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Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

W. T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

Open File Report 5431

Mineral Resources of South-Central Ontario

by

G.R. Guillet

1983

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E.G. Pye, Director
Ontario Geological Survey

FOREWORD

Mineral production in the South-Central Region of Ontario is now valued at more than $300 million annually. All production is now industrial minerals which are largely consumed within the Region, although substantial amounts of cement, bricks, gypsum products and roofing granules are exported to other parts of Ontario, the United States and Western Canada. The Region contains important reserves of gypsum, brick shales, cement raw materials and building stone. Early mining history included also iron, gold and marl.

This report is an inventory of mineral resources in the South-Central Region, excluding the mineral aggregates, crushed stone, sand and gravel. Resources of cement raw materials, clay and shale products, gypsum, building stone, lime and flux stone, marl, peat, silica, marble, traprock, iron and gold are detailed. The report also speculates on the possibilities for base metals, uranium and oil shale, as well as the development of underground resources of limestone and shale. Immediate opportunities are believed to exist for the further development of building stone, silica sand, and traprock.

The area covered by this study is that which has been designated for administrative purposes by the Ontario Ministry of Natural Resources as the South-Central Region. It includes part or all of the regional municipalities of Durham, Haldimand-Norfolk, Halton, Hamilton-Wentworth, Niagara, Peel, Waterloo and York; also the counties of Brant, Dufferin, Northumberland, Peterborough, Simcoe, Victoria and Wellington.

E.G. Pye, Director
Ontario Geological Survey

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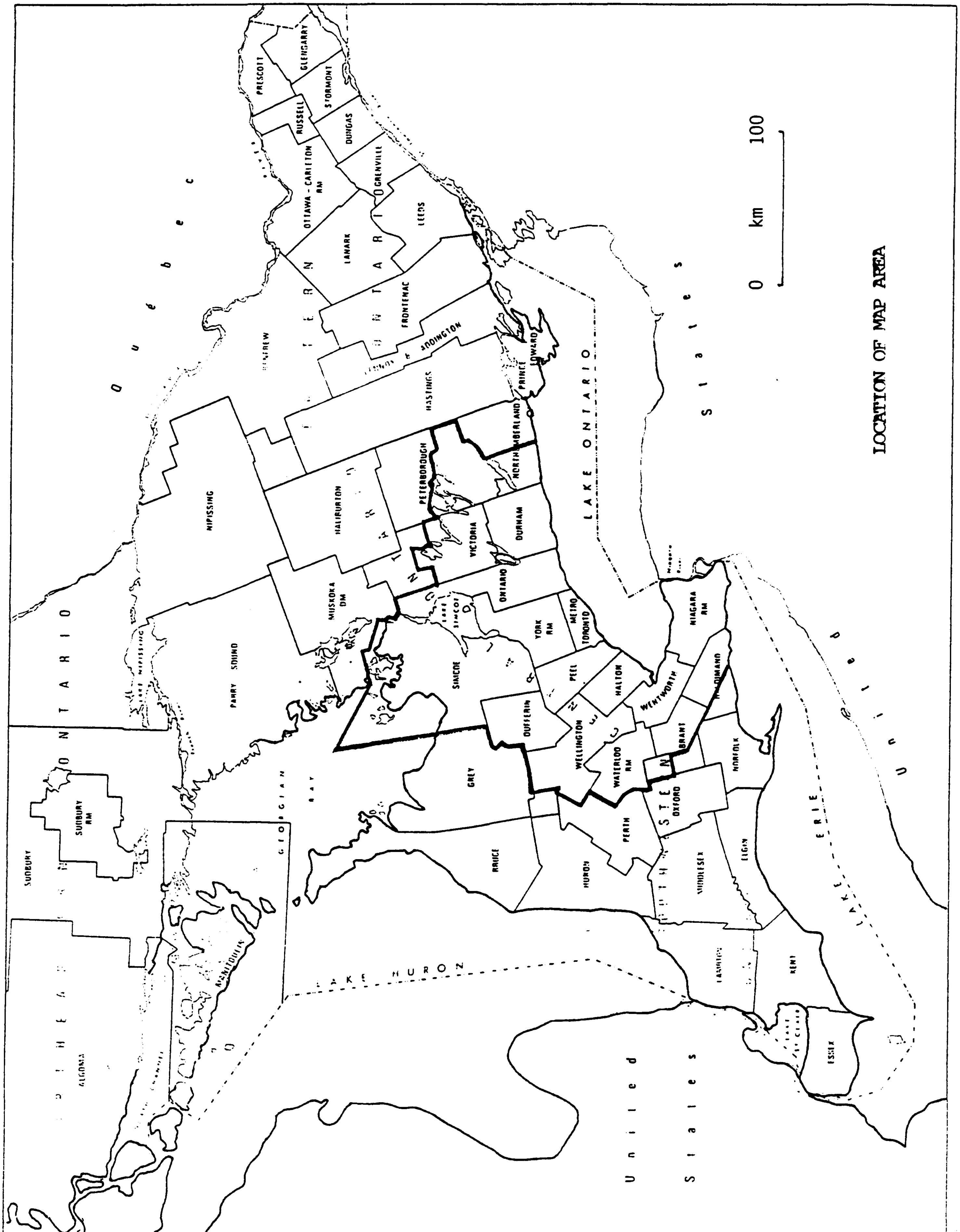
LOCATION OF MAP AREA
0 km 100
Quebec
ONTARIO
United States
LAKE ONTARIO
LAKE ERIE
LAKE HURON
GEORGIAN BAY
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GLENGARRY
PRESCOTT
STORMONT
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PERTH
MIDDLESEX
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SUDBURY
SUDBURY RM
ALGOMA
MANITOULIN

SUMMARY

This map area which also coincides with the Central Administrative Region of Ontario's Ministry of Natural Resources (which in this report shall subsequently be referred to as the Central Region) is a significant producer of mineral commodities. While as a group the construction aggregates (crushed stone, sand and gravel) have been predominant both in terms of volume and value, cement and clay products have also been most significant. These three commodity groups continue to grow in economic importance, and in 1980 they represented about 90 percent of the total value of mineral production in the Region (approx. $300 million).

This report is an inventory of mineral resources in the Central Region, excluding the construction aggregates which have been thoroughly documented elsewhere. In addition to cement and clay products, this report includes gypsum, building stone, marl, peat, oil, shale, lime and flux stone, silica, marble, traprock, iron, gold, base metals and uranium. It also speculates on the possibilities for underground mining of limestone and shale at Toronto.

The combined value of cement shipped from two plants in the Central Region in 1980 was $76,115,175 (Weatherson 1982, p. 44-45) representing about 75 percent of their total capacity. As cement plants consider 85 percent their normal maximum, this represented a relatively favourable level of production. A substantial Toronto market and a high level of exports to the United States were together responsible for this prosperity. The industry is among the most innovative, and administratively competent in the province, and it does not need special government involvement to maintain an optimum level of development. The Region is well-endowed with raw materials for cement-making: limestone, clay, shale, gypsum.

The clay products industry is primarily the production of bricks from shale; only small amounts of clay are now used solely by manufacturers of drainage tiles. Ontario produces and consumes more than half of all the bricks used in Canada, and more than 90 percent of these are made in six plants in the Central Region. Suitable shales are practically restricted to the Region, and while shale resources are abundant, competitive land use pressures and environmental concerns greatly limit their accessibility. The industry is well administered and capable of maintaining its optimum level without special government assistance, except in being assured of access to future shale resources. The Region has a duty to preserve sufficient shale resourcesfor future needs. A preliminary inventory of these resources has been made (Proctor & Redfern 1978) from which a selection of the most favourable will depend on testwork recommended in this report.

Surficial clays, which are now used only sparingly for making drainage tiles, are widespread but of poor quality. Superior interglacial clays of the Toronto area, and an unusual clay in the Hamilton-Burlington area, have been lost to urbanization. In neither case does there appear to be an opportunity for further development.

The production of building stone other than crushed aggregate has almost vanished from the Central Region where once it was most significant in terms of numbers and diversity. Most important have been deposits of grey dolomitic limestone and grey, brown and red sandstone in the Niagara Escarpment. Elsewhere, deposits of limestone and granite have been important. In most cases suitable resources of these materials are believed to exist, and government encouragement for their development is recommended. A further delineation of these resources is recommended in this report.

There are three gypsum mines in the Central Region, the newest of which commenced production in 1978. All are underground mines which create a minimum of disturbance to the surficial environment. In 1981 a total of 688,000 tonnes of crude gypsum was mined. Its reported value was $5,353,000 (Weatherson 1982, p.247), before its conversion to plaster and wallboard. Its value in finished form would greatly exceed this amount. The industry is presently operating much below capacity because of a low level of residential construction. Gypsum reserves in the Region are ample, and the three producers are easily capable of meeting any foreseeable market demand. Hence, there does not appear to be any reason to encourage further gypsum development at this time.

Although marl was the principal raw material for cement-making at four locations in the Central Region in the early years of this century, it has not been used commercially in Ontario for many years. Several large deposits are available in the Region but its further use for cement, or its use as a mineral filler or soil conditioner, is most unlikely because of its impurity, poor colour, and moisture content. It is generally believed that as long as limestone is readily available marl cannot be economic. Hence, there appears to be little opportunity for development of these resources.

There are two producers of dolomitic lime in the Central Region. A third producer closed in 1979 because of reduced utilization in the steel industry and as mortar mix for construction purposes. At least one new potential quarry development is awaiting more favourable economic conditions; hence there is little reason to encourage further development at this time. Dolomite resources are ample in the Region.

Silica quarried out of the Region is processed and distributed to the glass industry from a plant in Midland. However, the market for glass and foundry sands in the Central and Southwestern Regions substantially exceeds the local supply, and because of high transportation costs for imported silica an opportunity exists for further silica production in Ontario. A possible silica source in the Central Region is being considered for glass-making.

Two peat harvesting operations in the Central Region produce horticultural products largely for export to the United States. At least ten peat bogs in the Central Region have been worked to a greater or less extent in years past. While the quality of Ontario peat is generally inferior to that of New Brunswick and British Columbia, a re-evaluation of the major bogs in the Central Region may be warranted. An evaluation of Ontario bogs as potential sources of fuel is planned by the Ontario Government.

Oil shale is currently being studied by the Ontario Government in the Central Region and elsewhere. Significant amounts of "organic carbon" have been indicated in basal strata of deep Ordovician shales.

The only Canadian producer of roofing granules is in the Central Region, using traprock as a raw material. Similar deposits nearby could be used as asphalt aggregate for road surfacing subjected to high traffic volumes where superior resistance to abrasion is required. Such materials are in short supply and command premium prices. A further evaluation of these resources is recommended.

Iron was economically significant a century ago in the eastern part of the Region, and might again be important. However, the outlook in the near term is unfavourable and no special measures are recommended to encourage the redevelopment of known deposits at this time.

Gold, and minor silver, was also economically significant in the eastern part of the Region. Private studies now in progress involving bulk leaching of gold tailings and low-grade ores deserve encouragement, not only for their benefit to the Central Region but for their larger application to all old gold camps throughout Canada. Financial or technical assistance is warranted.

A deposit of white calcitic marble has been undergoing field and laboratory studies in recent years towards the production of high-purity mineral filler. Its feasibility is currently being considered in light of improved and expanded production from a major filler source in the Eastern Region. No specific action is recommended at this time.

Base metal mineralization, mainly zinc, is widespread throughout certain dolomite beds in the Niagara Escarpment, but its low grade and restricted local extent is not encouraging. No specific studies are recommended.

The possibility of significant uranium mineralization along the north-east fringe of the Region is not considered likely. However, private exploration in the wake of recent geological studies by the Ontario Geological Survey should not be discouraged.

The underground mining of limestone and shale beneath Lake Ontario just off the Metro Toronto shore may be an important future source of mineral aggregate, expanded shale aggregate, brick shale, oil shale, and cement raw materials. The utilization of mined-out space for hydrocarbon storage, surge electric power generation, or other industrial uses might be significant byproducts. Further government studies of these possibilities are warranted as a possible alternative to increased transportation costs and environmental disturbance from surface operations.

RECOMMENDATIONS

Traditionally, the role of government in encouraging new mineral development has been the provision of background studies and basic research, the results of which may indicate opportunities not previously recognized. It is with this idea in mind that the following recommendations are made towards encouraging optimum development of the Region's resources.

1. Ample resources of shale for brick-making have been indicated by previous studies. The problem is how to make a selection of these resources to be protected for future industry use.

   Because the quality of the shale varies from place to place, it is recommended that the major shale areas that have already been identified be tested by diamond drilling and laboratory evaluation. In most cases a single vertical hole of 30 m length would be adequate. Such information as frequency of hard limy and sandy layers, content of gypsum impurities, and iron to lime ratios could readily be determined from the drillcores. A consideration of quality data, location, environmental and other physical aspects, and competing land use pressures, would permit a resonable determination as to the priority level of the shale resource.

2. It is recommended that a more detailed review of certain building stone resources be undertaken, specifically "Queenston" limestone, Whirlpool sandstone, and "Longford" limestone.

   It is understood that the Ministry has already planned such a review for the Whirlpool sandstone. In respect to Queenston limestone, a brief study should be made to determine whether or not further resources are available. A detailed map of the Longford limestone area and its old quarries should be prepared as a basis for estimating the feasibility of renewed operations at longford.

3. In view of the current interest in peat resources for their potential fuel value, and the studies the Ministry has already planned it is recommended that the major peat bogs in the Central Region be tested also for their value for horticultural purposes.

4. There is believed to be an unsatisfied market for traprock aggregate for road surfacing. Deposits in Belmont Township appear to be closest to the Central and Southwestern markets. We recommend a detailed mapping of these deposits, and further sampling and testing to confirm their suitability in liaison with officials of The Ministry of Transportation and Communications.

5. Gold leaching studies presently in progress in Belmont Township deserve encouragement. Laisir Gold Inc. has plans to reopen the Cordova Mine, which was a significant gold producer and is believed to contain further reserves that might be amenable to bulk cyanide leaching. It is recommend that appropriate assistance and encouragement be offered during the research stages of this project.

6. With escalating transportation costs and environmental concerns, underground mining of limestone and shale resources off the Toronto waterfront becomes an interesting alternative. Raw materials for construction aggregate, cement, chemical limestone and lime, bricks, oil shale and expanded shale aggregate might be accessible on different working levels from the same inclined shaft. As a preliminary step the drilling of a single vertical hole to the Precambrian surface (450 to 500 m) and laboratory evaluation of the drillcore for these various uses is recommended.

This report is respectfully submitted.

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Specialist, Industrial Minerals

REGISTERED PROFESSIONAL ENGINEER
G. R. GUILLET
PROVINCE OF ONTARIO

March 31, 1982

THE CENTRAL REGION

The Ministry of Natural Resources divides Ontario into eight administrative Regions having a total area of 412,582 square kilometres. The Central Region comprises five Districts with land areas as follows:

District	Land area (sq. km)
Cambridge	7,141
Huronia	6,550
Lindsay	6,856
Maple	4,812
Niagara	2,670
	28,029

The Region includes parts or all of the regional municipalities of Durham, Haldimand-Norfolk, Halton, Hamilton-Wentworth, Niagara, Peel, Waterloo and York; also the counties of Brant, Dufferin, Northumberland, Peterborough, Simcoe, Victoria and Wellington.

The Central Region represents about 6.8 percent of the total area of Ontario, but it houses 68 percent of the province's population. It is therefore a major consumer of mineral commodities as well as an important producer of them.

MINERAL RESOURCES

While Ontario is noted particularly for its nickel, copper, uranium, gold, silver, iron and zinc, the Central Region is noted mainly for its industrial minerals. The historical record of economic mineral production in the Region has included clay, shale, limestone, dolomite, sandstone, gypsum, marl, granite, traprock, peat moss, iron and gold.

Clay and shale have been used extensively for brick-making, as well as for drainage and structural tiles, sewer pipes and flowerpots. Limestone, dolomite, sandstone and granite have been used for building stone; dolomite also for burned lime and fluxstone for steel and glass-making; sandstone also as a source of silica for rock wool and glass. Limestone and shale are used for cement, and marl was used for this purpose around the turn of the century. Gypsum is used primarily in the manufacture of wallboard, but it is also a minor constituent of cement. Traprock is used in making roofing granules for asphalt shingles. Peat moss finds horticultural applications.

The value of mineral production in recent years is given in Table 1.

All mineral commodities which have been produced in the Central Region, and others for which there may be economic interest, are reviewed in detail on the following pages. Only the construction aggregates - crushed stone, sand and gravel - have been omitted in this inventory, as they have been adequately reviewed in previous studies.

TABLE 1 - CENTRAL REGION MINERAL PRODUCTION

VALUE IN DOLLARS

	1972	1976	1980 *
Cement		48,827,430	76,147,682
	58,115,597		
Stone **		46,016,731	77,868,904
Clay products	28,159,647	45,536,198	49,840,031
Gypsum			5,728,570
		3,275,297	
Peat	5,307,431		622,766
Lime		3,494,771	7,593,085
Sand & gravel	34,616,593	59,566,092	74,123,619
	126,199,268	206,716,519	297,653,227

*Approximate

**Includes crushed stone aggregate, building stone, and roofing granules.

References: Patten 1974, p. 225
Narain and Ghandikota 1978, p. 125
Weatherson 1982, p. 39-46.

BASE METALS

Disseminated sulphide mineralization has been reported from three parts of the Central Region: Belmont Township, Harvey Township, and the Niagara Escarpment. However, deposits of significant grade have yet to be discovered and their presence in the Region is not considered likely.

Belmont Township

Metalridge Mining Corporation Limited carried out exploration work on a disseminated sulphide deposit in lot 27, concession I, Belmont Township during the 1960's. The work included geological mapping, geochemical soil surveying, a magnetometer survey, and 1,600 m of diamond drilling. A deposit consisting primarily of pyrrhotite with traces of chalcopyrite, sphalerite and magnetite was outlined in graphitic schist.

Consideration has been given to the possibility of producing iron and sulphur, but as the market for these commodities is currently weak there has been little interest in the deposit in recent years. The prospect should be protected for future consideration when economic conditions are more favourable.

Harvey Township

The presence of felsic and mafic metavolcanic rocks, and evidence of widespread pyroclastic volcanism, would indicate a potential target for base metal exploration. According to Morton (1978, p. 130):

> Sulphide gossans and zones of disseminated to stringer pyrite mineralization containing minor chalcopyrite, sphalerite, arsenopyrite and pyrrhotite are widespread in the interlayered felsic pyroclastics and chemical metasediments in Harvey Township 1) south of Highway 36 on lots 17 and 18, concessions XII and XIII, and on lots 14, 15 and 19, concession XII; 2) north of Highway 36 on lots 20, 27 and 30, concession XI; and 3) south of Little Bald Lake on lot 15, concession XI and lot 14, concession XII. Small showings of chalcopyrite and molybdenite with pyrite and traces of bornite occur in breccia zones within and along the contacts of the synvolcanic quartz monzonite stock in central Harvey Township on lot 22, concession XI, lot 20, concession IX and lot 19, concession XII. The breccia zones consist of numerous mineralized stringers, veins and open space fillings which surround and seal small fragments to large blocks of quartz monzonite.

