION, 1957

Formations	Tonnage	Percentage of Total	Number of Quarries
Precambrian	.....	less than 1	1
Beekmantown	959,329	5.6	3
Trenton–Black River	4,684,475	27.5	11
Guelph-Lockport	4,692,829	27.6	10
Bois Blanc and Bertie-Akron	2,429,725	14.3	10
Detroit River and Delaware	4,158,540	24.4	7
Total	17,012,898	.....	42

CHARACTERISTICS AND UTILIZATION OF ONTARIO LIMESTONE HORIZONS

The specifications required for limestone used in different industries have been given in an earlier section of this report. This section summarizes the characteristics of the various stratigraphic horizons of limestone present in Ontario in a general way indicating general characteristics and suitability of the various types of stone for the four main limestone industries:

1. Crushed stone industry.
2. Portland cement industry.
3. Lime industry.
4. Flux, metallurgical, and chemical stone.

The percentage of total production used by each of the above industries in each major geological subdivision is given in (148).

This table indicates that four of the five main geological horizons used by commercial quarries mainly produce crushed stone. However, in the case of the Detroit River and Delaware limestones, crushed stone is a minor part of the production, most of the stone being consumed by the cement, lime, and flux industries. The Trenton–Black River limestone horizon supplies much stone for the cement and flux industries. The Guelph-Lockport dolomite supplies dolomitic flux and constitutes a major part of dolomitic lime production.

Formations	Percentage of Total Production Used, by Industries 1957						
	Crushed Stone and Building Stone	Cement	Lime	Flux	Misc.	Total	Tonnage
	percent	percent	percent	percent	percent	percent	percent
Trenton–Black River (limestone)	69.6	27.6	.....	2.5	0.3	100	4,684,475
Guelph-Lockport (dolomite)	82.8	0	4	13.2	.....	100	4,692,829
Bois Blanc and Bertie-Akron (limestone and dolomite)	95.4	4.6	0	0	.....	100	2,429,725
Detroit River and Delaware (mainly limestone)	13.8	38.4	29.8	15.8	2.2	100	4,158,540
Beekmantown (dolomite)	100	.....	.....	.....	.....	.....	959,329

A. Crushed Stone Industry

BEEKMANTOWN DOLOMITE

Commercial operators in the Beekmantown dolomite of eastern Ontario are producing crushed stone suitable for concrete aggregate and bituminous construction. The high content of silica and alumina makes this stone unsuitable for the manufacture of lime or for flux. Tests indicate that the Beekmantown dolomite has good durability in concrete mixes.[1]

TRENTON–BLACK RIVER LIMESTONES

A large amount of good-quality crushed stone is produced from the Black River and Trenton limestone formations of the Lake Ontario and Ottawa–St. Lawrence lowland areas. Los Angeles abrasion tests range from 16 to 20 percent loss, absorption from 0.3 to 1.3 percent, and $MgSO_4$ soundness from 3 to 12 percent loss, with occasional samples showing poor soundness, unacceptable for aggregate, running from 12 to 26 percent loss. The samples showing poor soundness generally come from shaly portions of the Upper Black River or Trenton formations in the eastern Lake Ontario or Ottawa areas. Such shaly sections should be avoided.

Reactive aggregate unsuitable for concrete occurs in the Black River limestone formation of the Kingston area.[2]

Cryptocrystalline limestones of the Black River group may be unsuitable for asphalt construction owing to poor stripping tests. These stones may have a very smooth and dense surface texture.

GUELPH-LOCKPORT DOLOMITE

Large amounts of good quality crushed stone are produced from the Lockport and Amabel formations in the Niagara Peninsula–Dundas–Georgetown area. These formations tend to be rather soft, and an objectionably high dust content may result. Frequently the top few feet of these formations are rusty weathering and porous and may be unsound. Chert may occur in portions of the Lockport (Ancaster chert beds), and as this chert may be of the porous unsound variety, it should be watched for. Parts of the Lockport formation above and below the Vinemount shaly beds may be of poor soundness.

The Lockport formation shows average Los Angeles abrasion tests range from 13 to 25 percent loss, with occasional soft sections in the Gasport member up to 39 percent loss. $MgSO_4$ soundness ranges from 2 to 12 percent loss, with some unsound shaly stones occasionally reaching 22 percent loss. Absorption ranges from 0.4 to 1.8 percent with occasional unsuitable stone as high as 10 percent absorption.

The Amabel formation is generally medium crystalline and may be reefy. The reefy sections may be softer and more porous. Los Angeles abrasion tests range from 21 to 35 percent loss, indicating the rock is generally rather soft. $MgSO_4$ soundness ranges from 2 to 9 percent loss. The stone is sound. Absorption ranges from 0.4 to 1.6 percent.

The Guelph dolomite is soft and porous and is therefore not very suitable for crushed stone uses where durability is required.

[1] R. H. Picher, *Durability of Aggregates in Concrete Mixes*, Can. Dept. of Mines and Technical Surveys, Mines Branch, Memorandum Series No. 129, 1954.

[2] E. G. Swenson, *A Canadian Reactive Aggregate Undetected by A.S.T.M. Tests*, A.S.T.M. Bull., No. 226, Dec. 1957, pp. 48–51.

BOIS BLANC LIMESTONE AND BERTIE-AKRON DOLOMITE

The production from the Bois Blanc limestone and Bertie-Akron dolomite formations goes almost entirely to the crushed stone industry. The Bois Blanc limestone is extremely cherty and for this reason may be in part unsuitable for concrete aggregate. However, not all varieties of chert are unsound. Fresh chert tends to be sound, but weathered chert becomes porous and is reactive in aggregate. Porous unsound chert generally has a specific gravity of less than 2.4 and can be recognized by its white, chalky appearance. Tests of cherty Bois Blanc limestone indicated poor durability in concrete mixes.[1] Los Angeles abrasion tests show about 14–18 percent loss; $MgSO_4$ soundness 4–10 percent loss with rare samples over 12 percent; absorption ranges from 0.7 to 2.0 percent in samples tested.

The Bertie-Akron dolomite is chert-free and may be a more suitable aggregate for concrete. Los Angeles abrasion tests show 17–23 percent loss; $MgSO_4$ soundness, 3.3–12 percent loss; and absorption, 1.1–4 percent. Absorption may be high in parts of the Bertie-Akron. The shaly unit of the Bertie-Akron is unsound, with $MgSO_4$ soundness losses of 12–23 percent.

DETROIT RIVER AND DELAWARE LIMESTONES

Only a small amount of Detroit River and Delaware limestones is used in the crushed stone industry, since the quarry operators are mainly interested in the stone for its high chemical purity.

The Detroit River and Delaware limestones quarried in Ontario tend to be soft, with Los Angeles abrasion tests showing 22–32 percent loss. Soundness is generally good, but absorption may go as high as 4 percent in the Delaware limestone.

B. Portland Cement Industry

TRENTON–BLACK RIVER LIMESTONES

As indicated by chemical analyses in the section of the report describing the Trenton–Black River limestones, much of the Middle and Upper Black River formations, the Lower Trenton and the Upper Trenton, may be suitable for the manufacture of portland cement. Magnesia and alumina contents may be too high in parts of the Trenton group, particularly in the Middle Trenton.

[1] R. H. Picher, *op. cit.*

DETROIT RIVER AND DELAWARE LIMESTONES

The high-purity Detroit River limestone section in the Beachville area, the Anderdon limestone of the Detroit River in the Amherstburg area, and parts of the lower Delaware formation in the St. Marys area are suitable for portland cement manufacture, although it may be difficult to find a quarry site where overburden is not too thick.

C. Lime Industry

GUELPH-LOCKPORT DOLOMITE

The Guelph and Amabel dolomite formations of Silurian age are used by four lime plants, which produce most of the dolomitic lime for the building trades in Ontario. Both the Guelph and Amabel formations are high-purity dolomites containing less than 3 percent total impurities. The Guelph formation in the Hespeler-Guelph area is of very high purity, in places containing less than 0.5 percent impurities.

DETROIT RIVER LIMESTONE

The most important source of high-calcium limestone in Ontario is the 100-foot-thick section of Detroit River limestone in the Beachville area of southwestern Ontario. This stone is used by lime plants at Beachville, Niagara Falls, Chatham, and Wallaceburg, and the western extension of the formation is used by the Brunner Mond lime plant at Amherstburg. Detroit River limestone is used to make 83.2 percent of Ontario's lime. The major part of the remainder is dolomitic lime used in the building trade.

The Detroit River limestone in the Beachville area is noted for its chemical purity and high calcium content. It contains less than 1 percent combined silica, alumina, and iron oxides and less than 1.5 percent MgO.

BLACK RIVER LIMESTONE

Although Black River limestone is used to some extent for the production of calcium lime in Ontario, it is difficult to find high-calcium sections in the formation that contain less than 3 percent impurities. High-purity sections are limited to 10- to 12-foot thicknesses in the Lake Simcoe area.

D. Flux, Metallurgical and Chemical Stone

The Guelph-Lockport dolomite, the Detroit River limestone, and, to a lesser extent, the Black River Limestone formations provide adequate reserves of high-purity dolomite and high-calcium limestone for flux, metallurgical, and chemical requirements.

Summary

HIGH-CALCIUM LIMESTONE

As indicated by chemical analyses in earlier sections, the reserves of high-calcium limestone (less than 3 percent impurities) are limited to the following formations and areas:

1. Detroit River limestone: Beachville area.
2. Formosa limestone (Detroit River reef facies): Formosa-Walkerton area.
3. Anderdon formation, Detroit River limestone: Amherstburg area.
4. Middle and Upper Black River formations: limited thicknesses in the Lake Simcoe area.

HIGH-PURITY DOLOMITE

High-purity dolomite reserves in Ontario are limited to the following formations:

1. Guelph formation: central Ontario to Bruce Peninsula.
2. Amabel formation: restricted parts of this formation: central Ontario to Bruce Peninsula.

Reefs and Reef Structures

The subject of reefs and reef structures in limestone and dolomite may be of interest and commercial importance to the quarry operator for three reasons:

1. Higher chemical purity of reef rock.
2. Higher porosity and lower durability of reef rock.
3. Reef structures may dislocate quarry floors and quarry surface stripping to the point of involving serious difficulties and increased costs.

In Ontario, reefs occur, and are of commercial importance, in the Guelph and Amabel dolomites of Silurian age, and in the Bois Blanc and Detroit River limestones and dolomites of Devonian age.

TYPES OF REEFS

Reefs essentially consist of, and are built up by, sedentary colonial organisms such as corals, stromatoporoids, crinoids, and algae. Two types of reef structures are recognized in Ontario:

1. Biostrome: a lens-like, tabular sheet of massive, porous reef rock rarely over 15 feet thick, composed of sedentary organisms (corals, crinoids, stromatoporoids, etc.) in a normal bedded rock of different lithological character.
2. Bioherm: a mound-like or dome-like mass or core of massive, porous reef rock, composed of sedentary organisms, surrounded by normal bedded rock of different lithological character that dips off the reef mound at high angles.

RECOGNITION AND CHARACTERISTICS OF REEFS

Reef rock may be recognized by the following features:

1. Reef rock has a different texture, structure, and lithology than the surrounding rock.
2. Reef rock is composed of corals, stromatoporoids, algae or crinoids and is normally highly fossiliferous.
3. The reef is composed of massive porous rock lacking the bedding of the surrounding rock.
4. The biohermal type of reef is distinguished by its mound-like structure with the reef flank beds dipping off the mound at steep angles.

Reefs range in size from 200–300 feet to over ½ mile in diameter. Biostromes are rarely over 15 feet thick, while bioherms range from 20 to 70 feet in height. In exceptional cases, pinnacle reefs in the Guelph formation of southwestern Ontario (subsurface) stand up 200–300 feet in height.

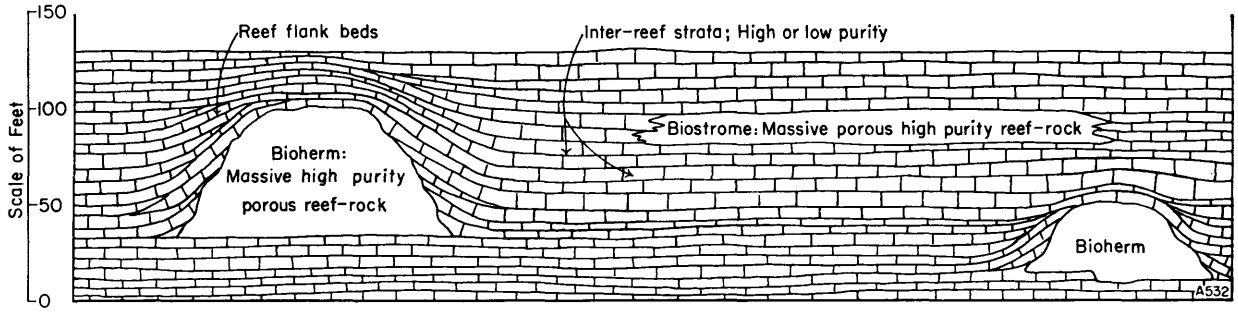
Typical cross-sections of reefs are illustrated in (149).

OCCURRENCE OF REEFS IN SOUTHERN ONTARIO

Amabel Formation of Silurian Age

The Amabel formation of Silurian age, which is the lateral equivalent of the Lockport dolomite in the Waterdown–Georgetown–Bruce Peninsula area, is characterized by the abundance of reef rock. Biohermal reefs a few hundred feet in diameter and 50–60 feet in height are very common, and are identified by the massive structure of the reef rock and the reef flank beds dipping off the mounds. Since the Amabel dolomite is normally of high

(149) SKETCH SHOWING TYPICAL REEF STRUCTURE IN CROSS-SECTION



purity, the reef rock is not greatly different in composition from the enclosing strata but will be highly porous, probably softer and less durable, and may have clay pockets and iron staining, particularly near the surface. The mound-like structures of the bioherms and the steep dips of the reef flank beds may disrupt the quarry floor and quarry surfaces. For these reasons Amabel bioherms may be regarded with disfavour.

Guelph Dolomite

Reefs have been observed in the Guelph formation in the Guelph-Hespeler area. Here the Guelph formation is normally of very high purity, and the reef facies, although of high purity (under 3 percent impurities), may contain more impurities than the inter-reef dolomite. Due to the coarser crystallinity and higher porosity, together with clay pockets, discolouration, and iron staining, which is prevalent in the reef rock, the reefs may be not as desirable for lime manufacture as the more uniform and often extremely high-purity inter-reef dolomite. Variable texture and porosity is to be expected in reef stone, and this may cause difficulties in getting a uniformly calcined lime product.

Bois Blanc Limestone

Biostromes occur in the Bois Blanc cherty limestone of Devonian age in the Port Colborne area. Here the Bois Blanc formation is cherty, and shaly or silty in places. The high-purity calcium limestone of the biostromes contains no chert, no shale or silt, has a low magnesia content, and is, therefore very desirable for cement rock, compared with the enclosing silty strata. The best cement rock in the Canada Cement Company quarries at Port Colborne is biostromal reef rock, which occurs in sheetlike layers 10–15 feet thick.

Detroit River Group

Biostromes 6–8 feet thick were observed near the base of the Detroit River limestone in the Beachville area, but are not of economic significance in the section.