Bright (1980, p. 67) also mentions copper associated with uranium in central Harvey Township.

Niagara Escarpment

Silurian dolomite of the Guelph-Lockport-Amabel formations form the caprock of the Niagara Escarpment from Niagara Falls to Manitoulin Island. Throughout this belt of rocks traces of sphalerite and galena have been found replacing fossils and filling hairline fractures and vugs.

Although most of the interest has been centred on occurrences of sphalerite in the Bruce Peninsula north of Wiarton, where brown to honey-yellow sphalerite occurs as a partial replacement of fossils in reef structures near the base of the Guelph Formation, both galena and sphalerite are widespread in these rocks within the Central Region. An occurrence near Beamsville in the Town of Lincoln is described by Logan (1863, p. 324) and J.E. Thomson (Guillet 1967, p.6).

The main showings are located on lots 18 to 21, concession V111, in the former Township of Clinton. Scattered crystals and tiny stringers of galena are widely but erraticly distributed over an area 1,350 m by 150 m in upper beds of the Lockport Formation. Thickness is unknown but believed to be shallow. There are no apparent structural features with which the mineralization might be associated. Although galena is more obvious because the honey-yellow sphalerite blends into the dolomite hostrock, zinc to lead ratios are typically four to one.

In 1951 two test pits were established about 420 m apart and bulk samples of 5 or 6 tonnes were tested by the Bureau of Mines in Ottawa. These samples revealed average lead contents of 0.12 percent and 0.09 percent, and zinc contents of 0.47 percent and 0.41 percent respectively (Guillet 1967, p.7).

Elsewhere in Lockport Dolomite, Bolton (1957, p.49) reports: "Vugs filled with calcite, gypsum, fluorite, and sphalerite are numerous, particularly in the Niagara Falls area."

The Dundas dolomite quarry of Steetley Industries Limited has been a well known collecting area for fine crystals of sphalerite, galena, celestite, fluorite and calcite for many years. Sphalerite and fluorite mineralization has also been noted in Genstar's Lincoln Quarry.

Williams (1919, p.102) says: "Particles of galena may be found in the Lockport dolomite at the top of the falls at Grimsby, at Rockwood, and east of Guelph. Zinc blende may be seen at Rockwood and elsewhere."

Trace metal studies by Warren and Delavault (1961, p.1271) on chip samples from quarries in southern Ontario show Lockport Dolomite to have far higher lead and zinc values than any other Paleozoic carbonate formations (Table 2).

The Ontario occurrences are remarkably similar, except in size, to the Mississippi Valley and Pine Point ores. Both hydrothermal and meteoric origins for the mineralization have been mentioned, the latter being favoured here. Concerning the Ontario occurrences, Liberty (1966, p. 7):

> "......favours an origin related to the known reefal growth in the Amabel-Guelph (Niagaran) strata. The hypothesis concerns extraction of the zinc from the Amabel (Lockport) sediments by reefal circulating waters and deposition of the zinc sulphide where brecciation, cavities, and pore space in the reef rock permit favourable temperatures and pressures. This explanation is supported by: the presence of mineralized fossil remains, stratigraphic restriction of mineralization, mineralization of low permeability rocks, simple mineralogy, low temperature of deposition, lack of evidence of igneous activity and apparent lack of migration routes, i.e. faults, for hydrothermal solutions. With the reefal growth being so very extensive, with zinc mineralization being known at many localities associated with reefs, and with mineralization being found at three localities in the map-area [the Bruce Peninsula], the writer considers more prospecting to be warranted."

TABLE 2 - TRACE METALS IN PALEOZOIC CARBONATE ROCKS FROM QUARRIES IN SOUTHERN ONTARIO

SYSTEM	FORMATION OR GROUP	NO. OF SAMPLES	PARTS PER MILLION Pb	Zn	Cu
Devonian (Middle)	Bois Blanc	4	3	18	6
Silurian (Upper)	Bertie Akron				
	Shaly dolomite	5	18	28	8
	Other members	11	3	11	6
(Middle)	Lockport				
	Amabel	5	6	14	6
	Eramosa, Goat Island, Gasport Members	8	65	520	8
Ordovician (Middle)	Trenton *	11	4	13	6
	Black River *	55	4	15	8
(Lower)	Beekmantown				
	Oxford	10	16	43	13
	March	3	9	24	20

Reference: Delavault 1961, p. 1271.

* Current terminology puts the Trenton and Black River in the Simcoe Group, which is comprised of four limestone formations: Lindsay, Verulam, Bobcaygeon and Gull River.

The occurrences of lead and zinc in the Niagara Escarpment are extremely low grade, and while there is no apparent reason why larger replacement deposits similar to the Mississippi Valley and Pine Point deposits should not occur, it is significant that no concentrations of commercial interest have in fact been found. These Silurian rocks have, after all, been rather extensively developed by quarrying throughout the Escarpment, and have been penetrated by thousands of oil and gas wells at depth throughout southwestern Ontario. The prospect of locating economic deposits cannot therefore be considered likely.

BUILDING STONE

Building stone in Ontario first became an important industry in the construction of the Welland and Rideau canals between 1824 and 1832. These major projects involved the extensive quarrying of limestone blocks for dams, locks and retaining walls. Many British stone masons were hired for this work, and a lot of them settled permanently in Ontario where they encouraged the continued use of stone in both commercial and residential construction.

While limestones and dolomite were the most widely used rocks in the early years, sandstone and granite became increasingly important also. Early construction techniques relied on massive stone foundations and thick stone walls for their load-bearing capability, and hence evenly-bedded Paleozoic rocks in naturally free beds 10 to 40 cm thick were particularly sought.

However, beginning in 1889 when the Portland cement industry was introduced to Canada, concrete began to displace stone in building foundations. About the same time a trend began in the use of steel framed buildings on which thin stone slabs were hung as a non load-bearing veneer.

Although its role had changed from one of load-bearing, involving massive stone blocks, to an architecturally pleasing veneer of thin stone slabs, building stone continued to be extensively used until the middle of this century and stone quarries were particularly numerous in the Central Ontario Region. Many hospitals and insurance offices constructed during this period may still be seen on Toronto's University Avenue, clad in grey limestone.

But the post war years brought a construction boom that saw widespread use of glass, concrete and precast concrete facings in the commercial sector and greater use of bricks for residential construction. Many local stone quarries were abandoned for lack of market, and with them went the masonry expertise so essential to any building stone industry.

Beginning in the 1970's and continuing strongly into the 1980's there is a resurgence of interest in natural stone in large commercial buildings. The bank towers which dominate downtown Toronto vie with each other not only in tallness but in the aesthetic appeal of their exteriors and interiors, both of which make extensive use of stone. But sadly, most of these materials are imported: granite from Quebec; marble from Italy and the United States.

Renewed interest in stone today derives from such aspects as prestige and aesthetics; an appearance of permanence and solidarity. Durability, insulating qualities, low maintenance, and proven performance are also attractive aspects of the increasing use of stone in commercial construction.

Our building stone quarries are greatly reduced in numbers; in fact where once they were numerous they are now almost extinct in the Central Ontario Region. But in most cases the raw materials are still available, and the renewed development of a building stone industry is considered to be one of the best mineral opportunities in the Region.

STONE RESOURCES

The Central Ontario Region is particularly well endowed with attractive stone resources which have been extensively used in the past and could again be developed. Unfortunately, many of our quarries were developed in dolomitic limestone and sandstone near the face of the Niagara Escarpment, the only place where these rock formations came to surface. However, other limestone resources, and granite, are accessible in less sensitive areas. Descriptions of the various resources follow.

GUELPH-LOCKPORT DOLOMITE

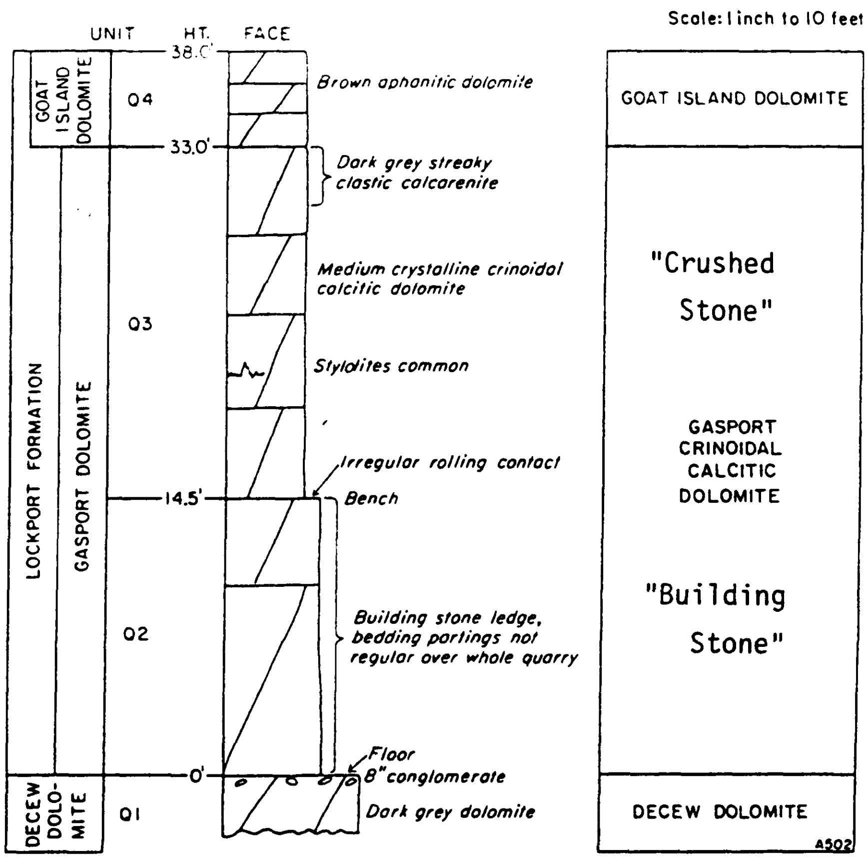
Queenston Quarries

In 1978 the largest building stone quarry in Canada, known as the Queenston Quarries Division of Steetley Industries Limited, ceased operations due mainly to exhaustion of suitable stone. The company continues to produce crushed aggregate from the 75 hectare site to which it has recently been licenced an additional 14 hectares. However, since the building stone equipment, some of it antiquated, has now been dismantled and removed, the company does not anticipate renewed production of dimension stone.

The property is located 3 km west of Queenston on the brow of the Niagara Escarpment in lots 47 to 49, concession X, in the former township of Niagara, now the Town of Niagara-on-the-lake in the Regional Municipality of Niagara.

According to Goudge (1933, p.76) "the history of the quarry extends back to 1837 when, it is stated, stone was obtained for the abutments of the original Queenston International bridge. In 1856 the imposing

FIGURE 1: 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+

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

Reference: Hewitt 1960, p.92

monument to General Sir Isaac Brock on Queenston Heights was constructed of this stone. From 1846 onwards the stone has been extensively used in the construction of the successive Welland canals, for railroad bridges and culverts, and for various other engineering projects in the Niagara district, as well as for general building purposes. The excellent state of preservation of the stone in the oldest structures bespeaks its durable nature."

The quarry exposed a 12 m section comprising 2 m of brown Goat Island Dolomite overlying 10 m of grey Gasport Dolomite, both members of the Lockport Formation of Silurian age which forms the caprock of the Niagara Escarpment. Only the lower 3 to 5 metres was suitable for dimension stone; the rest was crushed for construction aggregate. Bedding partings in the building stone unit varied from 0.5 m to 3 m apart, yielding quarried mill blocks up to 20 tonnes in size. The Knox quarrying method using drilling and blasting was employed.

A stone cutting plant in the quarry consisted of a variety of diamond and abrasive saws and guillotines.

Peninsula Limestone Limited, formerly Niagara Cut Stone Limited, produced dimension stone from a similar section of the Gasport Dolomite some years ago. The quarry was located in lots 44 and 45, concession TL, Thorold Township, now in the City of Thorold.

"Queenston" limestone is a medium-crystalline crinoidal dolomitic limestone which weathers to an attractive silvery-grey colour. The stone has been extensively used throughout Ontario, including the Whitney and Macdonald Block complexes at Queen's Park in Toronto.

Both the Queenston and Thorold quarries operated in the brow of the Niagara Escarpment. The favourable Gasport Dolomite section is restricted to the Niagara Peninsula, so it is unlikely that further development of this rock unit will be possible because of urbanization and environmental sensitivity.

Shelburne

Hewitt (1964 b, p. 37) mentions a small quarry 2 km east of Shelburne in lot 32, concession I, Amaranth Township, County of Dufferin. The quarry was operated for a few years in the 1920's and produced ashlar and interior slabs, some of the latter being used in the lobby of the Whitney Block, Queen's Park, Toronto. A 5 m face of buff-coloured medium bedded Amabel Dolomite was worked. The stone was reported to be soft and easily worked, but occasional vugs lined with calcite crystals detracted from its use for dimension stone. For this reason it is not considered an important building stone resource.

Erin

A small quarry was opened in the early 1930's in buff-weathering, medium to thick bedded, Guelph Dolomite, 6 km southwest of Erin station. The quarry is in lot 15, concession VI, Erin Township, Wellington County. A 5 m face exposes beds ranging in thickness from 20 to 60 cm. According to Hewitt (1964 b, p. 38) mill blocks proved too irregular and seamy. It is not considered an important resource.

MEDINA SANDSTONE

A group of small sandstone quarries in the Niagara Escarpment of the Georgetown - Inglewood - Limehouse area are now all but extinct. Of nineteen active quarries in 1962 only two were in substantial production in 1981. They produce ashlar, flagstone, steps and copings from the Whirlpool Sandstone Member of the Medina Group. The Whirlpool Member is a massive to thin bedded pale grey or red fine-grained sandstone. Red mottled zones occur near Inglewood, and deep chocolate red sandstone occurs near Terra Cotta and Credit Forks.

Red Medina Sandstone known as Credit Valley Sandstone, is the principal stone in Casa Loma and the main Parliament Buildings in the centre of Queen's Park, Toronto. Grey Medina Sandstone from the Georgetown area was used in the Royal Ontario Museum, Hart House, Knox College and Trinity College in Toronto. It was also used in the buildings of the University of Western Ontario in London.

The two active quarries, the Rice and McHarg, and the neighbouring Cohoon, near Limehouse, are important sources of flagstone and ashlar now much in demand for residential and commercial use.

They are small inconspicuous operations, employing perhaps a dozen quarrymen in total, and they contribute minimal noise, dust, and truck traffic. Workings are shallow and not extensive; environmental disturbance is restricted to small working areas and reclamation is simple and effective. Their operations should be protected and encouraged.

According to Hewitt (1964, p.38) the Medina Sandstone has also been quarried elsewhere along the base of the Escarpment from Niagara to Georgian Bay, specifically at Merritton, Rockway, Jordan, Grimsby, Hamilton, Waterdown, Milton, Orangeville and Duntroon.

As to further reserves of this important building stone, Parks (1912, p. 139) says: "The formation occurs along the face of the Niagara cuesta from near Merritton to Hamilton. Between Hamilton and Milton the cuesta is much broken up and the exposures are few, but from the latter place northward to Cataract, outcrops are numerous. Above Cataract, the stone is hidden very largely but an important outcrop is known east of Orangeville and again near Shelburne. At no place is the exposure wide, as it appears only along the face of the "mountain" and has scarcely any lateral extent. The widest and most accessible places occur where the sandstone forms the top of a shoulder, on the mountain side. Much of the quarrying has been done by removing a heavy overburden or by actually mining into the side of the hill. Unfortunately, those places where the stone is most easily obtained yield a poorer product than where it is less accessible. It may almost be regarded as a rule that the heavier the overburden the better the stone. For instance the widest exposures lie north of Limehouse, but this region has never produced the fine quality of stone obtained under the overlying Niagara rocks at the Forks of the Credit."

The MNR Cambridge office has carried out hammer seismic studies to determine overburden thicknesses in suspected sandstone areas. One area several kilometres east of Speyside in lots 14 and 15, concession IV, Town of Halton Hills, is of interest because the Medina Sandstone is believed to underlie about 2 m of clay till (E. Harvey, personal communication). What isn't known, of course, is the suitability of the stone particularly in terms of its bedding and splitting characteristics. However the area deserves serious consideration as a possible location in which this important industry might be revitalized. Similar stone is available nowhere else in the province except in the Escarpment itself.

Rice and McHarg Quarry

The Rice and McHarg sandstone quarry is located on lot 21, concession V, in the former Township of Esquesing, now the Town of Halton Hills. It is about 1 km south of Limehouse.

The quarry covers an area about 150 m by 200 m. The working face consists of flat-lying grey and buff sandstone in beds 5 cm to 15 cm thick. A useable section 1m to 2 m thick is overlain in places by 2 m of shale and 2 m of clay overburden; elsewhere the shale is absent. The south face exposes an interesting transition from a single massive sandstone bed 2 m thick at the east end to a thin bedded unit at the west end. However, the massive portion is finely streaked with grey-black laminations which impart a satisfactory "reed" to facilitate splitting into thin slabs. Reed is a term used by quarrymen to denote splitability. Absence or poor development of reed is a constant problem in the Medina Sandstone, since it is a characteristic that varies locally and over short distances.

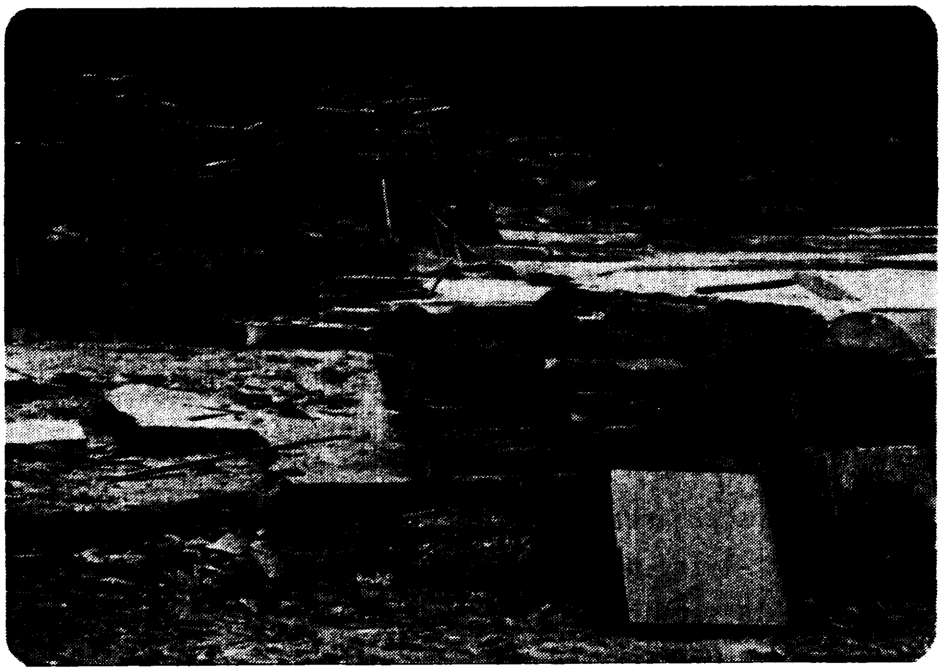


PHOTO 1 : MEDINA SANDSTONE, RICE AND McHARG QUARRIES

Quarrying is mostly carried out with pry bars, wedges and sledge hammers, and a minimum amount of light blasting. The operation employs 6 to 8 men and can produce as much as 100 tonnes per day. Value of the stone in 1981 varied from about $33 per tonne for random ashlar to $66 for patio stone; higher prices for dressed slabs and copings.

This operation has always been one of the largest sandstone producers in the area in spite of occupying only 3.4 hectares of licensed land. Recent licence approval to a small adjoining area will extend the life of this valuable resource. The operation is not conspicuously located, does not generate much noise, dust, truck traffic, or other environmental disturbance, and should be protected and encouraged. However, the operator could afford to take example from the neighbouring Century(Cohoon) Quarries in respect to site reclamation.

Cohoon Quarry

The Cohoon Quarry is operated by Century Quarries Limited on about 2 hectares of licensed land on lot 22, concession V, in the Town of Halton Hills, just north of Rice and McHarg. The operation is similar, producing mainly ashlar and flagstone. Clay till overburden to 4 m is usual. The entrance to the site is attractively landscaped with ponds, grassy knolls and sandstone retaining walls. This operation should also be encouraged for the same reasons previously cited.

Smithson Quarry

The Smithson Quarry is located on the east half of lot 26, concession VIII, Town of Halton Hills, about 5 km north of Limehouse. Although the licensed area is fairly large the reserves of suitable sandstone are almost exhausted, and the operator presently has to remove at least 2 m of cobbly clay overburden and 1 m of shale to expose his 1.5 m working ledge. The sandstone is medium bedded and grey in colour.

Inglewood Quarry

The Inglewood Quarry located on the west half of lot 19, concession V, Town of Halton Hills, is only occasionally worked now for coursing stone and as a source of silica for rock wool. In 1981 W.R. Barnes Limited held a license to 40 hectares. About 3 m of clay till covers the 1 m of useable sandstone.

Norrie Quarries

Two sandstone quarries were licensed in 1979 to Hazel M. Norrie. The larger one comprises 40 hectares and is the east half of lot 30, concession VI, Town of Caledon. This is a one man operation, producing patio stones, fireplace stone, and stone mantels. An older quarry comprising slightly more that 1 hectare is located on the east half of lot 1, concession III,Town of Caledon, but is no longer operating.

Deforest Brothers

A small family operation was still licensed (in 1979) to Deforest Brothers Quarries Limited on the east half of lot 4 and 5, concession 3 WHS, Town of Caledon. Shaly limestone 2 m to 3 m thick had to be removed to expose a 2.5 m section of medium and thin-bedded grey and red Medina Sandstone (Hewitt 1964d,p.38).

ORISKANY SANDSTONE

The only outcrop of Oriskany Sandstone in Ontario is restricted to a small area in the Town of Haldimand, 6 km west of Cayuga (Fig. 19). Maximum thickness of the sandstone is 6 m. It is a buff-coloured, more or less friable stone (depending on its content of dolomitic cement), and is thin to thick bedded. According to Hewitt (1964 d, p. 43) three small quarries were opened in lots 47, 48 and 49 respectively, all in concession I in the former Oneida Township. Parks (1912, p. 168) shows six more across the road in North Cayuga Township.

The variability of the stone both in composition and bedding thickness, and its friability, does not recommend its use for building stone. Parks (1912, p.167) mentions the unsightly occurrence of rusty staining on some of the sandstone blocks, but he finds the better blocks to be durable. However, it may have potential as a source of silica (see "Silica" in this report). The area is environmentally sensitive, although two licensed crushed stone quarries are operating in the underlying Bertie-Akron Dolomite from which the sandstone must necessarily be stripped.

SPRINGVALE SANDSTONE

Both Hewitt (1964 a, p.3) and Parks (1912, p. 167-8) refer to the early Winger Quarry at Springvale west of Hagersville. According to Parks the Springvale Sandstone (incorrectly called Oriskany) is either too soft or too hard and is often badly iron-stained. It is not considered a resource of any value for building stone.

GULL RIVER LIMESTONE

Longford Mills

One of the most important limestones for building purposes was extensively quarried at Longford Mills, Rama Township, Simcoe County, from 1883 to 1933. Main production was a white-weathering, high-calcium, lithographic, thick-bedded limestone known as "Longford Stone." Latterly an attempt was made to market a lower unit of buff-weathering, thick-bedded, dolomite known as "Rama Stone".

The old quarries extend for 1 km north from Longford Mills along the west shore of Lake St. John. They now form an almost continuous shallow depression 50 m wide with their floors a few metres above lake level. The northernmost quarry, separated from the others by a short unmined wooded interval, is actively being quarried for crushed stone. Quarry faces range in height from 2 m in the south to 6 m at the north end.

The stone taken from the Longford quarries belongs to the Gull River Formation of the Simcoe Group of Ordovician age. The buff "Rama Stone" dolomite is part of the lower member of the Gull River Formation; the white "Longford Stone" is part of the middle member. A thin capping of limestone of the Bobcaygeon Formation forms the top of the quarry section.

Hewitt (1960 p. 37-40) gives a detailed description of the quarry face; it is reproduced with modification on an accompanying page. Goudge (1938 p.141) gives analyses for individual beds of the Rama Stone unit. A composite of these analyses is reproduced below, along with an analysis of the 2 m interval of limestone just above the Rama Stone, and the overlying 6 m of high-calcium limestone that includes the Longford Stone unit and the Bobcaygeon caprock.

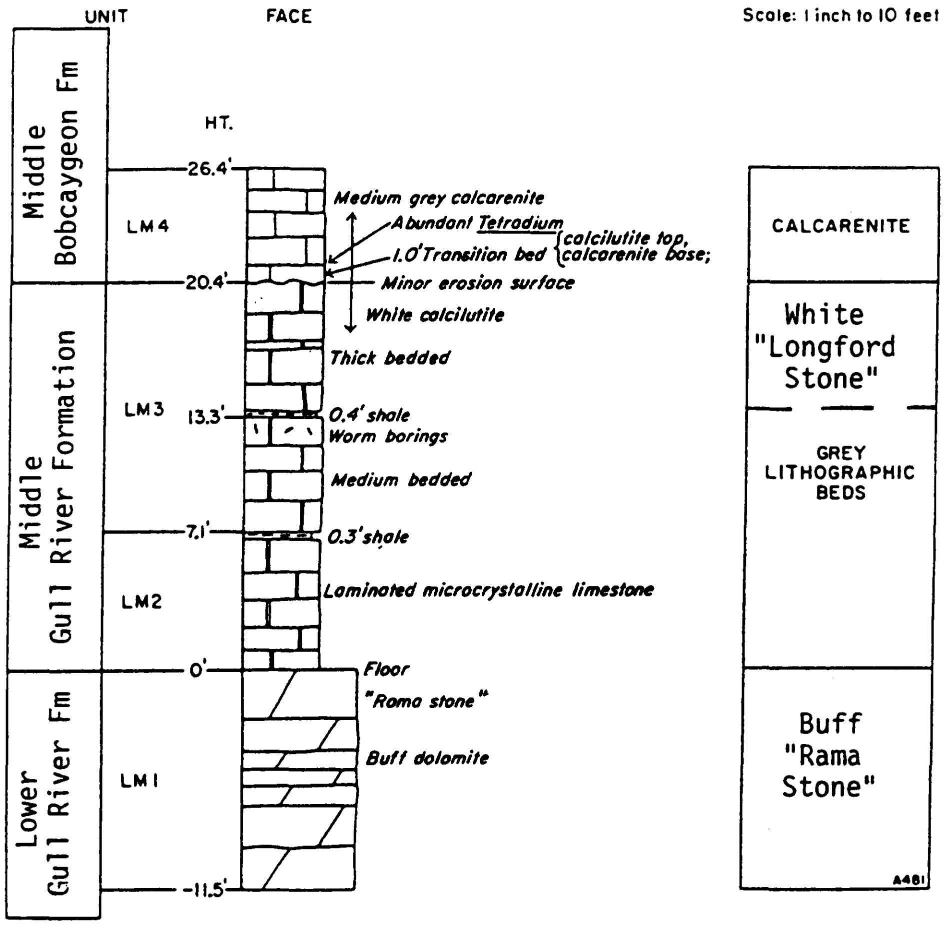
TABLE 3- CHEMICAL ANALYSES - LONGFORD QUARRY

	Unit LM1 Rama Stone	Unit LM2	Units LM3 & LM4 Includes Longford Stone
$CaCO_3$	60.14	92.19	96.64
$MgCO_3$	31.86	2.44	0.32
SiO_2	4.13	2.62	1.42
Al_2O_3	1.52	0.30	0.96
Fe_2O_3	1.13	1.03	0.40
S	0.08	0.06	0.04
Total	98.86	98.64	99.78

Goudge (1938 p. 135) describes the quarrying of the white Longford Stone as follows, and mentions its use also for making lime, crushed stone and for flux.

> "The dense-textured Black River limestone composing the upper part of the bluff along the west side of lake St. John, just north of Longford, was formerly quarried on a large scale for building stone, and was shipped

FIGURE 2 : 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

Modified from Hewitt 1960, p.39

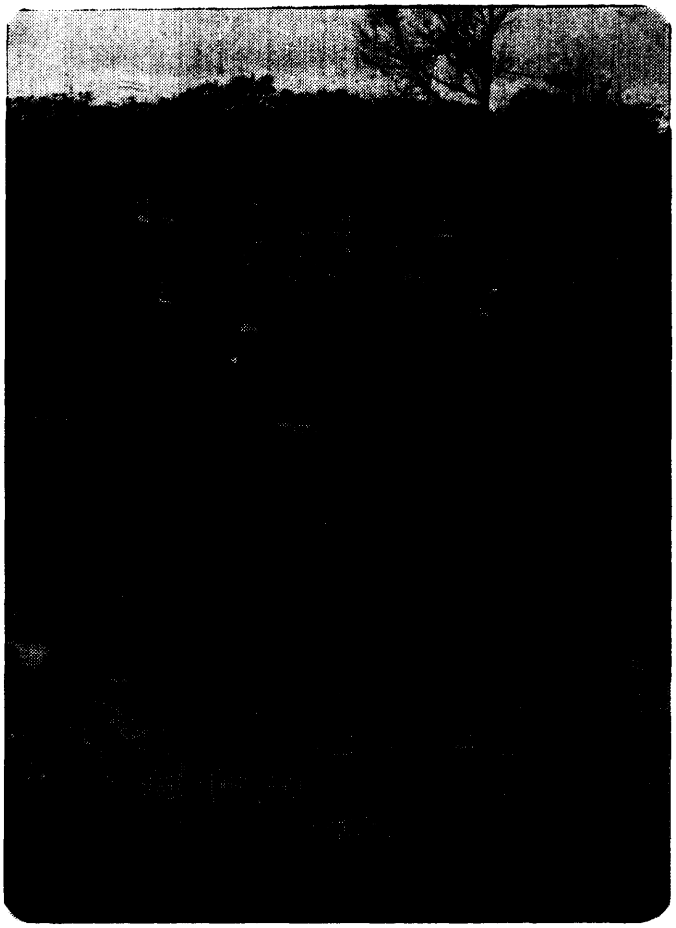
> as far afield as Toronto, Hamilton, North Bay, and Sudbury, as well as to the neighbouring cities and towns; it was also quarried for flux, crushed stone, and for making lime...... [It] is available beneath very little overburden in a 30-foot escarpment bordering the entire west shore of lake St. John, and is well exposed in the old quarries that have been opened along the shore of the lake for more than one-half mile north of Longford; it is also seen on the east shore of lake Couchiching.... The first quarry in this district was opened in 1883 on the shore of lake Couchiching at a place opposite the quarry of Longford Quarries, Ltd., and stone was shipped by scow to various points on lake Couchiching and lake Simcoe."

The old quarry on Lake Couchiching is at the foot of Quarry Road and is now overtaken by cottage development.

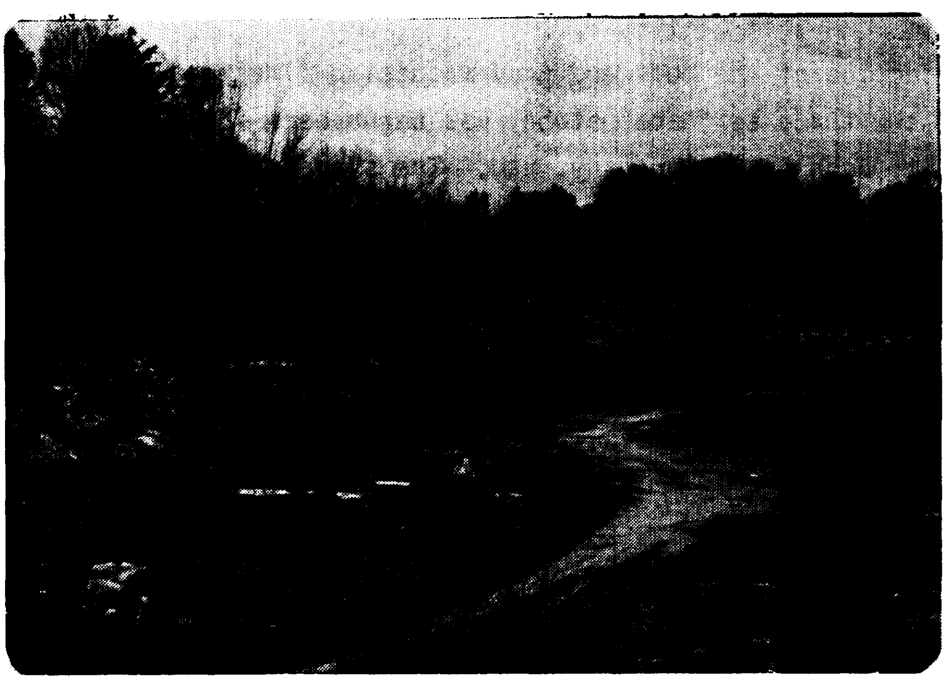
The production of Rama Stone appears to have lasted only a few years in spite of favourable reference to it by Goudge (1938, p.135):

> "The production of the buff and grey magnesian limestone, known to the trade as "Rama" stone, was begun here in 1933 by Lake St. John Quarry Company, Ltd. The stone takes a good polish and is marketed for use as marble, as well as for exterior building stone. Because of its even texture and pleasing colour the buff bed has been used for sculpture."

A stockpile of quarried blocks has been abandoned (see accompanying photograghs). Liberty (1969, p. 96) says:



PHOTOS 2 & 3 : QUARRIED BLOCKS OF BUFF RAMA STONE BENEATH A SECTION OF WHITE LONGFORD STONE.



> "The uniformity of texture and ease with which it was worked were offset by its tendency to weather yellow, which proved an undesirable characteristic for users of this stone."

Concerning Longford Stone, Liberty (1969, p.96) says:

> "This stone has fallen into disfavour as a commercial stone owing mainly to the difficulty with which it was worked (too hard and too brittle). In addition, its texture is not uniform because of irregular distribution of 'calcite eyes' (particles of crystalline calcite) in it."

Nevertheless, the beauty and durability still obvious in buildings constructed of this white-weathering Longford Stone leads to the conclusion that it is an important resource that should be commercially re-examined. The stone is flat-lying in even beds of various thicknesses, and the bedding planes are smooth and open. Overburden of less than 1 m, and high-calcium Bobcaygeon Limestone of 1.5 m, is all that covers the 2 m Longford Stone section. Moreover, the vicinity of the old Longford quarries is completely undeveloped and is not environmentally sensitive. Virtually unlimited reserves extend west to Lake Couchiching beneath the flat limestone plain.

Renewed production of building stone at Longford Mills could undoubtedly market its waste rock as a high-quality crushed stone aggregate. Purity of the stone might also recommend its reconsideration for flux stone and for making lime.

The CNR track from Orillia to Washago lies less than 200 m west of the old quarries.

GRANITE

Belmont

A small quarry was opened during the 1960's on the crest of a bare rock ridge in lot 31, concession X, Belmont Township. Known commercially as "Belmont Rose" the stone is a pink medium grained biotite granite with accessory zircon, sphene and apatite. Three vertical diamond drillholes proved the continuation of the granite to a depth of 21 m, where it was intersected by a horizontal diabase sill 3 m thick. The granite is uniform and massive with few joints or mafic streaks. More than 500 cubic metres of stone have been quarried in large mill blocks (see photo). In 1982 quarrying was renewed by Fairmont Granite Ltd.

Granite masses reasonably free of jointing are not common, and this deposit is considered a valuable building stone resource. Its operation imposes little environmental disturbance. The CPR spur line from Havelock to Nephton is nearby.

Stoney Lake

Two small granite quarries were worked from 1940 to 1942 at the east end of Stoney Lake in lot 32, concession XIII, Dummer Township, Peterborough County. The stone is a pink coarse grained porphyritic biotite granite with phenocrysts of microcline to 1 cm in size. According to Hewitt (1964 e p. 23) a well-developed horizontal sheeting allowed the removal of mill blocks to 1 m thick.

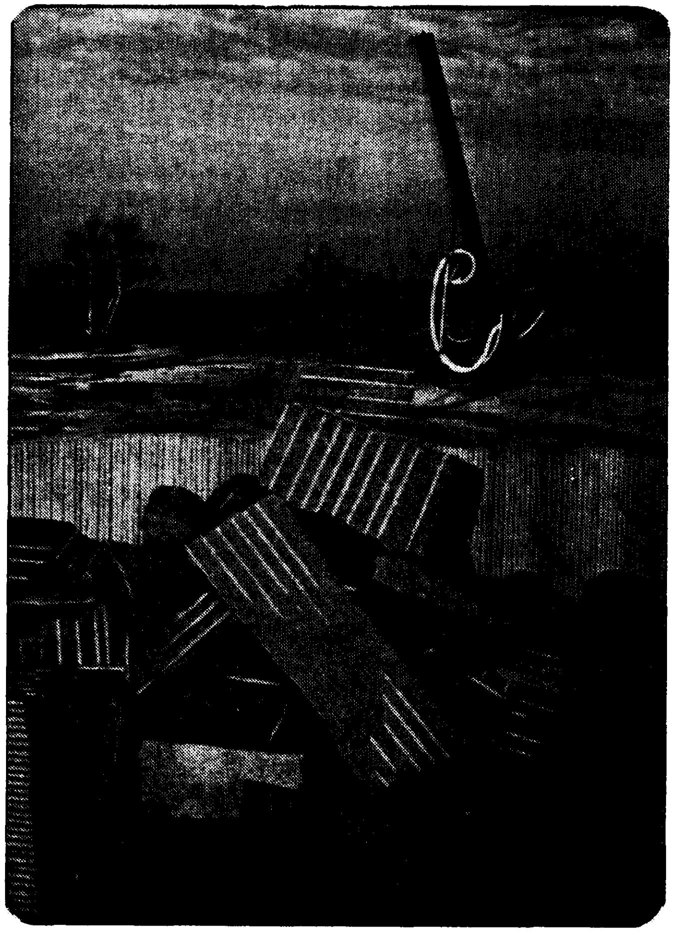


PHOTO 4 : BELMONT ROSE GRANITE

PHOTO 5 : RAMA GRANITE SLABS

Granite was also quarried at one time on Quarry Island near the mouth of Eels Creek in Stoney Lake.