The Formosa reef limestones of the Formosa–Walkerton area ("Alpena limestones"), are biohermal reefs in the Detroit River dolomite. They are of economic interest because of their high-purity calcium limestone content in an area of impure dolomite. They are composed of the characteristic porous massive reef rock.

Summary

1) Although reef rock is commonly of high-chemical purity, if reefs occur within areas of high-purity rock, as for example in the Guelph dolomite, the reef rock may be of inferior purity and texture compared with the inter-reef strata. In areas of low-purity rock, reefs are invariably of much higher purity than the surrounding rock and will lack chert, silt, etc.

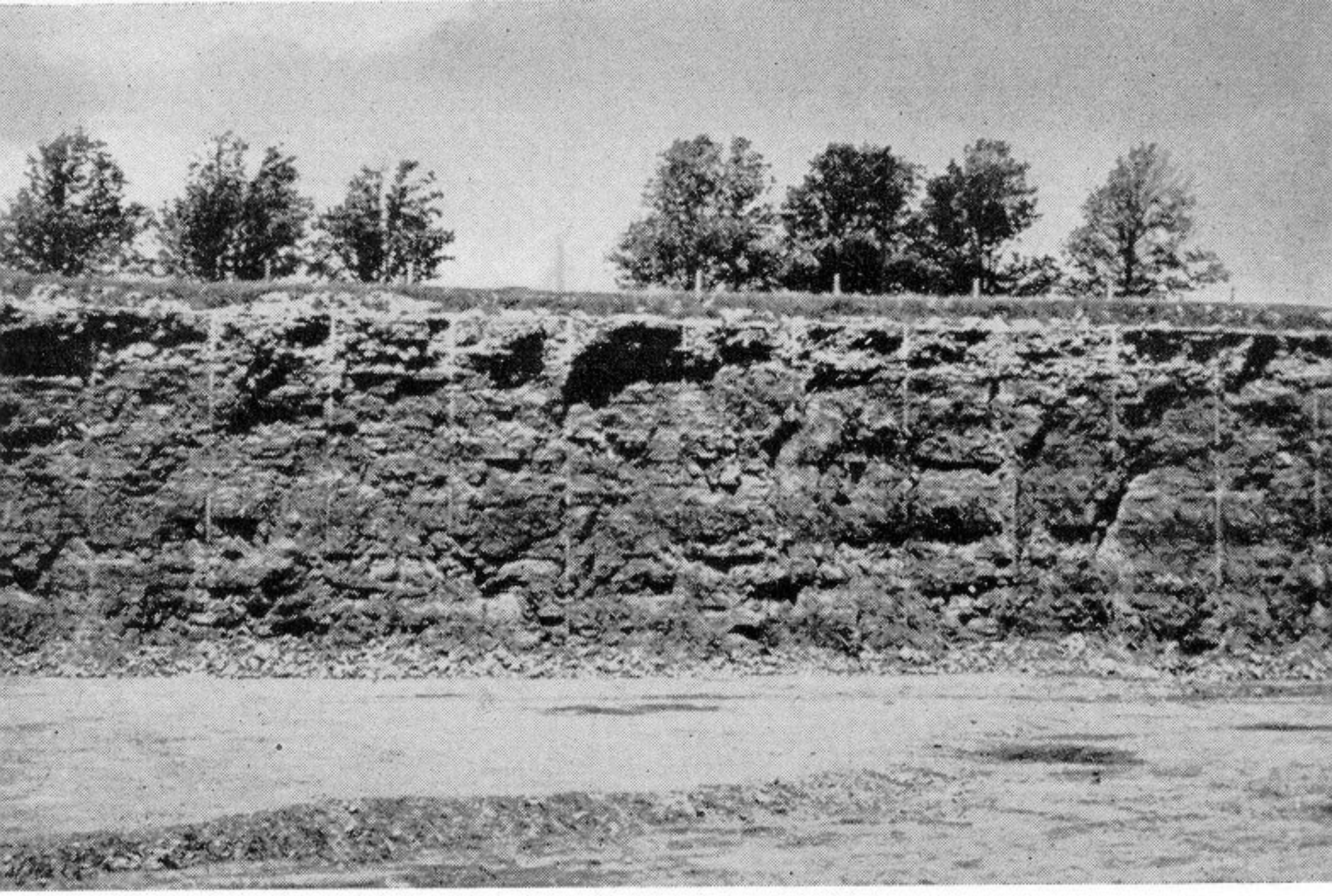
2) Porosity will invariably be high in reef rock, and the stone will usually be softer and less durable than inter-reef strata. Clay pockets and iron staining may be prevalent.

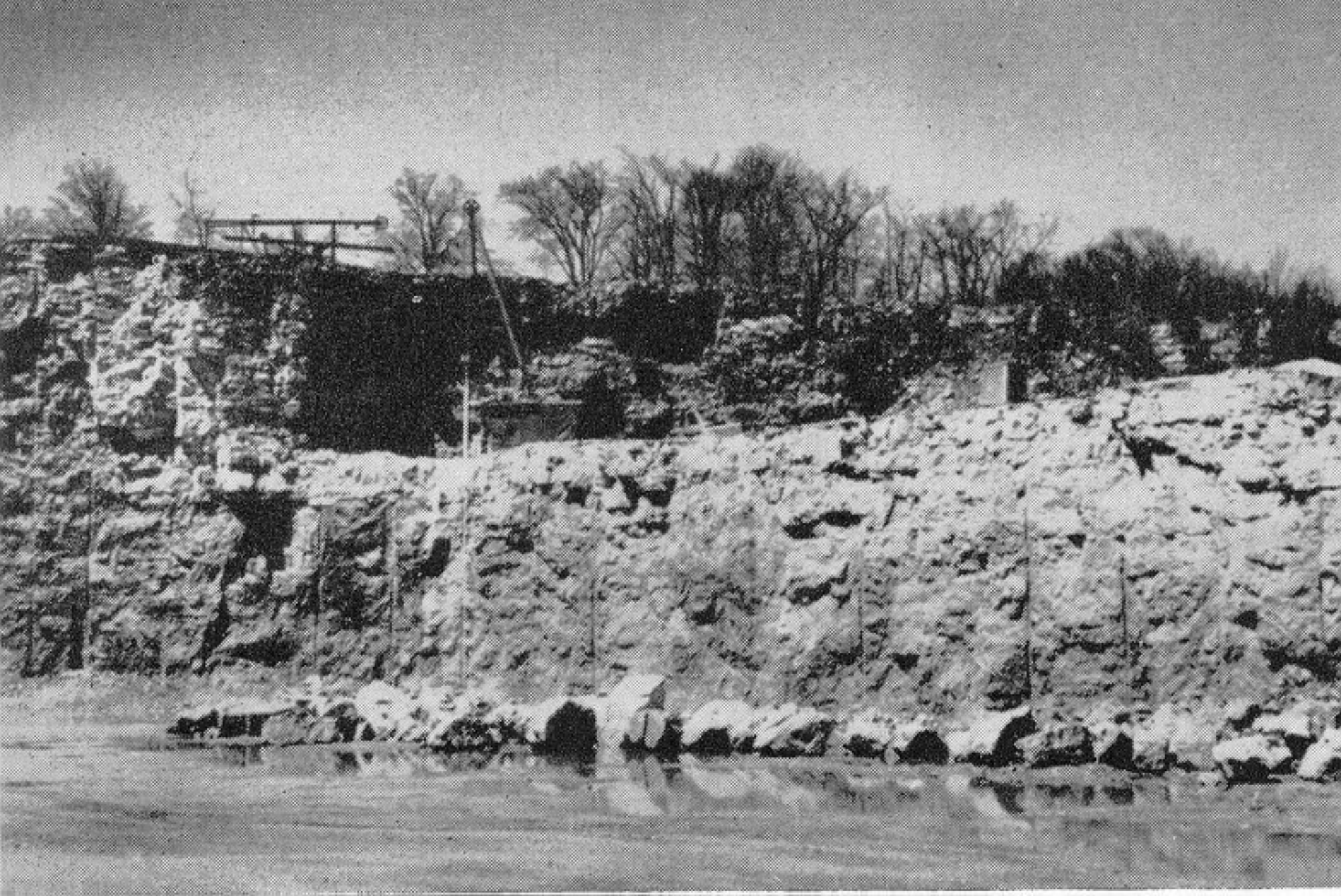
3) Biohermal reef structures may disrupt the quarry floor and surface stripping.

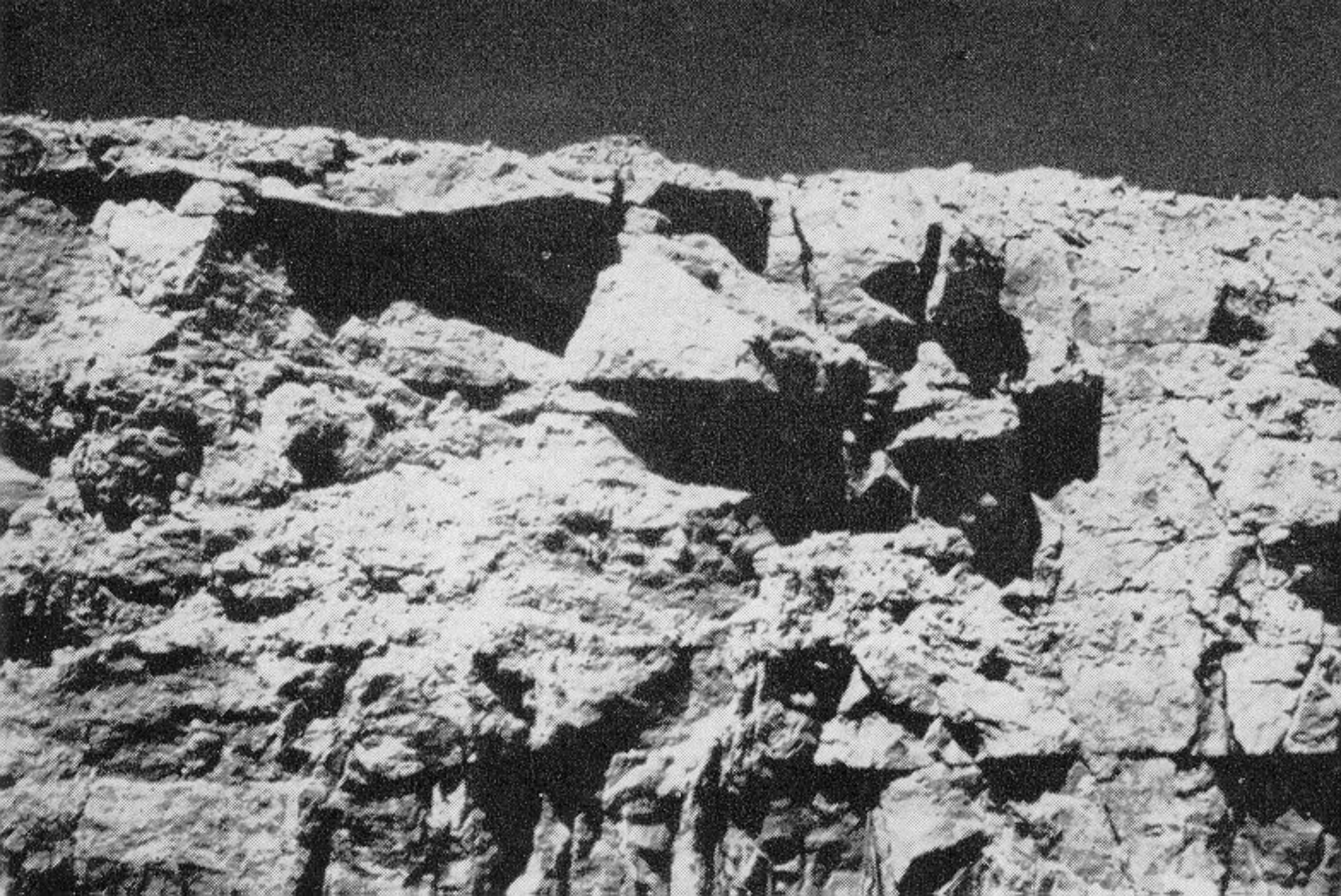
Index

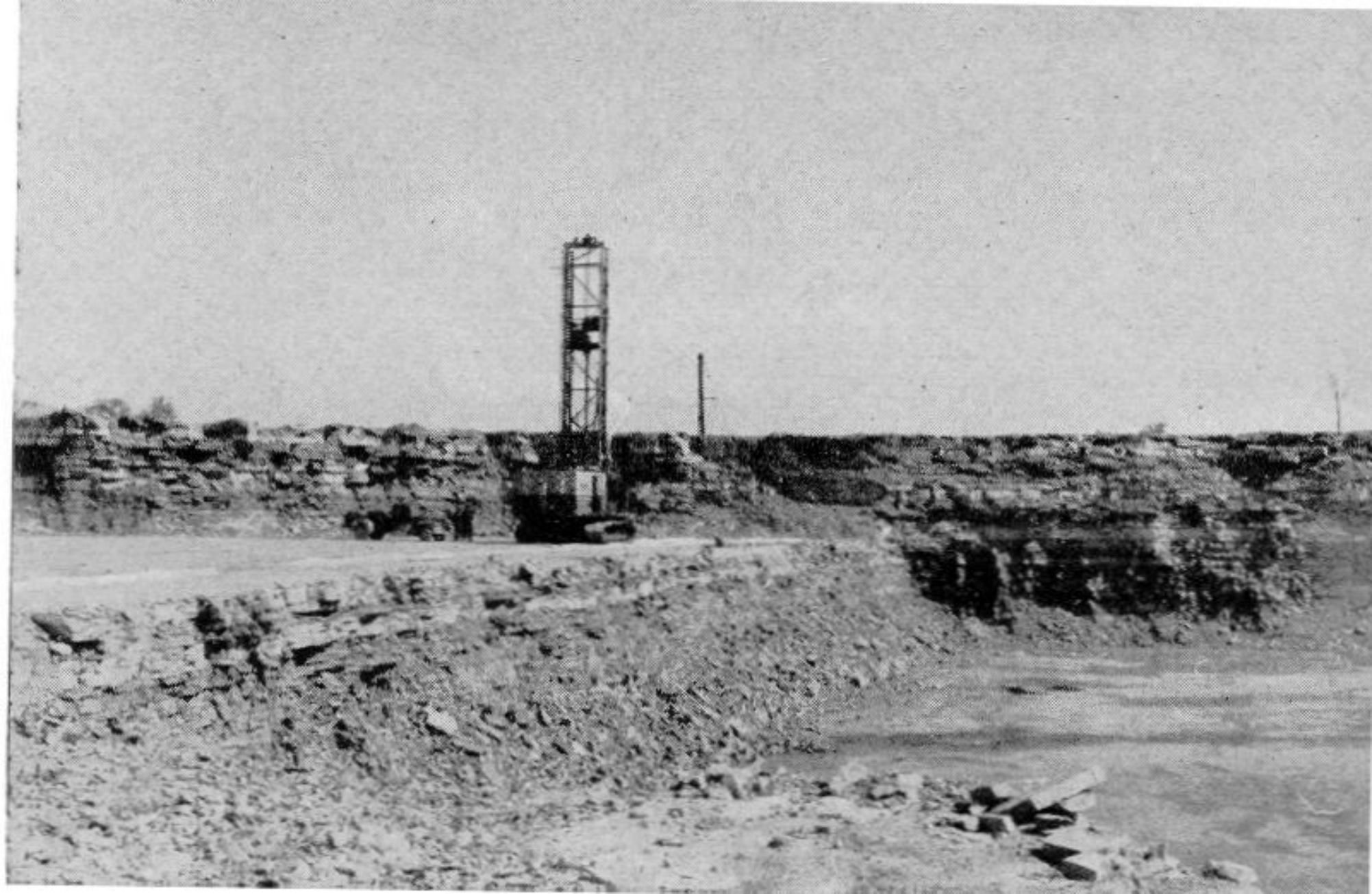
Industrial Mineral Circular No. 5

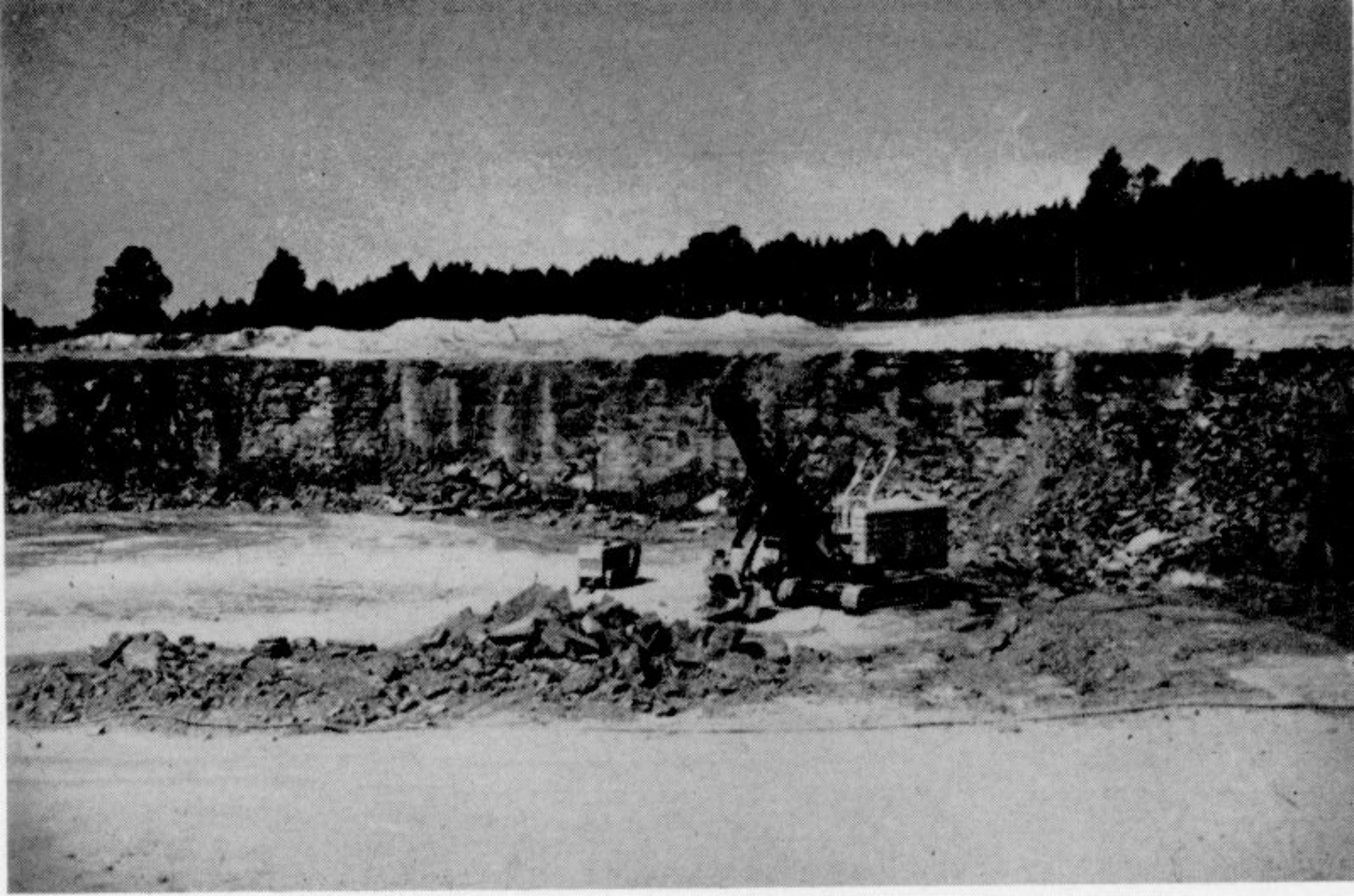
2,000–1960–6460



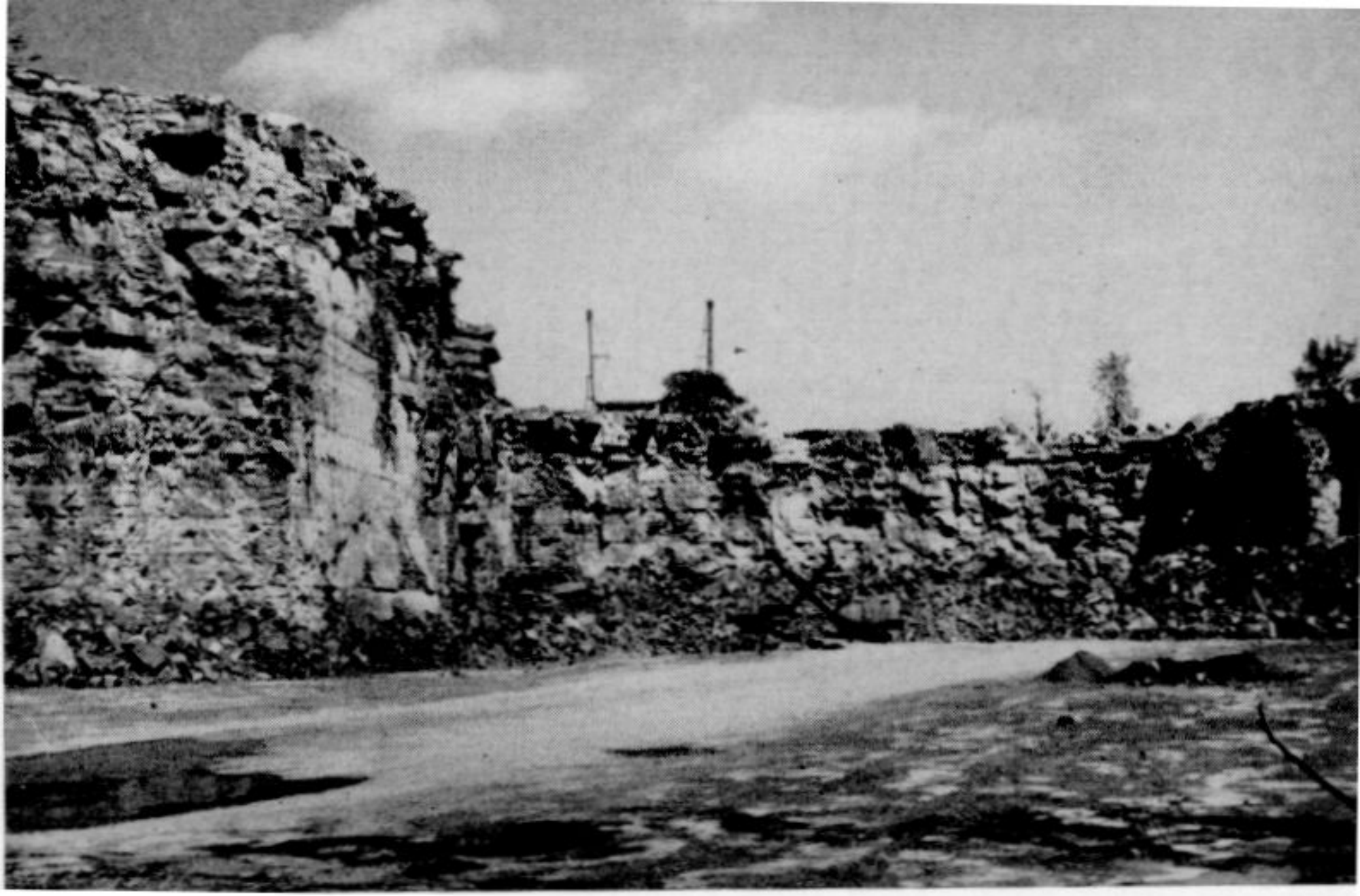


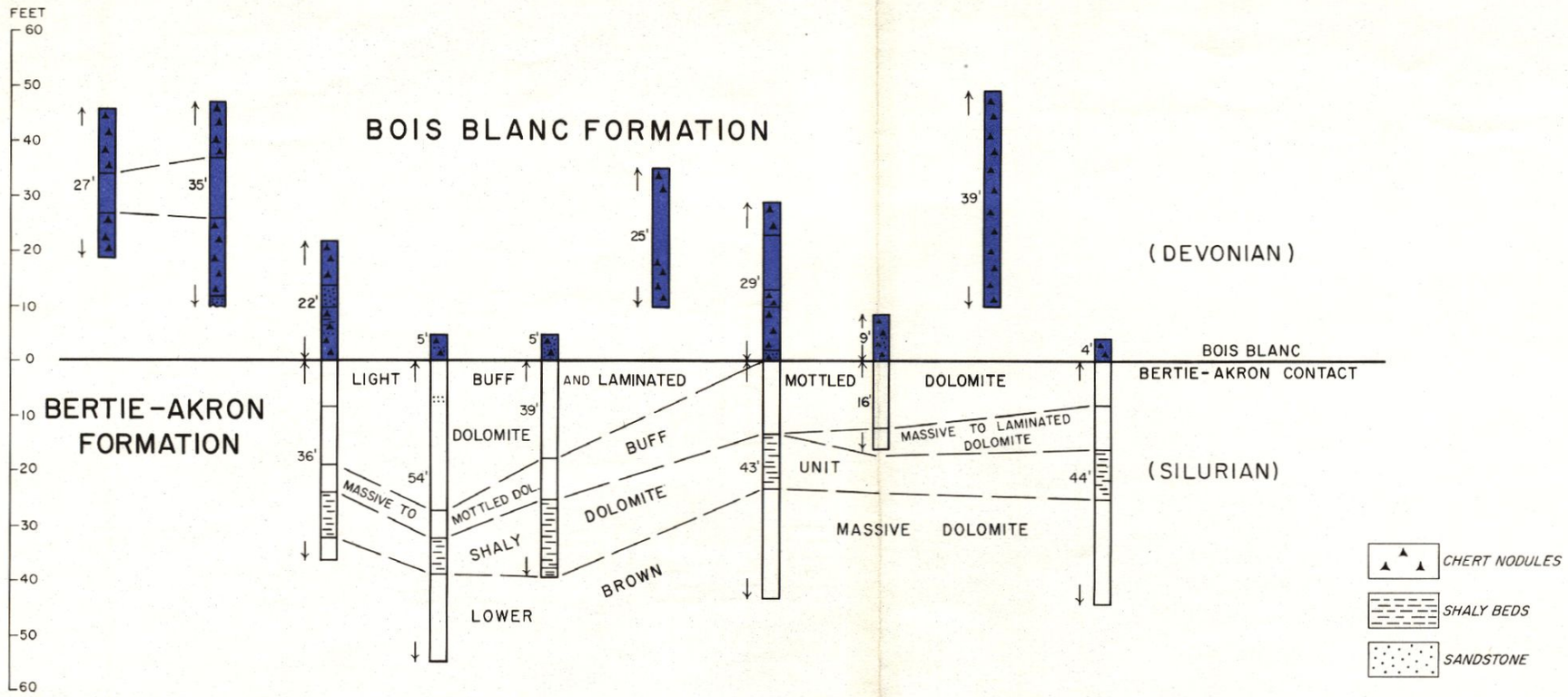




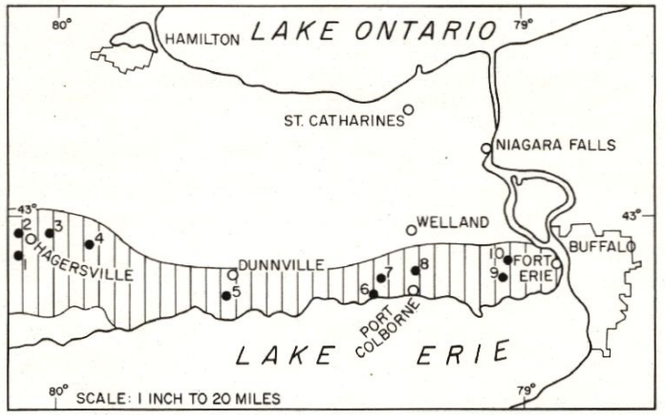



MASSIVE LITHOGRAPHIC MARKER (MR 7)
GREEN MARKER BED





1. THE HAGERSVILLE QUARRIES, HAGERSVILLE