Neither of these locations offer much prospect for further development.

Rama

Small scale quarrying of irregular granite slabs, about 10 cm thick and up to 0.5 m in diameter, was initiated in the early 1970's on the east side of Simcoe Road 21 just north of the community of Floral Park. The stone is a medium grained red hornblende granite locally streaked with biotite schist and with occasional pegmatitic patches. It finds particular acceptance in decorative walls and fireplaces. Quarrying includes drilling, light blasting, prying and hand sorting, and the product is palletized and bound with wire for shipment. Workings are shallow and scattered over a small area.

While this is a small operation it is conducted in a careful and considerate manner and should be encouraged. The workings are not visible from the road, and at the present scale of activity should not cause any disturbance for the nearby cottage community. It is the nearest occurrence of granite to Metro Toronto, and has been found suitable in certain road surfacing uses in place of traprock.

A partial chemical analysis of the stone gave the following result (D.G. Minnes, personal communication):

TABLE 4 - CHEMICAL ANALYSIS - RAMA GRANITE

	Percent
Al_2O_3	8.44
K_2O	6.63
Na_2O	1.07
Fe_2O_3	4.81

CEMENT

There are two cement plants operating within the Central Region:- St. Lawrence Cement Company in Mississauga and St. Marys Cement Limited in Bowmanville. Because of their proximity to the Toronto market, which has retained a moderately strong level of commercial construction, these plants are operating at more profitable levels than average for the province. Their locations on the lakeshore give them the opportunity also to serve certain U.S. markets accessible to lake shipping. In 1980 they shipped a combined total of 1,702,515 tonnes valued at $76,115,175, which represented about 75 percent of their total capacity (Weatherson 1982 p. 44-45).

Raw materials for cement-making are readily available in the Central Region. However, the industry is well located for the market and adequately able to meet any reasonable market demands. Cement-making is not considered an area that requires government stimulation to reach its optimum working level.

St. Lawrence Cement Company

The Mississauga plant of St. Lawrence Cement Company is the largest cement plant in Canada. It presently (1982) has a capacity of 1,680,000 tonnes of cement klinker annually. In 1980 it shipped 1,111,060 tonnes valued at $52,969,959 (Weatherson 1982, p.45).

The plant was built in 1957, and uses both a wet and dry process; there are two wet kilns and one dry kiln and preheater. Either coal or bunker oil can be used, and the company has been innovative in its attempt to develop less costly fuel alternatives. Waste motor oils collected from service station sumps, and chlorinated hydrocarbons (such as PCBs), have been used successfully both as supplementary fuels and as a means of safe disposal for otherwise unwanted or dangerous liquids.

Raw materials for cement-making include limestone of the Lindsay Formation received by boat from the Company's quarry at Ogden Point on the shore of Lake Ontario just east of the Region. Shale from the Georgian Bay Formation is obtained from a quarry adjacent to the Mississauga plant. Gypsum is trucked from mines in the Caledonia area, and iron oxide from Hamilton steel plants.

Finished cement is sold mainly within the Region, and large quantities of klinker is exported to the United States.

St. Marys Cement Limited

St. Marys Cement operates two plants in Ontario, one at St.Marys constructed in 1912, and the Bowmanville plant which was opened in 1968. The Bowmanville plant has a klinker capacity of 635,000 tonnes per year. In 1980 it shipped 591,455 tonnes valued at $23,145,216. (Weatherson 1982, p.44).

The Bowmanville plant is a wet process using two coal-fired kilns. Limestone of the Lindsay Formation is quarried adjacent to the plant site on the southwest outskirts of Bowmanville between the lakeshore and Highway 401 and the CNR. Glacial till and stratified silts 6 to 12 m thick overlie the bedrock which here includes about 5 m of dark brown Collingwood Shale above the limestone. Clay from the overburden is blended as necessary with the limestone, and gypsum is obtained from Nova Scotia. Anhydrite from Little Narrows, Cape Breton Island, is often used instead of gypsum.

About half of the plant's production is shipped as finished cement by truck, principally to destinations within the Central Region. Substantial amounts of klinker are shipped by boat from the Company's own wharf to its subsidiary in Michigan, Wyandotte Cement Company. The Wyandotte facility is now only used as a grinding plant and distribution centre for St. Marys cement. Spot markets are also available to boat shipping on the Great Lakes, the Hudson Valley, and the Eastern Seaboard. Rail facilities are also available, and rail shipments have been made to the Canadian Prairies and the U.S. West.

While the Bowmanville quarry has only been worked to a depth of 45 m, a total thickness of 180 m of Simcoe Group limestones are available on the site, most of which is suitable for cement-making. Reserves are ample for many years.

The quarry has been worked in two 16m benches, but recently a third bench has been developed. The middle level is of purer composition, requiring blending with 2 to 5 percent of overlying shale or clay to supply the necessary silica, alumina and iron. Rather than being a detriment therefore, these overlying materials play an important role in the cement-making process.

CLAY

The clays of the Central Ontario region offer the greatest variety to be found in Ontario. Their potential as a resource was discussed by Vos (1975). However, their utilization has generally been in decline since the 1920's and the pressures of urbanization have all but eliminated the best of them from future availability.

Pre-Wisconsinan interglacial clays unique to the Toronto area were known as the Scarborough and Don Beds. Clay of the Scarborough beds was prized in earlier years for the rich maroon-coloured soft-mud bricks which it produced. It was formerly used by six plants on Greenwood Avenue (Keele 1924, p. 106) in east central Toronto. The last one closed in 1962 (Guillet 1967, p.193-197).

The interglacial deposits of the Toronto region were deposited about 100,000 years ago, prior to the last (Wisconsinan) glacial stage. In distribution they appear to be restricted to an area within about 8 km of the Lake Ontario Shore, extending between the Humber River on the west and Highland Creek on the east. A thick cover of overburden, consisting of Wisconsinan till and varved clay, and Lake Iroquois sand, has restricted exposures to deeply-cut river banks, Scarborough Bluffs, and subway excavations.

The lowest unit known as the Don Beds, is a fossil-bearing sequence of stratified sand, clay, and fine gravel, that was deposited in a lake 18 m higher than Lake Ontario at a time when the climate was about 3°C warmer than the present (Terasmae 1960, p.39). The upper unit, known as the Scarborough Beds, is a fossiliferous sequence of stratified clay, silt, and sand that was deposited in a lake 60 m higher than Lake Ontario when the climate was about 6° cooler than the present.

In the Hamilton area an unusually good quality clay was deposited in shallow lagoons separated from Lake Iroquois by bars of sand and gravel at the mouth of the Dundas valley. These clays were restricted in origin to the nearby eroding terraces of Queenston Shale, and were particularly valuable in the manufacture of sewer pipe, structural tile, and flower pots. The deposits were shallow and of limited extent, one extending into west Hamilton, the other east past Aldershot. The Hamilton deposit has long since been exhausted or rendered unavailable by urbanization. The Aldershot clay was effectively eliminated by the opening of Highway 403.

Clays have several unusual properties that have encouraged their use since early times in the making of bricks and tiles. These are the properties of plasticity and vitrification. However, shales generally enjoy the same properties when they have been finely ground and,because the composition and uniformity of certain Ontario shales is preferable, they have all but eliminated the use of surface clays.

Vitrification is the condition of partial fusion that takes place when a clay or shale is heated in a kiln to a high temperature, resulting in greater density and hardness, and reduced porosity. All clays and shales in Ontario are comprised of varying proportions of clay minerals and non-clay "rock flour." Hence the glacial varved clays and other surficial clays of the Central Region reflect a predominantly limestone bedrock in their compositions.

Clays in which the content of iron exceeds that of lime achieve a greater degree of vitrification and a red-fired colour due to oxidation of the iron. However, limy clays may fail to vitrify at all, but rather tend to expand and become less dense and more porous, and assume a yellow or buff-fired colour and a soft chalky texture. It is for this reason that surficial clays are rarely used in the Central Region where better quality shales are available. To a minor extent such limy clays may be blended with shales for special brick applications, or the top 1 m or so of a clay bed which has been partially leached of its lime may be used for making drainage tiles where an open porous texture may not be undesirable.

For the same reason the clays of the Central Region show little value for the production of expanded aggregate (Wilson 1963); limy clays tend to become sticky and soft at the temperature at which bloating takes place.

Further information on the chemical, mineralogical and ceramic properties of Ontario clays is given by Guillet (1967 and 1977).

N. S. Bauman Limited

The tile plant of N.S. Bauman Limited is located near Wallenstein, 6 km west of Elmira, in lot 20, concession XIV, Wellesley Township, in the Regional Municipality of Waterloo. Surface clay is obtained from two shallow deposits in Wellesley Township:- in lot 7, concession XIII, West Section, and in lots 20 and 21, concession XIV, East Section. The plant is described by Guillet (1967, p.123-126).

GOLD AND SILVER

Two gold mines, one of significant economic interest, have been worked in the Central Region, both in Belmont Township. The Ledyard and Cordova mines are adjacent and geologicaly related. Both were opened in the 1890's and the Cordova produced intermittently until 1940. The Cordova mine is presently the object of gold leaching studies by Laisir Gold Inc.

Cordova Mine

The Cordova Mine is located in the east half of lot 20, concession I, Belmont Township. The deposit was discovered in 1890 and was ultimately developed by three shafts giving access to fifteen working levels to a maximum depth of 343 m. Production was recorded for the years 1892 - 1893, 1898-1903, 1912-1915, 1917, and 1939-1940. A total of 109,448 tonnes were milled from which 22,774 ounces (645.6 kg) of gold and 687 ounces (19.5 kg) of silver were recovered. Average grade of the milled ore was 0.19 ounces (5.4 grams) gold per ton (0.907 tonnes) (Gordon, J.B. *et al*, 1979, p.38).

Gold mineralization occurs in shear zones averaging 2 m in width near the western margin of a mafic intrusive. The carbonate-feldspar-quartz veins contain as much as 50 percent pyrite with which the gold is associated; native gold has not been reported.

Ledyard Mine

The Ledyard Mine is located immediately south of the Cordova, on the east half of lot 19, concession I, Belmont Township. Gold was found in a 2 m quartz vein cutting the same mafic intrusive. The vein was developed by a shallow (30 m) shaft and a small amount of drifting and crosscutting. About 13 ounces (368 grams) of gold were recovered from 50 tonnes of ore milled during the years 1893-1894 (Gordon, J.B. *et al*, 1979, p. 38).

Laisir Gold Incorporated

In 1979 Laisir Gold Inc. began research studies into the possibility of recovering gold from the Cordova Mine by a cyanide leaching process. Testwork has been carried out on mine tailings as well as unmined gold ore. To date several hundred tonnes of tailings have been leached and gold has been recovered. The process, when perfected, could have significant application throughout Canada, especially where gold values are otherwise too low for conventional treatment.

Preliminary testwork was carried out by the Ontario Research Foundation, and a process was developed involving cyanide leaching, extraction of the gold from solution by activated charcoal, and recovery of the gold in an electrolytic cell. Stripping of gold from the charcoal, and its recovery in the electrolytic cell, has not been as effective as the laboratory tests had indicated, and tests are now underway on a zinc precipitation method instead.

Some 20,000 tonnes of development ore averaging 0.06 ounces of gold per tone (1.9 grams per tonne) are available on surface, and 180,000 tonnes of ore averaging 0.18 ounces of gold per ton (5.7 grams per tonne) remain underground, some of which has been broken but not removed. The company plans to dewater the old workings and recover the remaining ore for treatment in a leaching facility on surface.

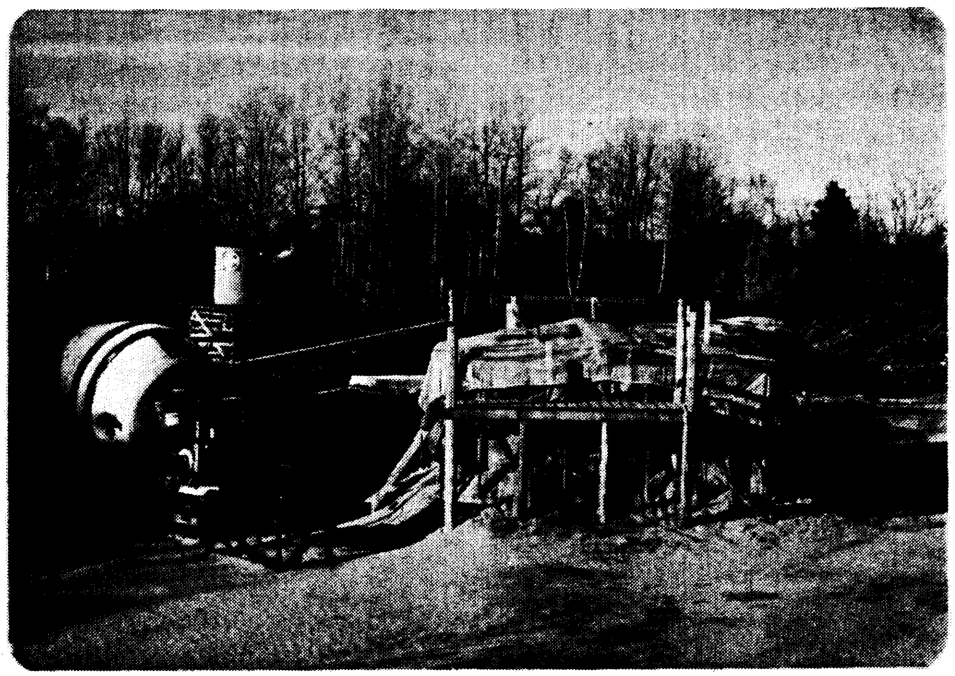


PHOTO 6 : GOLD LEACHING PROJECT, CORDOVA MINE

The company has gone to considerable effort to meet the requirements of the Ministry of the Environment, and its operations are being constantly monitored. If the project proves to be economically viable it could have very important implications in other Canadian gold areas. While these implications are not great within the Central Region itself, the company should be given whatever encouragement is available.

GYPSUM

INTRODUCTION

Gypsum is a soft, light-coloured, mineral that has formed by precipitation from concentrated sea waters in lagoons and embayments along former ocean margins. In its pure form gypsum is white, but it may be grey, light brown, or pink due to impurities. It is commonly interlayered with thin laminae or beds of dolomite and shale.

Gypsum is the hydrous form of calcium sulphate, and has the chemical formula $CaSO_4.2H_2O$. The two molecules of water in its crystal structure are largely responsible for its commercial value. Three-quarters of this water can be driven off by heating at a low temperature. The $CaSO_4.\frac{1}{2}H_2O$ that remains is known as plaster of paris; when re-mixed with water it quickly sets to a hard rock-like mass. Anhydrite, $CaSO_4$, with which gypsum is frequently associated, has little commercial value and can only be tolerated in small amounts in gypsum feed to the plaster plant.

Gypsum plaster is largely consumed by the building industry in the form of plaster, lath, or wallboard in home construction. Wallboard is its major use today, and Ontario's three gypsum mines have their own wallboard plants. Raw gypsum is also added to Portland cement to control its setting time. As these are its two principal markets, the health of the construction industry determines the health of the gypsum industry.

Raw ground gypsum known as land plaster used to be an important fertilizer and soil conditioner, but it is rarely so used today.

Gypsum is widespread in the Salina Formation of Silurian age in the Central Region. The Salina Formation outcrops in a narrow belt parallel to and west of the Niagara escarpment, where it forms part of a southwesterly-dipping monocline of Paleozoic rocks. In the vicinity of its outcrop the formation is about 100 m thick. Gypsum occurs in a number of thin lenticular beds interbedded with dolomite and dolomitic shale.

Gypsum is mined underground by room-and pillar methods. Canadian Gypsum Company Limited mines a 1 m bed at a depth of 20 to 40 m near Hagersville. At Caledonia, 13 km north of Hagersville, Domtar Construction Materials Limited mines a 2.4 m bed at a depth of 25 m. Both companies have calcining and wallboard-fabricating plants at the mine sites. In 1963 Western Gypsum Products Limited opened a plaster and wallboard plant in Mississauga, using gypsum from the other two gypsum companies and from the Maritimes. In 1978 Westroc Industries Limited commenced production from a new mine at Drumbo to serve the Mississauga plant.

The gypsum wallboard industry is well developed in Ontario, and the mines on which the industry depends have ample gypsum reserves. Because the mining of gypsum is carried on underground there is minimal environmental disturbance. The three producing companies are well able to monitor and adjust to normal economic demands, and in the foreseeable future there does not appear to be any opportunity for, or reason to encourage, further development of gypsum resources.

GYPSUM RESOURCES

In 1981-2 gypsum consumption was well below the productive capabilities of Ontario's three mines. Even under more normal economic conditions it is probable that these mines could meet all likely demands. In any event, from a geological viewpoint there is ample reason to believe that further gypsum resources are not scarce in the western part of the Central Region.

A study of drill cuttings from oil and gas exploration wells is a useful preliminary step in searching for gypsum. A library of such well cuttings is maintained in the Southwestern Ontario regional geologist's office in London. Distribution of gypsum seams as derived from an examination of these cuttings is outlined on the following pages. The study indicates that a sequence of four to six gypsum or anhydrite beds are present in the Salina geological column.

In addition to the notes that follow, L.H. Cole (1913, pp.59-62) gives some information on the occurrence and distribution of gypsum beds in Brant County and the Regional Municipality of Haldimand-Norfolk based on drilling during or before 1911. W.S. Dyer (1925, pp. 45-48) also gives an account of gypsum occurrences, principally for the Brant-Haldimand area.

Regional Municipality of Niagara

The Salina Formation is the bedrock for much of the southern part of Niagara Region. An examination of oil and gas-well cuttings in the City of Port Colborne, the Town of Fort Erie and Wainfleet township indicates some concentration of gypsum at depths of 35-45 m and 70 - 80 m.

Regional Municipality of Haldimand - Norfolk

The Salina Formation is bedrock for the Town of Haldimand. Most of the gypsum produced in Ontario has come from the former townships of Seneca, Oneida, and North Cayuga which with South Cayuga make up the new Town of Haldimand.

Although small concentrations of gypsum fragments were present in the cuttings from most of the borings made between Caledonia and Hagersville, gypsum was not present in the amounts that might have been expected considering the mining activity in the area. Three main gypsum horizons were noted: - the first at a depth of 18 m in the northwest part of the former Oneida Township, deepening to 30 m in the southwest; the second ranging in depth from 40 m in the northwest to 55m in the south; the third at a depth of 52-61 m.

Gypsum was not common in drillhole cuttings from the eastern part of the Town of Haldimand. Only one horizon of significant gypsum concentration was noted. In the former Seneca Township and near the north boundary of the former North Cayuga Township a small concentration of gypsum was noted at depths varying from 18 to 33 m. Further south it is 50-55 m deep, and near the lake Erie shore it varies from 58 to 70 m deep. Significant amounts of gypsum are scarce in drillhole cuttings in the Town of Dunnville.

Brant County

Drilling information is scarce for nearly all of Brant county. Much of the drilling along the Grand River in Onondaga and Tuscarora townships is old, and the cuttings have not been saved. During the early years of gypsum mining in Ontario a number of small mines were opened in outcropping gypsum seams in the banks of the Grand River. These are described in a later section.

The Salina Formation is the bedrock for most of Brant County. In the southern part of Brantford Township several local concentrations of gypsum are present in the zone between 70 and 84 m. Only a few holes in Onondaga Township showed minor concentrations of gypsum; these are in the zone 35-40 m. Of the several holes available for study from Tuscarora township, one near the Grand River showed some concentration of gypsum at a depth of 25 - 30 m. Near the centre of Tuscarora township gypsum is slightly concentrated between 60 m and 67 m.

Oxford County

Only Blenheim Township lies within the Salina outcrop belt. Well data is largely restricted to the southwest corner, and gypsum is noted at four horizons; at a depth of about 70 m, 82 to 88 m, 90 to 96 m and 100 to 105 m.

Regional Municipality of Waterloo

No significant concentration of gypsum was noted in the few holes available for study; these were principally in the vicinity of Kitchener and in Wilmot Township. However, the Regional Municipality of Waterloo is largely underlain by Salina rocks, and the negative results from the few holes available should not discourage exploration for gypsum particularly in the western half of Waterloo.

Wellington County

The west part of Wellington County is underlain by Salina rocks but there are no test borings available for study. It is likely that thin lenticular beds of gypsum will occur here in the shallow subsurface, as elsewhere.

GYPSUM PRODUCTION

The statistics on annual gypsum production have been continuously recorded since 1878 (Guillet 1964, p.76). In 1981 a total of 688,000 tonnes, valued at $5,353,000 were mined in Ontario by three companies (Weatherson 1982 p.247). Descriptions of their mines and plants follow.

Canadian Gypsum Company Limited

Canadian Gypsum Company Limited has been operating at Hagersville since 1931. The mine and plant are located 5 km north of Hagersville on the west side of Highway 6 in concessions III and IV of the former Township of Oneida, now the Town of Haldimand.

The gypsum bed is about 1 m thick and is located 20 to 40 m below surface. Access is by an inclined ramp about 100 m long on an 18° slope. Mining is by room and pillar methods using trackless loaders and shuttle cars. Drilling is done by electric hydraulic auger drills mounted on rubber - tired carriers. Main haulageways are brushed to a height of 1.5 m. The underground workings now extend over an area 5 by 1.5 km.

The gypsum bed is overlain by 6 to 15 m of dolomite and an equal amount of till. The gypsum is a fine grained white material of relatively high purity; thin shaly or dolomitic laminae comprise less than 10 percent. About 82 percent of the gypsum bed is recovered; the rest remains as pillars to support the roof of the workings.

Mined gypsum is initially crushed underground, and the minus 15 cm discharge is transported to surface by conveyor and distributed by radial stacker to an open stockpile. Feed for the plant is reclaimed as needed by front-end loader, and is further sized by rolls crushers and screens. Dolomite and anhydrite are separated from the lighter-weight gypsum by heavy media beneficiation. Further grinding is accomplished in a Raymond mill or Tube mill prior to calcining

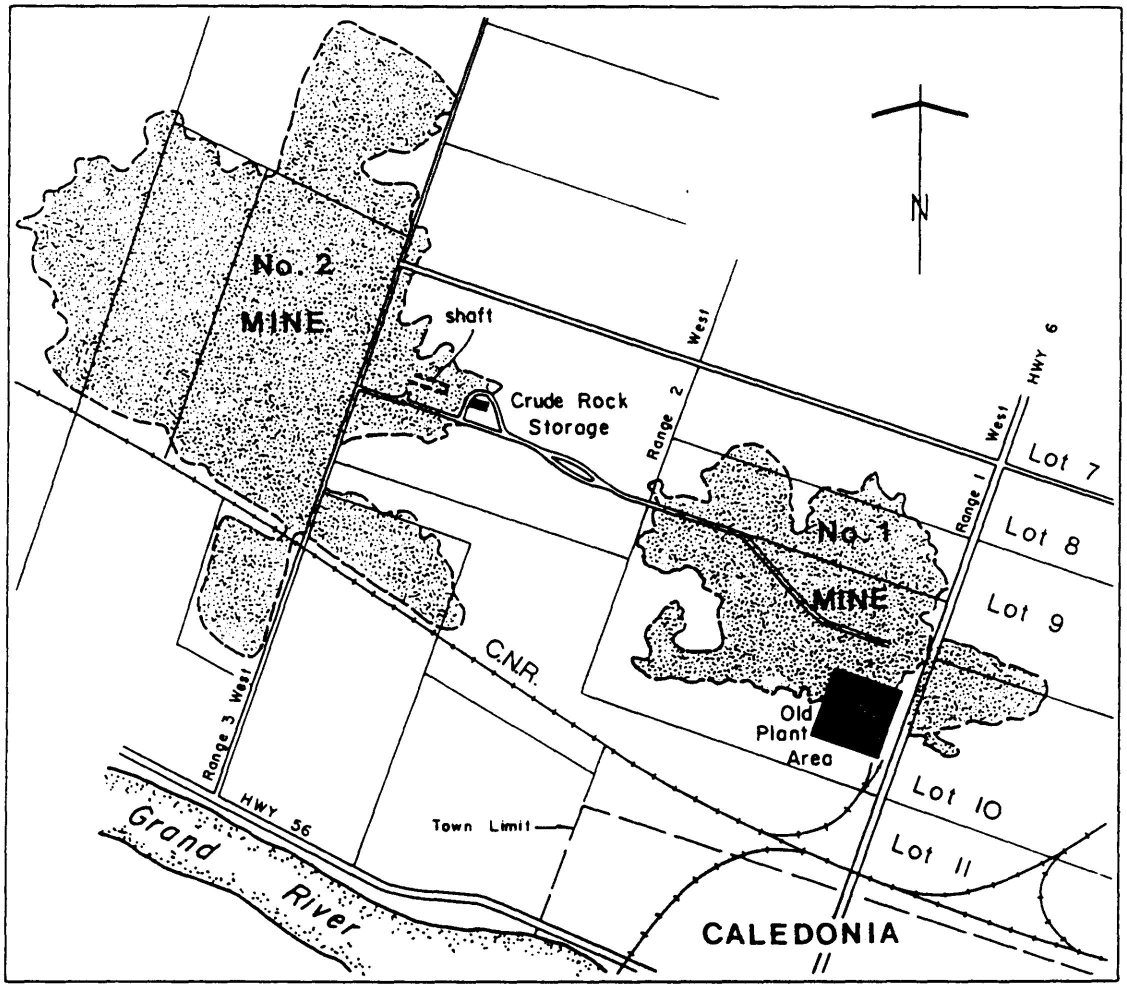


Figure 3

Domtar's Gypsum Mines At Caledonia

Area Mined Out

Scale
0 300 600
metres

in kettles 4.5 m in diameter. There are two wallboard production lines, both of which are highly automated.

About 65 are employed in the mining function and 225 to 260 in the plant.

Domtar Construction Materials Limited

Domtar's gypsum operation is located just north of the Grand River and the village of Caledonia in the Town of Haldimand. The No. 1 Mine at this location was continuously operated from 1905 to 1953, and the No. 2 mine has been operated since 1952. The early history and development of the No. 1 Mine are described by G.E. Cole (1925 p. 12-15).

The No. 2 Mine is serviced by an inclined ramp on a 28 percent grade. The 2.5 m gypsum bed is located at a depth of about 25 m; it is overlain by up to 5 m of dolomite and 20 m of clay. Mining is by trackless room and pillar methods.

The gypsum is fine-grained, massive, and white to pale brown and grey in colour. It is interlayered with brown dolomite and grey or green shale. Gypsum layers range in thickness from thin laminae to nearly pure units of 5 to 10 cm. The thicker and purer units often consist of massive nodular gypsum.

Domtar now has a new and highly automated plaster and wallboard plant compared to the one described by Guillet (1964, p.85). Calcining is accomplished in kettles as before. Domtar is the largest producer of wallboard in Ontario.

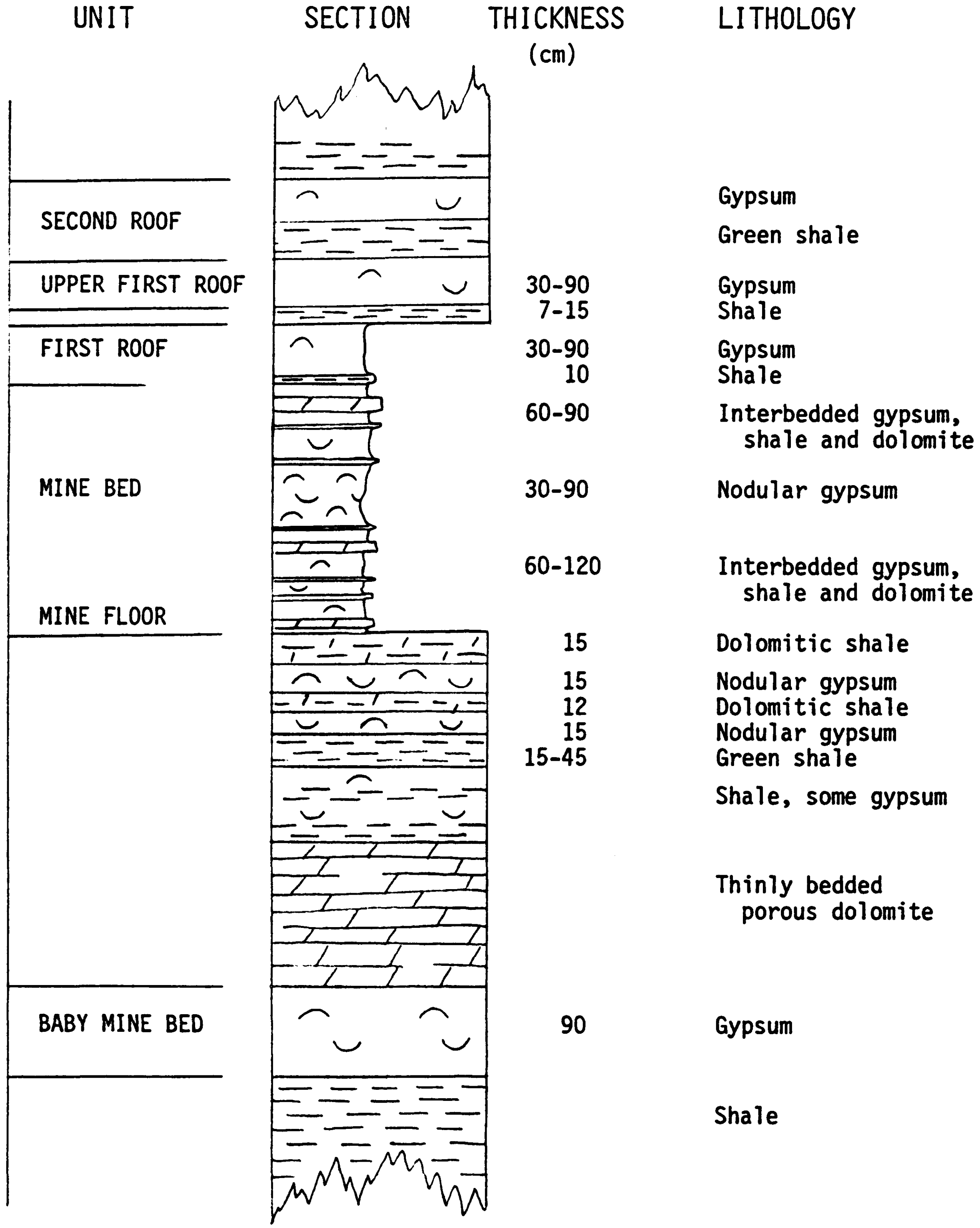


FIGURE 4 - DOMTAR'S GYPSUM SECTION, CALEDONIA NO.2 MINE

Westroc Industries Limited

Widespread exploration drilling by National Gypsum identified a gypsum bed near Drumbo in Blenheim Township, Oxford County, in 1958. Seventy-nine boreholes were subsequently (1960) drilled by Western Gypsum Products Limited, and in 1961 a test shaft 110 cm in diameter was drilled to a depth of 128 m on the west half of lot 21 concession VI.

In 1963 a plaster processing and wallboard plant was constructed on the lakeshore in Mississauga, and gypsum was obtained from the other Ontario producers and Maritime sources. But in December 1978 the first gypsum from the Drumbo Mine was received at the Mississauga plant. The plant is described by Guillet (1964 p.93).

The Drumbo Mine comprises about 70 ha of mining rights. A new production shaft 3.8 m in final inside liner diameter was drilled to a depth of 140 m using a special drilling rig with a 4.5 m bit diameter. Overburden thickness at the shaft site was 50 m. The gypsum bed was intersected at a depth of 116 m near the base of the Salina Formation.

Two gypsum beds are present in the mine area: an upper bed about 1 m thick is separated from the main bed by 1.6 m of dolomite. Only the main bed is mined; it has an average thickness of 1.7 m and a purity of about 88 percent. Mine run average is slightly lower grade but is adequate for wallboard. There is no anhydrite.

Mining is by the room and pillar method using trackless equipment. Rooms are 6 m wide and pillars are 6 m square, for an overall extraction rate of 75 percent. Roof bolting at 1.5 m centres is standard practice.

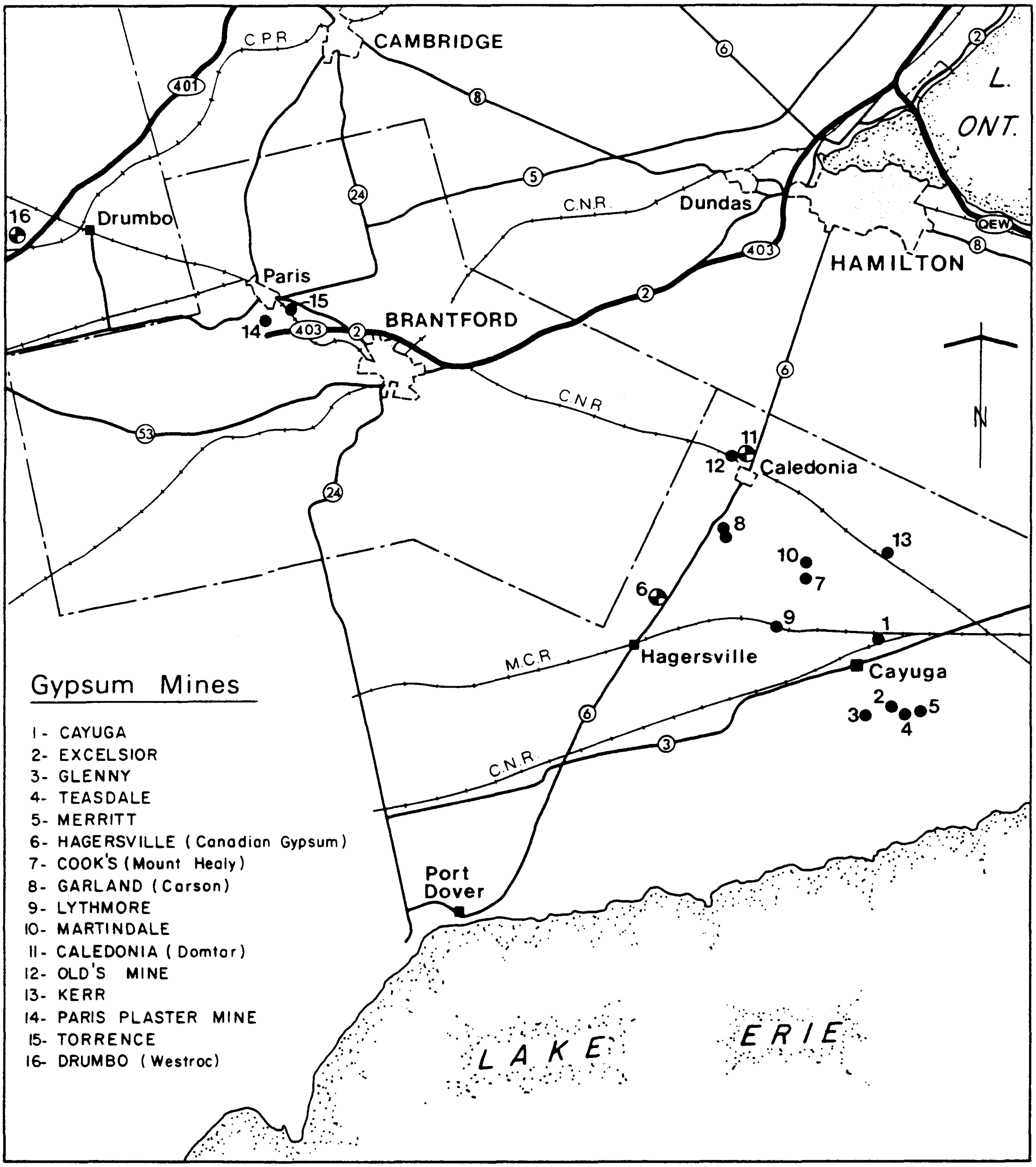


Figure 5

Gypsum Mines Past & Present

Legend

ACTIVE MINE

ABANDONED MINE

Scale

5 0 10

km

Gypsum is transported to a crushing and loading station by conveyor belt where it is reduced to minus 12 cm and hoisted to surface in 5 tonne skip loads. Lump gypsum is stockpiled on surface for trucking to the Mississauga plant, about 100 km distant.

In normal times the mine is operated on a two-shift basis, employing a total of 27 hourly and salaried people. Rated production is 180,000 tonnes per year, but current operating levels are lower because of weak construction markets. Total cost of the mine development was $5.5 million.

Past Producers

The history of gypsum mining in Ontario dates from 1822 when a small gypsum bed was opened in the bank of the Grand River about 1.5 km south of Paris. Fifteen other mines have since been opened, all but three of them in the Town of Haldimand. Most active development of the gypsum occurred in the latter half of the 18th century when many deposits were worked principally for land plaster. Since World War 1 only five mines have been active, three of which are still operating. L.H. Cole (1913, pp. 63-76) traces the history of these mines to 1913, and G.E. Cole (1925, pp. 5-7) summarizes their operations to 1924. Figure 5 shows the locations of the principal mines.