2. CANADA CRUSHED AND CUT STONE, HAGERSVILLE
3. HALDIMAND QUARRIES AND CONSTRUCTION, HAGERSVILLE
4. CAYUGA QUARRIES, CAYUGA
5. DUNNVILLE QUARRIES, DUNNVILLE
6. CANADA CEMENT, PORT COLBORNE
7. R.E. LAW CRUSHED STONE, PORT COLBORNE
8. NIAGARA CRUSHED STONE, (HUMBERSTONE), PORT COLBORNE
9. RIDGEMOUNT QUARRIES, RIDGEMOUNT
10. GEORGE C. CAMPBELL, RIDGEMOUNT



MAP SHOWING LOCATION OF QUARRIES OR REFERENCE SECTIONS

A514

Geological Quarry Sections, Bois Blanc and Bertie-Akron Formations, Hagersville–Fort Erie Area

FEET

AMABEL FORMATION

TRANSITION ZONE

GUELPH FORMATION

ERAMOSA DOLOMITE

VINEMOUNT SHALY DOLOMITE BEDS (ERAMOSA MEMBER)

GOAT ISLAND DOLOMITE

55' covered interval

LOCKPORT FORMATION

ANCASTER CHERT BEDS (GOAT ISLAND DOLOMITE)

GASPORT DOLOMITE

DECEW DOL.