Gypsum was formerly mined by inclined open cuts that followed the beds a short distance underground from their outcrops in the banks of the Grand River. More extensive workings were developed from inclined adits, and the gypsum was mined at shallow depths by room and pillar methods. Track haulage was common, the motive power being supplied by hand or horse.

Cayuga Mine

The Cayuga mine was opened in 1942 and closed in 1949; it was operated by the Cayuga Gypsum Company. A 1 m seam of white gypsum was worked from a vertical shaft located in the northwest corner of lot 25, concession IV, in the former township of North Cayuga. The gypsum seam lies at a depth of 26 m, and is overlain by 9 m of shale and 16 m of clay.

Excelsior Mine

The Excelsior mine was located on the north side of the Grand River in lot 2 of the Jones Tract in the former township of North Cayuga. It was opened by A.W. Thompson in 1875, and was worked successively by Messrs. Gill, Allan, and Brown, the Adamant Manufacturing Company, and the Alabastine Company until 1895. A grinding mill was built on the property in 1875 and a calcining plant in 1891. The 1.2 m bed of white gypsum, at a depth of 15 m, was reached by an inclined tunnel.

Glenny Mine

The Glenny mine, located on the south side of the Grand River in lot 3 of the Jones Tract in the former township of North Cayuga, was opened by Robert Glenny in 1874, but may have been worked on a small scale as early as 1850. It was operated by the Grand River Plaster Company from 1880 to 1892, and was re-opened by the Imperial Plaster Company in 1902. It was purchased by the Toronto Plaster Company in 1911, but appears to have been closed shortly thereafter. A grinding mill was built in 1878, and a calcining plant in 1886. The 1.2 m gypsum bed, located at a depth of 13 m, was reached by a 90 m inclined tunnel.

Teasdale Mine

The Teasdale mine was opened by Thomas Teasdale in 1889, leased to the Alabastine Company in 1890, and closed in 1895. The property was located on the north side of the Grand River, and included lot 1 of the Huffman Tract and lot 4 of the Jones Tract in the former township of North Cayuga. Production from the 1.4 m bed of white gypsum was transported to Paris, Ontario, for calcining.

Merritt Mine

The Merritt mine, located on the north side of the Grand River in lots 2 and 3 of the Huff Tract in the former township of North Cayuga, was opened about 1850. It was operated by the Grand River Plaster Company from 1880 until it was closed in 1893. A grinding mill was built on the property in 1878, and a calcining plant in 1886. A 1.4 m bed of white gypsum was worked from a tunnel driven from the river bank.

Cook's Mine (Mount Healy Mine)

In 1838 a grinding mill was built at York to grind gypsum from Cook's mine which was located on the south side of the Grand River in the Cook Block of the River range in the former township of Oneida. It is uncertain when the mine was first opened, but in 1870 it was re-opened by W. Donaldson and Company and re-named the Mount Healy mine. Originally a quarry operation, it was later taken over by the Crown Gypsum Company and worked from a 150 m inclined tunnel. The 1.2 m bed of white gypsum was located at a depth of 21 m. The mine was closed in 1919.

Garland Mine (Carson Mine)

N. Garland opened two mines on adjoining lots south of Caledonia. The first was opened in 1870 on property originally owned by Joseph Brown, lot 13, concessions V and VI, in the former Oneida township. Ownership was transferred to L.J. Johnson in 1881, but it reverted to N. Garland in 1891 and was closed in 1895. Mr Garland opened a second mine in 1886 on the west half of lot 14, concession V in the former Oneida township. It was purchased by William Smith in 1898. Later, both properties were taken over by the Alabastine Company and re-named the Carson mine. During the early years, gypsum from the mines was ground in a mill at Caledonia, but the Alabastine Company transported their production to a mill at Paris, Ontario.

Access to the first mine was by an inclined drift driven southwest from Mackenzie Creek. The 1.5 m bed of white gypsum occurred at a depth of 16 m. An inclined drift also gave access to the second mine, where the gypsum bed was found at a depth of 21 m.

Lythmore Mine

The Lythmore mine was located in lot 29, concession III, in the former Oneida township, just northwest of Lythmore station. It was opened in 1916 by the Ontario Gypsum Company, and was later operated by Gypsum, Lime, and Alabastine Canada Limited. It was closed in 1932. A 2-compartment, 1.8m by 3 m, vertical shaft, 35m deep, intersected a 2.4 m bed of grey gypsum at a depth of 25 m, and 1 m of white gypsum at 35 m. The 2.4 m bed was broken into 1 m and 1.4 m seams by a 0.3 m shale bed. An air shaft 0.4 km west of the main shaft, and collared 17 m above the latter, encountered the 2.4 m bed at 42 m. It also intersected 1m of white gypsum at 22 m, and 1.7 m of grey and white gypsum at 32 m; these two seams apparently cut-off at the bedrock surface before reaching the main shaft. The two shafts were connected by a drift at the 27 m level, driven along the 2.4 m grey bed. Broken gypsum was trammed by battery locomotive on a 0.9 m gauge track, and hoisted to surface in a 2-tonne skip. A grinding and calcining plant on the property had been built by the Crown Gypsum Company in 1908 to process gypsum from the Martindale mine. It was expanded and used throughout the life of the Lythmore mine.

Martindale Mine

The Martindale mine was located 1 km below York on the south side of the Grand River; the property included lots 56 and 57 of the River range, in the former Oneida township. The mine was opened by John Martindale in 1846 and was worked almost continuously for 50 years. In 1908 it was re-opened by the Crown Gypsum Company. By amalgamation in 1917 with the Alabastine Company, the Crown Gypsum Company became the Ontario Gypsum Company, and the mine was worked under this name until it closed in 1919. In the early years the gypsum was processed in a grinding and calcining plant at York, but after 1908 it was handled in a new plaster plant at Lythmore. The bed of white gypsum was reached by a tunnel from the river bank.

Old's Mine

In 1910 the Caledonia Gypsum Company sank an inclined exploration shaft on the farm of John Old. The property, located 1 km northwest of Caledonia, adjoined the Caledonia mine; it consisted of lot 10, range II west, in the former Senca township. Thin lenticular beds of gypsum were found at depths of 17 m and 21 m. When its mill was burned in 1911 the mine was closed.

Kerr Mine

Sometime prior to 1913 the Crown Gypsum Company sank an exploration shaft on the Kerr property. The property lies 7 km east of York, at Cooks station on the C.N.R. Pink gypsum was encountered intermittently in the bottom 9 m of the 24 m shaft, but no production is recorded.

Paris Plaster Mine

A mine opened by Wm. Holmes in 1822 on the west bank of the Grand River about 1.5 km below Paris was one of the earliest mining ventures in Ontario. The property included the farms of Messrs. Miller and Martin, lot 12 concession I, Brantford township, Brant county. The mine was purchased by the Alabastine Company in 1890, and was closed in 1905. A grinding mill was built in 1823, and calcining facilities were added later. The mine was worked from a tunnel driven from the base of a hill. A bed of grey gypsum, 1.4-1.8 m thick was worked at a depth of 30 m.

Torrence Mine

First prospected in 1846, a mine was later opened by Wm. Hynes and James Wright on lot 16, concession I, Brantford township, Brant county. Drifting in the mine was of an exploratory and development nature only; no production is recorded.

IRON

Historically, iron has been an important product of the Central Region and might again be significant on a modest scale. A number of iron occurrences are known in Belmont Township, of which two became mines. The Blairton Iron Mine was a major economic feature for many years around the middle of the last century, and it still contains significant reserves of iron.

Blairton Mine

The Blairton Mine is located on lots 7 and 8, concession I, Belmont Township, on the south shore of Crowe Lake. Three pits were opened on the property (Table 5), largest of which was the Lake Pit located within 30 m of the shore. It is accessible from the south via an attractive wooded trail along the lakeshore, the abandoned roadbed of a rail link with Trent River built between 1867 and 1875. The Derick Pit and adjoining Morton Pit are located 300 m southwest of the Lake Pit. The mine operated intermittently during the period 1820 - 1875 and produced 270,000 tonnes of magnetite ore. Subsequent drillhole exploration between 1908 and 1959 has indicated reserves of about 2,000,000 tonnes with an average grade of 52.3 percent iron (Table 5).

The magnetite deposit is of contact metasomatic origin. It is located in a narrow zone of metamorphic pyroxenite and amphibolite which occurs at the contact between crystalline limestone to the west and gabbro-diorite intrusions to the east. The southern part of the deposit is overlain by Paleozoic conglomerate, ferruginous dolomite and limestone. Fine-grained magnetite occurs in disseminations, stringers and layers in sheared and altered skarn. Pyrite also is found in varying amounts throughout the deposit.

TABLE 5 - BLAIRTON IRON MINE

Existing Pit metres	Deposit	Mineralized Zone metres	Reserves tonnes	Average Grade Iron %	Sulphur %	Phosphorous %
75 X 20	Lake	180 X 60 X 90 deep	1,630,000	51.8	0.824	0.018
50 X 50	Derick	90 X 30 X 90 deep	450,000	54.2	0.340	0.010
20 X 20	Morton					

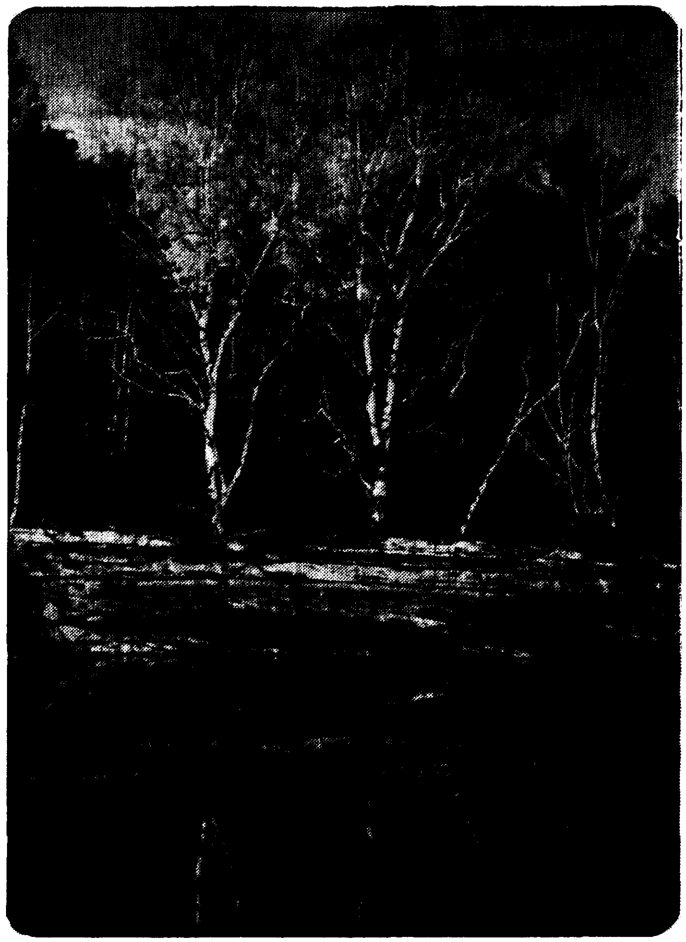


PHOTO 7 : THE DERICK PIT, BLAIRTON IRON MINE

The Blairton deposit is located on well-wooded and moderately rugged terrain in a scenic area that is rather sparsely developed with cottages, a trailer park, and a cluster of houses in the old nearby mining centre of Blairton. The site could be reworked with minimal disturbance to the environment and significant economic benefit to the local people.

Belmont (Ledyard) Mine

The Belmont Mine, formerly known as the Ledyard, is located in lot 19, concession I, Belmont Township, a short distance south of the community of Cordova Mines. Two pits were opened on a magnetite deposit located at the contact between Grenville marble and a dioritic intrusive body. The magnetite zone strikes nearly north-south and dips steeply west.

Intermittent ore shipments between the years 1899 and 1913 totalled about 7,600 tonnes. Between 1911 and 1914 a vertical shaft was sunk to a depth of 78 m and levels were established at 30 m, 50 m, and 70 m. A small amount of drifting in 1913 was credited with the bulk of the recorded production by the Buffalo Union Furnace Company. Reserves of about 1 million tonnes grading 31.47 percent magnetic iron have been estimated (Shklanka 1968, p.287).

As with the Blairton Mine, this site could be reworked with minimal disturbance to the natural environment.

Belmont Lake Iron Prospect

A zone of magetite-hematite-quartz (chert and jasper) banded iron formation 18 m wide is exposed over a length of 400 m in volcanic rocks. A grab sample is reported to have assayed 24.06 percent iron and 0.024 percent sulphur. The occurrence is in lot 20, concession 1V, Belmont Township, 400 m west of Belmont Lake. It appears to be too low grade to have any economic importance in the foreseeable future.

Deer River Iron Prospect

A small outcropping of magnetite-hematite-quartz iron formation, 6 m by 30 m in extent, is located 30 m east of the bridge over the Deer River in lot 21, concession III, Belmont Township. The occurrence is low grade and of no economic importance.

Pershing Iron Prospect

In 1954 a magnetic anomaly on lots 1 and 2, concession 1V, Belmont Township, was drilled as the result of an aeromagnetic survey. Disseminated magnetite and sulphide minerals were discovered beneath a Paleozoic cover 40 m thick (Shklanka 1968).

Round Lake Iron Prospect

Banded iron formation is exposed over an area 75 m by 45 m enclosed in green volcanic schists on lot 25, concession V1, Belmont Township. The deposit is of little economic interest.

West Belmont Lake Iron Prospect

A low grade zone of hematite-quartz iron formation 6 m wide is exposed in lot 15, concession V, Belmont Township, near the west shore of Belmont Lake. It is of no commercial interest.

Port Hope Anomaly

A strong aeromagnetic anomaly under Lake Ontario 5km offshore from Port Hope may be due to a magnetite body similar to those at Marmora and Blairton. A deep hole is reported to have been drilled in Hope Township in 1952, presumably in this connection, but the findings are not reported (The Port Hope Evening Guide, May 31, 1982, p.2).

LIME AND FLUX STONE

Ample resources of high-purity dolomite and high-calcium limestone occur in the Central Region. Both materials are used in raw lump form and as calcined lime for flux in steel-making; also as a fluxing ingredient of the glass batch, and in pulp and paper mills. Calcitic lime is also extensively used by the chemical industry in the manufacture of such products as calcium carbide and soda ash; also to neutralize acid wastes from uranium leaching plants. Both calcitic and dolomitic lime are used in the building industry for mortar mix and in the production of sand-lime bricks and other masonry units.

For all of these uses, high purity is required: Normal tolerances allow a maximum of 3 percent of non-carbonate impurities such as silica, alumina, iron and other acid insoluble materials. In the Central Region dolomite of the Guelph Formation (and sometimes the Lockport and Amabel formations) and limestone from portions of the Gull River and Bobcaygeon formations of the Simcoe Group, are of high purity. However, limestone from the Detroit River Formation in Southwestern Region is even purer than limestones of the Simcoe Group, and hence the latter are not now being used.

Producers of metallurgical dolomite and dolomitic lime have excess capacity at the present time and the older lime plants are having difficulty remaining competitive. Nevertheless, development of Steetley's Puslinch property should be encouraged because of its favourable railside location with respect to the Nanticoke steel mills and its excellent quality for both metallurgical and aggregate uses. The company does not contemplate building a lime plant on the site, but would continue to operate the Dundas plant and quarry for lime manufacture.

As to renewed production of calcitic lime in the Central Region, the Coldwater and Coboconk quarries contain suitable reserves of high calcium limestone. However, they have not been able to compete with the slightly purer limestones of the Beachville-Ingersoll area in Southwestern Region.

The following notes pertain to quarries currently active as well as some which are no longer operating.

DOLOMITE AND DOLOMITIC LIME

Dundas Quarry

The Canada Crushed Stone Division of Steetley Industries Limited operates a large quarry on the north side of Highway 5 in lots 10 and 11, concession III, Flamborough Township, in the Regional Municipality of Hamilton-Wentworth. The company is planning to open a new quarry in concession IV as they anticipate stone reserves will be exhausted at the present site within a few years.

About 15 m of the Eramosa Member of the Lockport Dolomite is quarried both for crushed aggregate and for metallurgical flux and lime. The operation is well located with respect to the Hamilton steel mills, and production levels have been maintained at a relatively high level. The company has its own lime plant to which it feeds crushed dolomite of high purity. The operation has been described by Hewitt (1960, p.106-111 and 1972, p. 47-48).

Guelph Quarry

Guelph Dolime, the lime division of Dominion Foundries and Steel Limited, operates a quarry on the southwest outskirts of the City of Guelph. A 12 m section of high purity Guelph Dolomite is quarried for use in the company's lime plant. The operation has been described by Hewitt (1960, p. 124, and 1964 p.55).

Hespeler Quarry

The quarry and lime plant of Domtar Chemicals Limited are located at Glen Christie, 5 km north of Hespeler. The operation was closed in 1979 due to a weak demand for flux in the steel industry and dwindling sales for mortar mix. Although ample reserves of high purity Guelph Dolomite remain, the plant is not expected to reopen. The operation was described by Hewitt (1960, p.123-124, and 1964, p.57).

Rockwood Quarry

Rockwood Lime Company Limited operated a small lime plant and quarry 1 km northeast of Rockwood willage in concession V, Eramosa Township, Wellington County. A 10 m section of Amabel Dolomite was quarried. The operation was described by Hewitt (1960, p.122) but it appears to have closed in the mid to late 1960's.

Puslinch Quarry

Although inactive since 1935, the Puslinch quarry of Steetley Industries Limited contains high purity dolomite of the Guelph Formation overlying

Eramosa Dolomite of the Lockport Formation. The property is located north of the Beverly Swamp in the south parts of lots 31 to 35 in the Gore of Puslinch Township, Wellington County. The company has not proceeded with reopening the quarry because of heavy environmental pressures. It was intended that the resources serve the needs for crushed dolomite flux for the new Lake Erie steel plants as well as the Hamilton plants. Its location on rail is an advantage that the company's Dundas quarry does not enjoy. Furthermore it would allow the conservation of dwindling Dundas reserves for use solely in the lime plant at that location.

Steetley's Puslinch property is an important dolomite resource that deserves development encouragement. It is believed that a protected zone around the environmentally sensitive Fletcher Creek watershed would ensure its protection and still permit economic quarrying on adjacent lands.