ROCHESTER SHALE

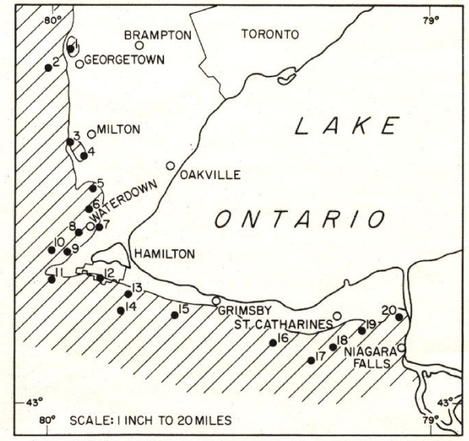
IRONDEQUOIT DOLOMITE

REYNALES DOLOMITE

DECEW DOLOMITE

BASE OF LOCKPORT–AMABEL

GASPORT DOLOMITE



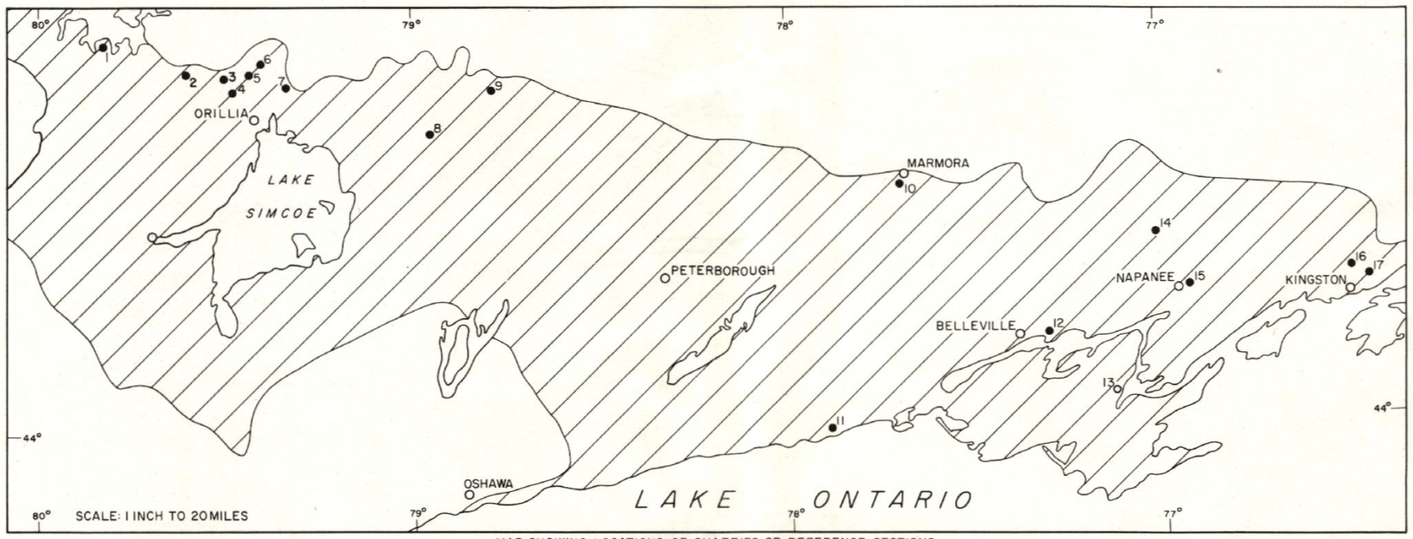
MAP SHOWING LOCATION OF QUARRIES OR REFERENCE SECTIONS

1. INDUSTRIAL SAND AND GRAVEL, GEORGETOWN
2. ARMSTRONG BROTHERS, GEORGETOWN
3. GYPSUM LIME AND ALABASTINE, MILTON
4. MILTON QUARRIES, MILTON
5. LOWVILLE QUARRIES, LOWVILLE
6. NELSON CRUSHED STONE, NELSON
7. OLD NELSON QUARRY, WATERDOWN
8. KING CITY SAND AND CRUSHED STONE, CLAPPISON CUT
9. SYDENHAM ROAD, REFERENCE SECTION (BOLTON)
10. CANADA CRUSHED AND CUT STONE, DUNDAS
11. ANCASTER REFERENCE SECTION (BOLTON)
12. WENTWORTH STREET REFERENCE SECTION, HAMILTON
13. STONY CREEK REFERENCE SECTION, NO. 20 HIGHWAY (BOLTON)
14. A. COPE AND SONS, STONY CREEK
15. ARMSTRONG BROTHERS, VINEMOUNT
16. VINELAND QUARRIES AND CRUSHED STONE, VINELAND
17. DECEW FALLS REFERENCE SECTION (BOLTON)
18. ST. CATHARINES CRUSHED STONE, ST. CATHARINES
19. WALKER BROTHERS, QUARRIES, THOROLD
20. QUEENSTON QUARRIES, QUEENSTON

CHERT NODULES
SHALY BEDS
SANDSTONE

A501

Geological Reference Sections and Quarry Sections, Lockport–Amabel Formations, Niagara Falls–Dundas–Georgetown Area



MAP SHOWING LOCATIONS OF QUARRIES OR REFERENCE SECTIONS

Geological Quarry Sections, Reference Sections, and Diamond Drilling Information, Black River–Trenton Groups, Georgian Bay–Lake Ontario Area

ONTARIO

DEPARTMENT OF MINES

HON. JAMES A. MALONEY, *Minister of Mines*

H. C. Rickaby, *Deputy Minister* M. E. Hurst, *Provincial Geologist*

Map No. 1960c
ONTARIO LIMESTONE INDUSTRIES

LEGEND

COMMERCIAL LIMESTONE HORIZONS IN ONTARIO

PALEOZOIC

DEVONIAN

- Delaware (Dundee) Formation *(limestone and dolomite)*
- Detroit River Group *(limestone and dolomite)*
- Bois Blanc Formation *(cherty limestone)*

SILURIAN

- Bertie-Akron (Bass Island) Formation *(dolomite)*
- Guelph-Lockport (Amabel) Formations *(dolomite)*

ORDOVICIAN

- Trenton-Black River Groups *(limestone)*
- Beekmantown Group *(dolomite)*

PRECAMBRIAN

SYMBOLS

- *Limestone quarry.*
- *Lime plant.*
- *Limestone quarry and lime plant.*
- *Cement plant.*
- *Limestone quarry and cement plant.*

SOURCES OF INFORMATION

Geological compilation and quarry information by D. F. Hewitt, 1959.

Field work by D. F. Hewitt, 1958.

Geology from maps of the Geological Survey of Canada.

Cartography by H. S. Cox, Ontario Department of Mines, 1959.

Base map derived from Map 1958B, Ontario Department of Mines.

LIST OF LIMESTONE QUARRIES, 1958 - 1959

PRECAMBRIAN

1. Bolenders Ltd., Eagle Lake
2. Bonter Marble Products, Marmora
3. W. F. Bonter Co. Ltd., Malone
4. Stoklosar Marble Quarries, Madoc
5. Canada Talc Industries Ltd., Madoc
6. Carleton Lime Products Co., Carleton Place
7. Jamieson Lime Co. Ltd., Renfrew
8. Dominion Magnesium Ltd., Haley
9. Canadian Dolomite Co. Ltd., Haley

BEEKMANTOWN DOLOMITE

10. Brockville Crushed Stone Ltd., Brockville
11. Iroquois Rock Co. Reg'd., Iroquois
12. Armstrong Brothers Co. Ltd., Greely

TRENTON-BLACK RIVER LIMESTONES

13. Limestone Products Ltd., Uhthoff
14. Kirkfield Crushed Stone Ltd., Kirkfield
15. Cobo Minerals Ltd., Coboconk
16. St. Lawrence Cement Co. Ltd., Ogden Point
17. St. Lawrence Cement Co. Ltd., Clarkson plant
18. Canada Cement Co. Ltd., Belleville
19. Lake Ontario Portland Cement Co. Ltd., Picton
20. Milltown quarry, Milltown
21. Storey quarry, Napanee
22. Robilndale Quarries Ltd., Robilndale Station
23. Frontenac Quarries Ltd., Kingston
24. McGinnis & O'Connor Ltd., Kingston
25. Frazer Duntile Co. Ltd., Ottawa
26. Ottawa Valley Crushed Stone Ltd., Ottawa
27. Dibblee Construction Co. Ltd., McCarthy Road quarry, Ottawa

TRENTON-BLACK RIVER LIMESTONES (Continued)