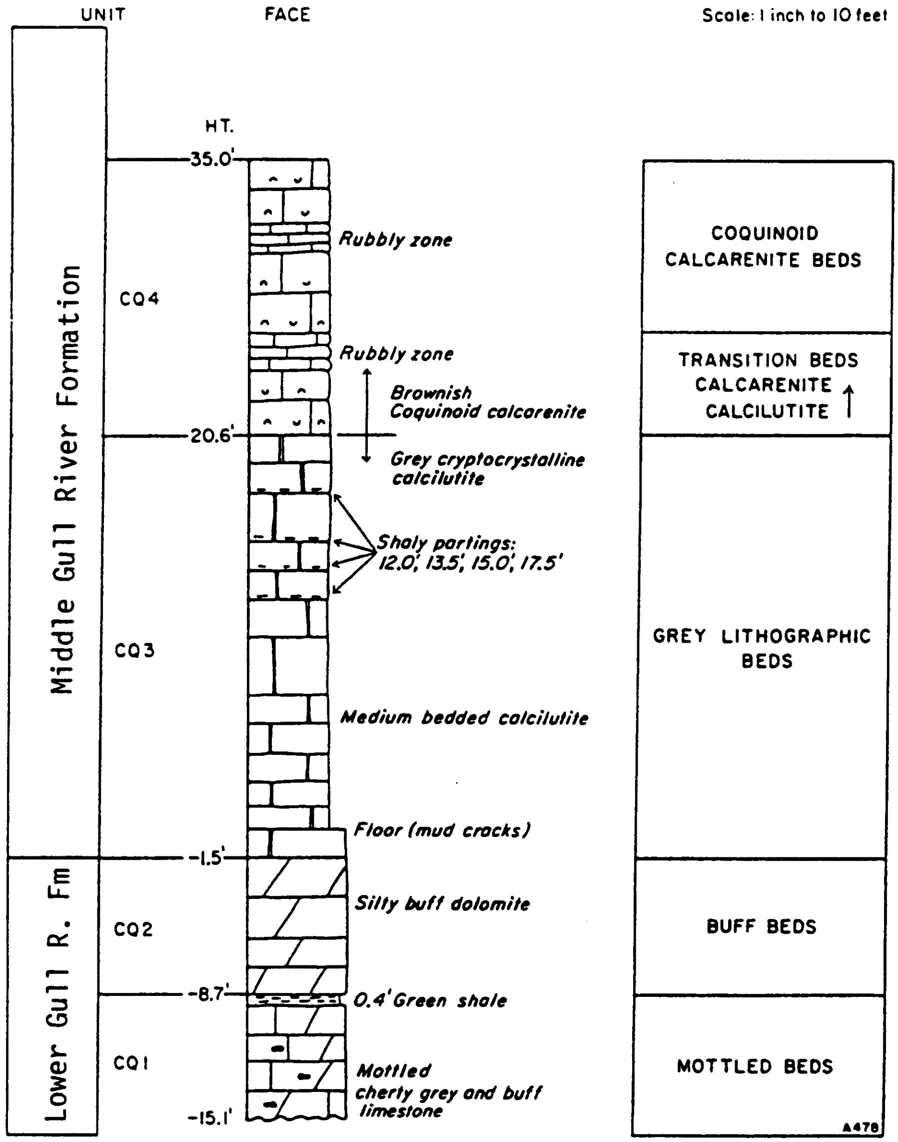
LIMESTONE AND CALCITIC LIME

According to Liberty (1969, p. 100-101) high calcium limestone forms at least part of the quarry sections at Uhthoff, Port McNicoll, Coldwater and Coboconk.

Uhthoff Quarry

This quarry, now operated by the Stone Products Division of Genstar, is primarily a supplier of crushed aggregate for construction purposes, but it has also shipped metallurgical flux. The limestone of the Gull River Formation at this location is not, however, pure enough to be a high calcium stone (Hewitt 1960, p. 31-33).

FIGURE 6 : 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

Modified from Hewitt 1960, p.30

Port McNicoll Quarry

This quarry was worked some years ago by the Canada Iron Furnace Company of Midland, but any reserves of high calcium limestone are limited by interbedding with shaly and dolomitic limestones (Hewitt 1960, p. 28-29).

Coldwater Quarry

A 10 m section of high calcium limestone of the Gull River Formation is exposed in the Coldwater quarry, lots 19 and 20, concession XIII, Medonte Township, Simcoe County. The accompanying quarry section is reproduced from Hewitt (1960, p.30). Chemical analysis of the top 10 m is given in Table 6.

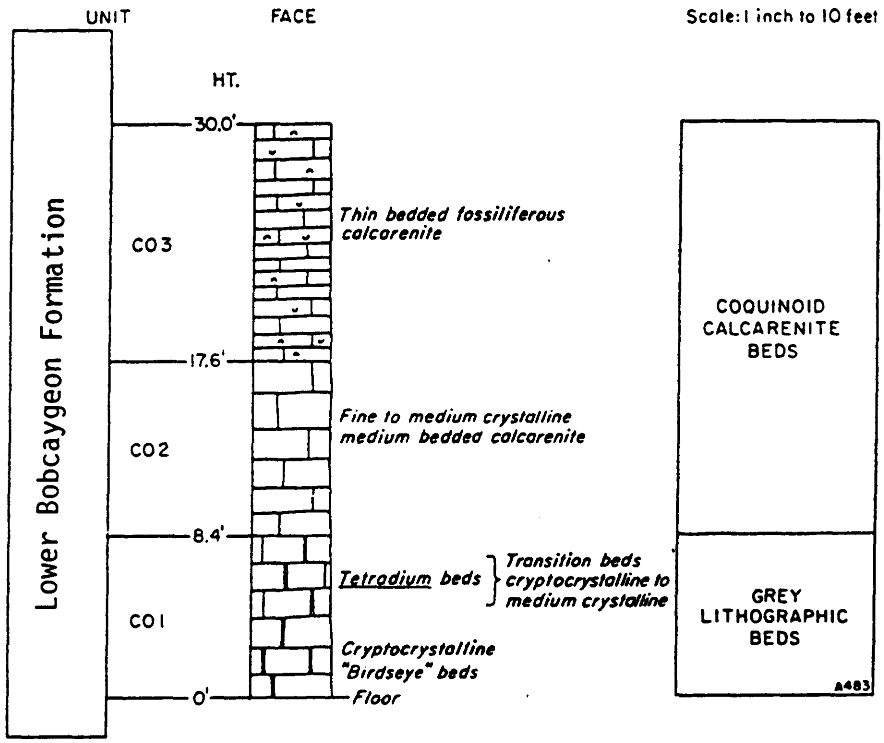
Coboconk Quarry

Of the several quarries at Coboconk, the Coboconk East quarry was most recently worked for its high calcium limestone by Cobo Minerals Limited. It closed in the early 1960's. Most of the quarried stone was calcined to lime in a coal-fired rotary kiln on the site. A 9 m section of Upper Gull River and Lower Bobcaygeon limestone was quarried. A quarry section is reproduced from Hewitt (1960 p. 43), and chemical analyses of the stone are given in Table 6.

An older quarry just south of this one was formerly worked by the Toronto Lime Company.

Both quarries are just within the Algonquin Region. The East quarry is now owned by Beamish Construction Limited, and it is occasionally used as a source of high calcium limestone by St. Marys Cement Limited.

FIGURE 7 : 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

Modified from Hewitt 1960, p.43

TABLE 6 - COMPOSITIONS OF SOME HIGH CALCIUM LIMESTONES

	COLDWATER QUARRY (10 m quarry face) Percent	COBOCONK QUARRY (top 2.5 m) Percent	COBOCONK QUARRY (bottom 6.5 m) Percent
SiO_2	1.56	1.38	1.20
Al_2O_3	0.54	0.51	0.57
Fe_2O_3	0.38	0.31	0.29
$CaCO_3$	96.98	96.55	96.70
$MgCO_3$	1.07	0.76	0.69
Total	100.55	99.53	99.52

Reference: Goudge 1938, p. 190 and 203.

MARBLE

White calcitic Grenville marble on the Whitney property in lot 31, concession V1, Belmont Township, is being explored for its possible finely-ground filler applications.

The property was initially explored by Northumberland Mines Limited in 1975 and 1976 involving about 900 m of diamond drilling and pilot plant testing by Ontario Research Foundation. A bulk sample of nearly 22 tonnes from a small quarry in the No. 1 zone was beneficiated by flotation to give on analysis:

	Percent
$CaCO_3$	96.6
$MgCO_3$	2.9
SiO_2	0.12
Al_2O_3	0.04
Fe_2O_3	0.10
	99.8

The product represented a weight recovery of about 70 percent of the original feed, and it had a brightness value (green filter) of 95.8.

In 1977 Englehard Minerals and Chemicals drilled 950 m in nine holes, further defining the No. 2 zone and locating a new No. 3 zone.

In 1980 Preussag Canada Limited carried out a further 854 m of drilling in nine holes on all three zones but concentrating mainly on the third zone. Beneficiation of the drillcores by Lakefield Research Limited resulted in residual silica contents up to 4 percent and brightness values in the low 90's. Checking the same drillcores, Ontario Research Foundation was able to greatly reduce the silica, but for some unexplained reason the brightness values were also reduced to the high 80's(W.L. Young, personal communication).

According to W.L. Young (personal communication) about 1.5 million tonnes have been proven in the No. 1 zone to a depth of 60 m. The no. 3 zone appears to have a width of 60 m and a length of 240 m.

The Whitney property is underlain by white, pink, and grey marble; both calcitic and dolomitic varieties are present, in places intimately interlayered. Quartz, mica, diopside, tremolite and iron sulphides are the principal impurities, irregularly distributed. Some bands of the marble are of high purity.

Further exploration and beneficiation studies are planned. The site is well located with respect to the principal filler markets in Ontario and nearby U.S. states. Its development, if economically viable, would not seem to impose serious environmental concern because of the flat open terrain and remoteness from residential locations.

MARL

Once the basis of a flourishing cement industry, marl has not been an important mineral commodity in Ontario for more than sixty years. Between 1889 and 1919 no less than fourteen cement plants in southern Ontario used marl as their principal raw material, four of them in the Central Region.

Marl is a soft white calcareous mud that forms the bed of certain small lakes and marshes. It is the product of a prolific algal growth in some spring-fed landlocked waters that are characterised by a strikingly clear blue-green colour. Often mistaken for white clay, it has few clay properties and in most respects is similar in appearance and application to finely-ground limestone.

Marl formation by algae is largely the result of precipitation of calcium carbonate as a natural byproduct of the photosynthetic growth process. Ontario deposits are geologically very young, having been formed only during the last 10,000 to 14,000 years since the retreat of the glacial ice. A limy environment is a prerequisite for marl formation; either carbonate bedrocks or deep calcareous surficial deposits are normally the source of lime-rich groundwaters that replenish the marl basins.

Unfortunately, marl deposits are not known in Ontario to be of high purity and whiteness. Such would be ideal for their use as mineral fillers in paint, paper, plastics, rubber and numerous other industrial applications. Instead, marl deposits normally contain appreciable amounts of silt, clay and organic matter, as well as a variety of snails, clams and ostracods.

TABLE 7-CEMENT PRODUCERS USING MARL IN THE CENTRAL REGION

COUNTY OR REG. MUNIC.	MARL DEPOSIT	COMPANY	PLANT LOCATION	YEARS OF ACTIVITY
Brant	Blue Lake	Ontario Portland Cement Co.	Blue Lake (Near Paris)	1904-1917
Peel	Orangeville	Superior Portland Cement Co.	Orangeville	1902-1913
Peterborough	Buckley Lake	Lakefield Portland Cement Co.	Lakefield	1902-1909
		Canada Cement Co. Ltd.		1909-1914
Victoria	Raven Lake	Raven Lake Portland Cement Co.	Raven L.(North-east of Kirkfield)	1904-1908
		Kirkfield Portland Cement Co.		1909-1914

The history of marl production in Ontario is almost entirely related to its use in cement during the period 1889 - 1919. In the Central Region marl was used for cement at four locations (see Table 7): Paris, Orangeville, Lakefield and Fenelon Falls. But its use was short-lived in favour of limestone because of the difficulties of quality control inherent in the dredging of marl.

Marl from a deposit near Kilbride in the Regional Municipality of Halton was being used in 1921 in the manufacture of concrete sewer pipe and culvert tile.

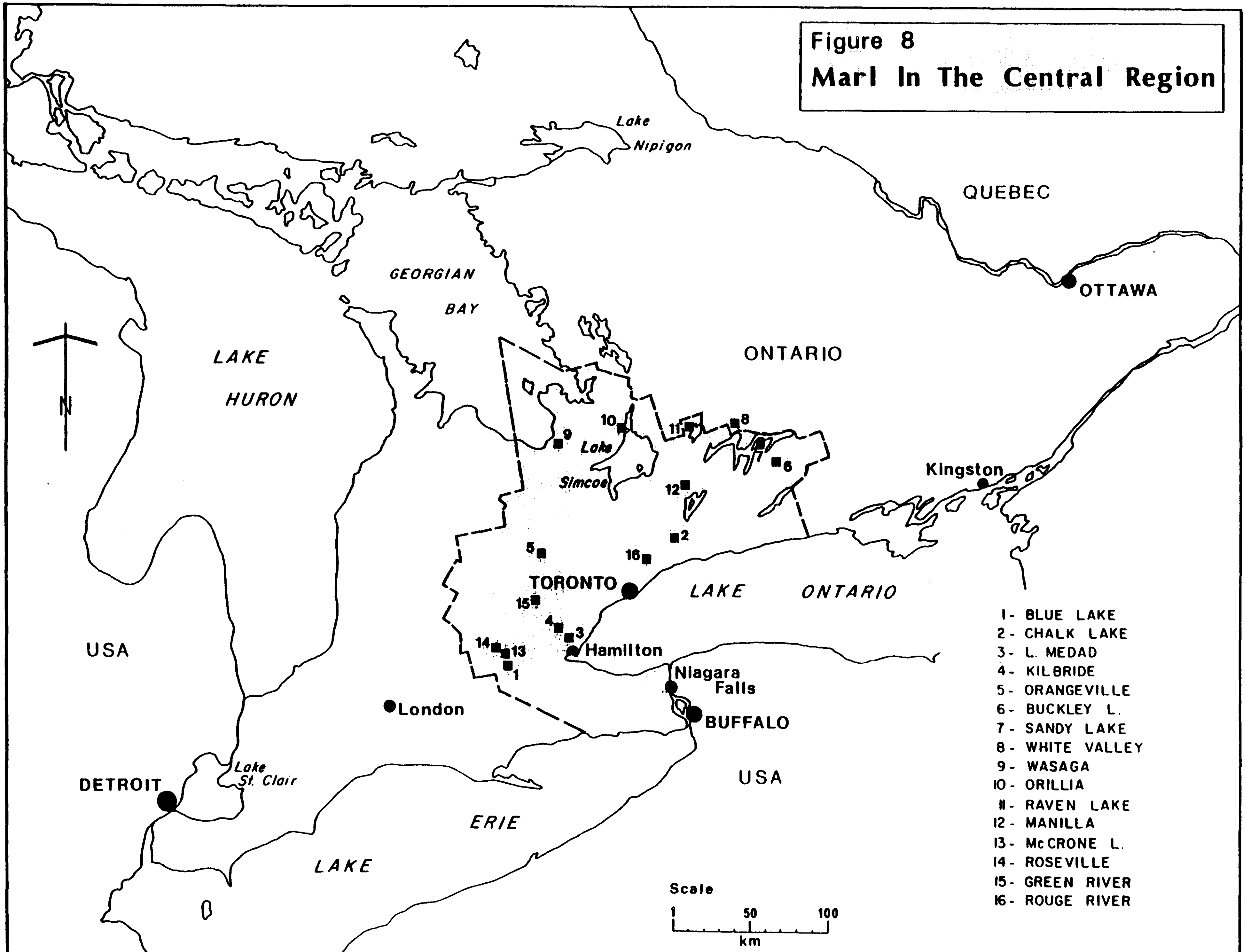
Since the decline of its use in cement, the most elaborate attempt at marl production was by White Valley Chemicals Ltd. in 1939-40. A small plant to produce filler grades was built at the deposit in Harvey Township north of Bobcaygeon, but the venture failed after sales of only 900 tons because of poor quality and a costly drying process. This deposit is just within the Algonquin Region.

During the war years when English chalk was difficult to obtain, the Ontario Paper Company used marl from Marlbank in eastern Ontario with moderate success.

Marl deposits are scattered throughout the Central Region. Sixteen have been documented, most of which have been examined in the field and evaluated for significant chemical and physical properties (Guillet 1969). They are briefly reviewed on the following pages.

As to possible uses for marl, most filler aplications require high calcium carbonate purity, freedom from grit, and brightness ratings in excess of 90 (as compared with a magnesium carbonate standard of 100). None of Ontario's marls qualify in their natural state.

Figure 8
Marl In The Central Region



An inexpensive means of purifying, bleaching and drying marl is needed, but is unlikely to be found. Other possible uses include carriers for pesticides, neutralizing acid soils, and stabilization of clay roadbeds. As long as suitable limestone is at hand, renewed use of marl for cement is unlikely.

Blue Lake, South Dumfries Township

Blue lake is located in lot 1 of the first concession east of the Grand River, in South Dumfries township, Brant county. It is 6 km northeast of Paris and 6 km west of St. George. The lake is an excellent example of a worked-out and rehabilitated deposit. It is only accessible by private roads to two homes located on opposite shores near the west end.

Marl was dredged from Blue Lake by The Ontario Portland Cement Company from 1904 to 1917. It was used with clay in the manufacture of cement in a plant located on the south shore. The operation is described by Gillespie (1905, p.154).

Blue Lake occupies an area of 8 hectares, but the marl underlying its waters has been largely removed. A further 6 hectares of marsh west of the lake may be underlain by marl.

Shells are common in the marl. Several species of snails are particularly common. Fragments of the alga Chara are abundant.

Although there appears to be little marl remaining on the lake bottom, a sample taken by the writer was of good quality. However, the marl has been much disturbed and may be contaminated in some places. A 1 m section analysed 90.0 percent $CaCO_3$, 3.5 percent $MgCO_3$, 0.11 percent Fe_2O_3, and 1.82 percent insoluble. The dry powder is buff-cream in colour with a moderate brightness.

This site has been attractively rehabilitated, and because further reserves are scarce, it does not represent a marl resource of further value.

Chalk Lake, Township of Scugog

Chalk Lake occupies parts of lots 1 and 2, concession 1 and lot 1, concession 11 in the former Township of Reach, now Scugog. It lies 20 km north of Pickering, and is accessible via Durham Road 23.

Chalk Lake occupies an area of 20 hectares. The lake is deep and the shoreline high. Cottages are numerous along the steep north shore. The lake lies along the southern edge of the Oak Ridges moraine.

Shells are only occasionally present in the marl; gastropods and Chara debris were recognized. Fibrous organic material is not common, but finely-divided plant remains contribute a dark colour to the crude marl.

The marl of Chalk Lake is of only fair quality. A 5 m section, omitting a 0.5 m peat layer near the base, analysed 87.0 percent $CaCO_3$, 1.6 percent $MgCO_3$, 0.14 percent Fe_2O_3, and 2.84 percent insoluble. The dry powder is buff coloured with moderately low brightness.

Marginal quality and heavy residential development bordering Chalk Lake makes this site unworthy of further consideration as a marl resource.

Lake Medad, City of Burlington

Marl underlies Lake Medad in lot 24, concession 11 NDS of the former township of Nelson. The lake is 3.5 km north of Waterdown. Marl may also underlie the long narrow marsh that extends for several miles north from the lake.