28. D. Grandmaitre Ltd., Ottawa
29. Bertrand & Frere Const. Co. Ltd., L'Orignal
30. Silvertone Black Marble Quarries Ltd., Crysler
31. Durham Wells quarry, Williamsburgh Tp.
32. Bonnechere Lime Co. Ltd., Eganville

GUELPH-LOCKPORT DOLOMITE

33. Queenston Quarries Ltd., Queenston
34. Walker Brothers Quarries, Thorold
35. Niagara Cut Stone Ltd., Thorold
36. St. Catharines Crushed Stone Ltd., St. Catharines
37. Vineland Quarries & Crushed Stone, Vineland
38. Armstrong Brothers Co. Ltd., Vinemount
39. A. Cope and Sons Ltd., Stoney Creek
40. Canada Crushed and Cut Stone Ltd., Dundas
41. Jas. D. Gray & Son, Carlisle
42. King City Sand and Crushed Stone Co. Ltd., Clappison's Corners
43. Nelson Crushed Stone Ltd., Nelson
44. Lowville Quarries Ltd., Lowville
45. Milton Quarries Ltd., Milton
46. Gypsum Lime and Alabastine Ltd., Milton
47. Halton Crushed Stone Ltd., Milton
48. Armstrong Brothers Co. Ltd., Georgetown
49. Limehouse Crushed Stone and Gravel Ltd., Georgetown
50. Industrial Sand and Gravel Co. Ltd., Georgetown
51. Rockwood Lime Co. Ltd., Rockwood
52. Canadian Gypsum Co. Ltd., Guelph

GUELPH-LOCKPORT DOLOMITE (Continued)

53. Gypsum Lime and Alabastine Ltd., Glen Christie
54. Owen Sound Ledgerock Ltd., Owen Sound
55. Cook, Ebel and Bruce Peninsula quarries, Wiarton

BOIS BLANC and BERTIE AKRON FORMATIONS

56. George C. Campbell Co. Ltd., Ridgemount
57. Ridgemount Quarries Ltd., Ridgemount
58. Niagara Crushed Stone (Humberstone) Ltd., Port Colborne
59. R. E. Law Crushed Stone Ltd., Port Colborne
60. Canada Cement Co. Ltd., Port Colborne
61. Dunnville Quarries Ltd., Dunnville
62. Cayuga Quarries Ltd., Cayuga
63. Haldimand Quarries and Construction Ltd., Hagersville
64. Canada Crushed and Cut Stone Ltd., Hagersville
65. The Hagersville Quarries Ltd., Hagersville

DETROIT RIVER and DELAWARE LIMESTONES

66. Gypsum Lime and Alabastine Ltd., Beachville
67. Cyanamid of Canada Ltd., Beachville
68. Chemical Lime Ltd., Ingersoll
69. Canada Cement Company Ltd., Woodstock
70. St. Mary's Cement Co. Ltd., St. Mary's
71. Blue Star Stone Ltd., Ipperwash
72. Brunner Mond Canada Ltd., Amherstburg
73. Amherst Quarries Ltd., Amherstburg
74. Rieger Brothers Const. Co. Ltd., Pelee Island

Map No. 1960c

ONTARIO LIMESTONE INDUSTRIES

Scale 1:1,267,200 or 1 inch to 20 Miles

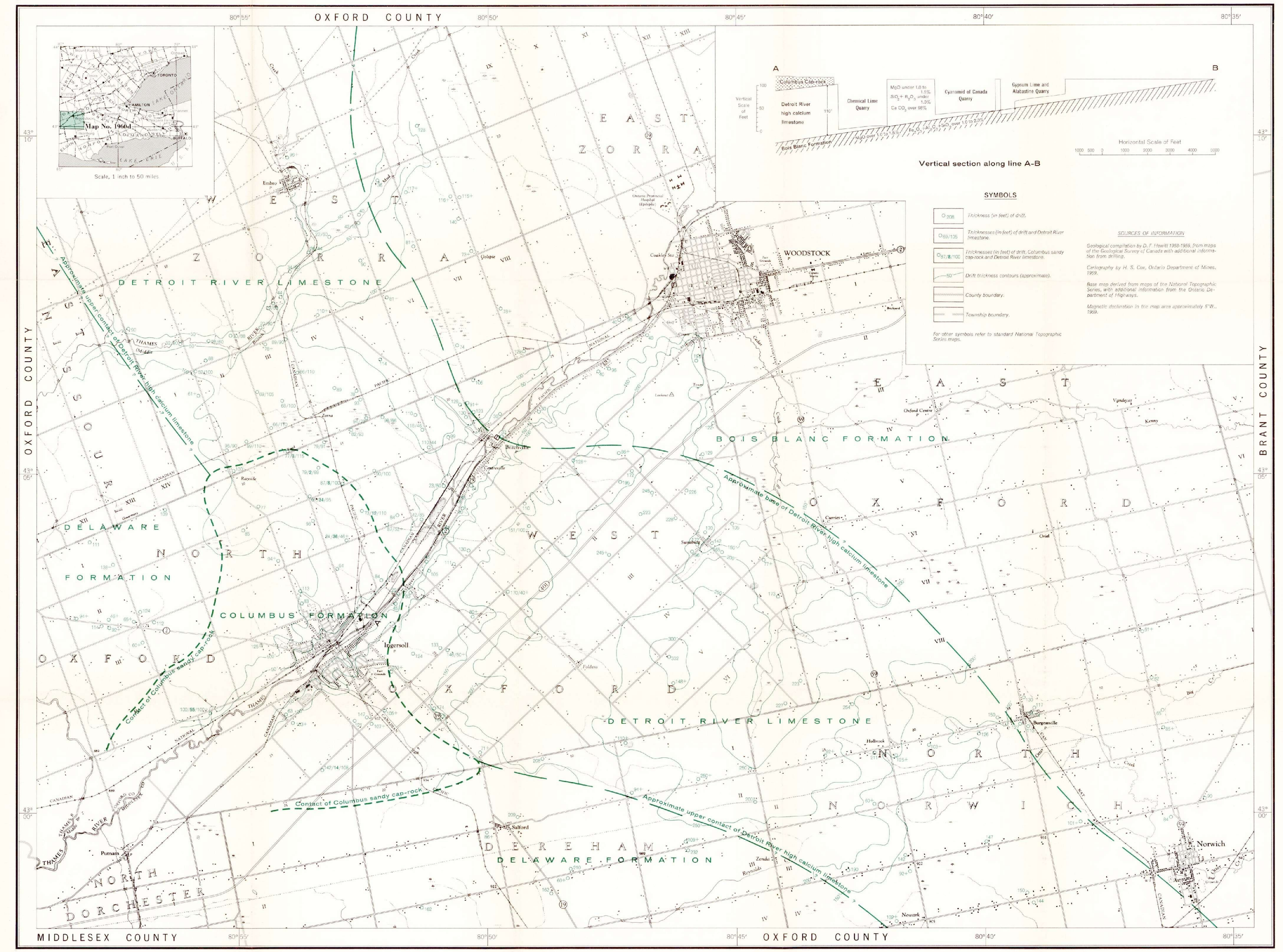
Miles 10 0 20 40 60 80 100 Miles

Kilometres 10 0 20 40 60 80 100 120 140 Kilometres

Map No. 1960d
BEACHVILLE AREA
Detroit River Limestone

ONTARIO
DEPARTMENT OF MINES

HON. JAMES A. MALONEY, *Minister of Mines*
H. C. Rickaby, *Deputy Minister* M. E. Hurst, *Provincial Geologist*



Map No. 1960d

Detroit River Limestone of the BEACHVILLE AREA showing drift thickness

Scale 1: 63,360 or 1 Inch to 1 Mile

Chains 80 40 0 1 2 3 4 5 Miles
Feet 10,000 0 10,000 20,000 Feet
Metres 1000 0 1 2 3 4 5 Kilometres