The deposit occurs in a narrow erosion basin along the west side of a low scarp of Guelph-Amabel Dolomite. According to A.R. Crozier (unpublished report, 1938) the marl varies to more that 3 m in thickness and underlies less than 1 m of peat. The marl is grey-white in colour and has a low content of organic impurities. A grab sample analysed by W.F. Green (Provincial Assayer, 1938) gave the following composition:

	Percent	
CaO	52.20	equivalent to 93.18% $CaCO_3$
MgO	1.52	equivalent to 3.18% $MgCO_3$
SiO_2	1.07	
$Fe_2O_3 + Al_2O_3$	0.16	
Ignition loss	45.83	includes Moisture = 1.94; CO_2 = 43.00
	99.89	

The resource is not considered sufficiently important to disturb the rural residential development that has grown up around it.

Kilbride, City of Burlington

A deposit of marl occurs in low ground on a tributary of Bronte Creek, on lot 13, concession II, in the former township of Nelson. The deposit is 3 km northwest of Kilbride, 5 km southeast of Campbellville.

The marl was being used in the manufacture of concrete sewer pipe and culvert tile by W.O. Morse in 1921. This company was succeeded by General Calcium Corporation Limited in 1928, but no record of production is available.

A grab sample taken by E. Harvey was analysed with the following result:

	Percent	
CaO	52.2	equivalent to 93.2% of $CaCO_3$
MgO	1.59	equivalent to 3.34 % $MgCO_3$
SiO_2	1.42	
Al_2O_3	0.23	
Fe_2O_3	0.39	
Na_2O	0.07	
K_2O	0.05	

The site is now owned by the Nature Conservancy and is managed by the Ministry of Natural Resources.

Orangeville, Town of Caledon

Marl underlies low ground west of Caledon Lake in part of lots 31, concessions IV and V, of the former township of Caledon. The deposit extends also into lot 1, concession B, East Garafraxa township, Dufferin country. The marl beds are 5 km southwest of Orangeville, and are accessible by the boundary road across the northwest corner of the township.

Courtesy Ministry of Natural Resources, Air Photo Library

1 cm = 160 m ; north is to the top.

Photo 8 - Orangeville marl beds; Caledon Tp., Peel Co.
Marl was dredged by the Superior Portland Cement Co., 1907-1913. There is no marl in the adjoining lakes.

Marl was dredged by the Superior Portland Cement Company from 1907 to 1913. A railway, now abandoned, connected the plant at Orangeville with the marl workings. A description of the plant during its construction is given by Gillespie (1905, p.160-162).

The marl deposit is not extensive, and it may have been largely depleted during the years it was worked. The workings occupy an area of 15 hectares and a summer cottage community has been developed on the dredged canals. Marl does not underlie "Second Lake" to the east, but the beach on the east shore of Caledon Lake is composed of impure shell marl. The marl area is rather heavily wooded.

A wide variety of shells characterize the Orangeville marl; species of gastropod, pelecypod, ostracod, and Chara debris occur in moderate amount. Fibrous organic matter is not abundant.

Orangeville marl is of fair quality. A 0.6m section averaged 90.3 percent $CaCO_3$, 3.3 percent $MgCO_3$, 0.49 percent Fe_2O_3, and 0.82 percent insoluble. The dry powder is buff-cream in colour with a relatively good brightness.

Limited marl reserves and heavy residential development eliminates this site from further consideration as a potential economic marl resource.

Buckley Lake, Douro Township

Buckley Lake occupies part of lots 14-16, concessions V and VI, Douro Township, Peterborough County.

Highway 134 passes west of the lake less than 1 km distant. Access to the lake may be obtained via a private road in lot 17, concession VI, or by canoe along the creek that drains from the south end of the lake.

Marl was dredged from Buckley Lake during the years 1902-1914, and used for cement at a plant in Lakefield. The Lakefield Portland Cement Company was merged in 1909 to form plant No. 7 of Canada Cement Company Limited. The operation is described by Gibson (1903, p.31) and Gillespie (1905, p.148 and 183).

Buckley Lake is a large marsh area occupying much of the north part of Douro Township. Parallel dredged channels along the west side occupy an area of 45 hectares. Reserves of marl northeast of these workings are probably very large. Buckley lake was drained at the time the marl was being excavated, and open water is now restricted to the old dredged channels; the rest is an open grass and cane marsh in which 0.5 m of fibrous peaty material overlies 3 to 4 m of marl.

Shells, both gastropods and pelecypods, occur in moderate amount and Chara debris is common in the upper part. Fibrous organic material is present in minor amount. Sand underlies the marl, and the lower marl strata are sometimes seriously contaminated by grains of quartz and mica.

The marl of the Buckley Lake deposit is of rather poor quality because of sand contamination and colour. An arithmetic average of three samples gave 75.8 percent $CaCO_3$, 0.5 percent $MgCO_3$, 0.55 percent Fe_2O_3, and 4.31 percent insoluble. Another sample was excluded from the average because of excessive sand comtamination. Colour of the dry powder is grey with very low brightness.

Buckley Lake has been a private hunting and fishing preserve for many years. Except for its value as a wetland nesting habitat the site could again be used in the unlikely event that markets might develop for such a low quality marl.

Courtesy Ministry of Natural Resources, Air Photo Library

1 cm = 160 m ; north is to the top.

Photo 9 - Buckley Lake, Douro Tp., Peterborough Co. A well-planned marl dredging operation that served the cement plant at Lakefield, 1902-1914.

Sandy Lake, Harvey Township

Sandy Lake occupies much of lots 6 to 12 in concessions XI and XII, Harvey Township, Peterborough County, about 6 km west of Buckhorn. Marl underlies most of the lake but is particularly well-developed at the north end. The lake supports a considerable cottage community. It is not considered an important marl resource.

White Valley Deposit, Harvey Township

Marl underlies a small lake and marsh in lot 31, concession XVIII, Harvey township, Peterborough county. The deposit is located in the northwest part of the township, 11 km north of Bobcaygeon. It is one of the few Ontario deposits that has been worked as a source of industrial filler. It is just within the Algonquin Region.

Five claims were staked in 1934, and White Valley Mines Limited was formed to develop the property. The company's name was changed to White Valley Chemicals Limited in 1939, and in 1940, 800 tonnes of whiting were sold for $9,600 (Satterly, 1943, p. 55). The property was purchased by Chem-Ore Mines Limited in 1944, but no further production is recorded. A plant was constructed on the property to produce 45 - 70 tonnes of product per day, using banks of infra-red lamps for drying. A detailed description of the plant is given by D.C. McLaren (1945).

The lake is uniformly shallow, mostly less than 0.5 m deep, and long cane reeds are common over most of its surface. The area of the lake is 20 hectares, but marl may also underlie the low wooded shores at the north end.

Shells are moderately common throughout the deposit, and finely-divided organic matter is responsible for the brown colour of the crude marl. Limestone of the Simcoe Group is the bedrock; it outcrops near the plant site at the south end of the lake.

Crude marl sampled near the centre of the lake is of good chemical quality, but is off colour due to organic matter. A 4 m section analysed 89.9 percent $CaCO_3$, 1.1 percent $MgCO_3$, 0.09 percent Fe_2O_3, and 0.58 percent insoluble. The dry powder is pale grey with a low brightness.

The site is located in remote undeveloped bush country where its further development for marl should not impose any serious social or environmental pressures.

Mara Lake, Flos Township

A marl pond 3 km east of Wasaga Beach is located in lots 24-25, concession VII, Flos township, Simcoe county. Access to the pond is by gravel road for a distance of about 1.5 km south from Highway 92.

The pond, and an extensive marsh area to the south, covers an area of 100 hectares. The pond is reedy and uniformly shallow. A golf course has been developed along the northwest side; elsewhere the area is open farmland. The pond lies just beyond the strands of beach and dune sands that fringe the foot of Nottawasaga Bay.

The marl is brown-coloured due to finely-divided organic matter. Roots are scarce, but pelecypod and gastropod shells are common.

Wasaga marl is of poor quality. A 3 m section analysed 81.9 percent $CaCO_3$, 0.9 percent $MgCO_3$, 0.43 percent Fe_2O_3 and 4.32 percent insoluble. The dry powder is grey-coloured and of very low brightness.

Low quality of the marl is not likely to encourage its consideration for commercial use, and hence it is not considered to be an important resource.

ORILLIA, ORILLIA TOWNSHIP

A geological report by R.E. Dean (1950, p.41) states that "the only deposit of marl seen in the Lake Simcoe area lies 3 miles north of Orillia. The marl is greyish white, and from 3 to 4 feet thick."

Location of the deposit is not precisely known, and it is expected to be small.

Raven Lake, Bexley Township

Raven Lake lies in lots 3 and 4, concessions II and III, Bexley township, Victoria county. It is west of Balsam Lake, 4 km north of Highway 46, and 13 km west of Coboconk. An abandoned CNR spur line to Coboconk lies along the southeast shore. The south side of the lake is accessible by road.

Courtesy Ministry of Natural Resources, Air Photo Library

1 cm = 160 m ; north is to the top.

Photo 10 - Raven Lake, Bexley Tp., Victoria Co.
Raven Lake is almost completely marl-filled. The small areas of dredging supplied marl for the cement plant on the southeast shore.

Marl was dredged from Raven Lake by The Raven Lake Portland Cement Company, 1904-1908, and The Kirkfield Portland Cement Company, 1909-1914. The plant and workings were on the south side, adjacent to the track. Clay was brought by rail from Beaverton. The operation is described by Gibson (1903, p. 32-33) and Gillespie (1905, p.157-159).

Raven Lake occupies an area of 115 hectares. Marl underlies most of the lake beneath 1 or 2 m of water, except for a dredged area of 10 hectares adjoining the old cement plant on the southeast shore. Low ground east, west, and north of the open water may extend the area underlain by marl to 300 hectares. Dredged channels in low ground off the south tip of the lake occupy an area of 4 hectares.

Shells are common in the marl; gastropods predominate, but in the upper part ostracods and debris of the alga Chara are common. Carbonaceous matter is scarce. Ordovician limestone outcrops nearby.

Raven Lake marl is of fair quality. A 5 m section averaged 81.8 percent $CaCO_3$, 2.7 percent $MgCO_3$, 0.17 percent Fe_2O_3, and 2.38 percent insoluble. The dry powder is pale grey with a low brightness.

This site is an important marl resource that might again be utilized if markets should develop. Renewed development might have some local environmental effects on the lake itself, but would have little social impact.

MANILLA, MARIPOSA TOWNSHIP

A deposit at Manilla, 20 km west of Lindsay, in Mariposa township, Victoria county, is mentioned by W.G. Miller (1904, p. 114). His analysis is reproduced in part, as follows:

	Percent	
CaO	53.27	Calculated $CaCO_3$ = 95.09%
MgO	0.77	Calculated $MgCO_3$ = 1.61%
Fe_2O_3 and Al_2O_3	0.59	
Insoluble	0.50	
Organic matter	1.61	
CO_2	42.60	

Location of the deposit is not precisely known.

McCrone Lake, North Dumfries Township

Two small lakes separated by marsh occupy a depression in the southern part of lots 29 and 30, concession VIII, North Dumfries township, Waterloo county. The lakes are visible from county roads 2 km east of Ayr, but are only accessible by private road.

In August 1965 marl was exposed in development work around a private dwelling on the southwest side of the smaller, westernmost, lake. W.A. Parks (1903, p. 149) mentions marl in the larger lake. The area of the lakes and surrounding marsh is 15 hectares, most of which is undoubtedly underlain by marl. Parks (1903, p.149) also mentions marl on the nearby Taylor and Easton farms.

Shells, especially gastropods, are moderately common in marl sampled from the smaller lake. A small amount of brown organic ooze is also present.

The marl is of only fair quality. A 4 m section analysed 83.8 percent $CaCO_3$, 3.5 percent $MgCO_3$, 0.25 percent Fe_2O_3, and 1.68 percent insoluble. The dry powder is buff coloured with a moderately low brightness.

The deposit is not considered an important marl resource.

ROSEVILLE, NORTH DUMFRIES TOWNSHIP

W.A. Parks (1903, p. 149) mentions 5 hectares adjoining a small pond on lot 31, concession X, North Dumfries township waterloo county. According to this description the occurrence should lie just south of interchange 33 on Highway 401, about 3 km southeast of Roseville.

The deposit is too small to ever be of commercial significance.

Green River, Eramosa Township

G.C. Hoffmann (1894, p.29) mentions "... a deposit three feet thick, underlying three feet of peat, in the neighbourhood of the Eramosa branch of the Green River, township of Eramosa, Wellington county..." An analysis of the marl is reproduced in part as follows:

	Percent	
CaO	43.71	Calculated $CaCO_3$ = 78.05%
MgO	0.76	Calculated $MgCO_3$ = 1.59%
Fe_2O_3	0.29	
Insoluble	10.36	
Organic matter	9.79	
CO_2	34.87	

The deposit is too small to be of any economic significance.

Rouge River, Town of Markham

A shallow deposit of marl is mentioned by P.F. Karrow (1967, p.46) on lot 2, concession VIII, in the former township of Markham, York county. The deposit in the Rouge valley, 1 km north of Steeles Avenue on the north side of the CPR, underlies less than 1 m of partly decomposed peat.

OIL SHALE

Early references to oil in the Collingwood Member of the Whitby Formation have generated little interest until recent years. Logan (1863, P.784) reported that crude oil was actually being distilled from Collingwood Shale on a commercial basis in 1860 at a location in Collingwood Township, Grey County. About 1,125 litres of crude oil were being extracted from 27 to 32 tonnes of shale daily. This indicates an oil content of about 3 percent in the shale.

In 1981 an extensive drilling program was initiated by the Ontario Geological Survey to test the possibilities for oil in shale throughout the province. The first target was the Collingwood Shale which underlies the west half of the Central Region and all of Southwestern Ontario. Outcrops of the shale are scarce; it can be seen in the Bowmanville quarry of St. Marys Cement Company and in scattered outcroppings along the shore of Nottawasaga Bay in the Collingwood area.

Drillholes so far completed in the Central Region include 5 in Nottawasaga Township, 2 in Metro Toronto, 2 in Pickering-Ajax, 1 in King Township north of Metro Toronto, and 1 near Shelburne. The Shelburne hole was drilled to the Precambrian, returning a complete section of the Paleozoic. A hole in the floor of Toronto Brick's Don Valley quarry intersected nearly 125 m of Georgian Bay and Whitby shales.

The Collingwood Member of the Whitby Formation is a black carbonaceous shale about 10 m thick. Significant amounts of organic carbon are present in the basal part of the shale unit and in the top of the underlying Lindsay Limestone. While the richest section is only several metres thick it shows remarkable lateral continuity.

Technical and analytical testing of the drill cores is being carried out at the University of Waterloo. It has not yet been determined what proportion of the observed organic carbon will in fact be crude petroleum, and what the recovery and economic potential might be.

Test drilling will be continuing over the next several years and be extended to other Paleozoic areas of the province.

In addition to many locations in the southwestern part of the Region exploratory wells for oil and gas are reported to have been drilled over the years in Oshawa, Whitby, and the townships of Carden, Eldon, Emily, Mariposa, Ops, Otonabee and Verulam (M.D.Billings, personal communication). Logs and rock cuttings for these holes are on file in the MNR Petroleum Resources Laboratory in London, Ontario.

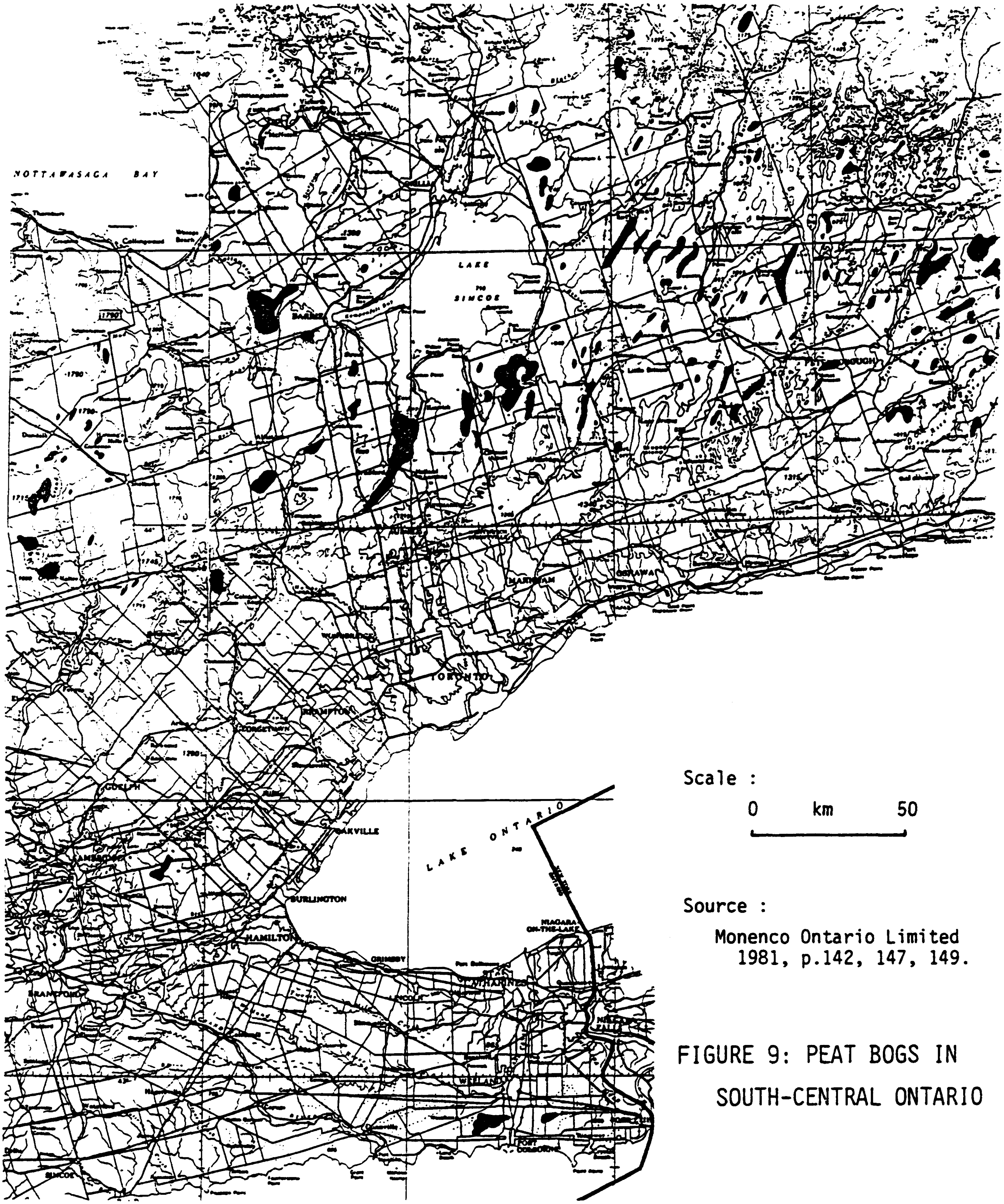
PEAT

Peat has been a resource of interest in the Central Region for many decades, particularly during the 1940's when a number of bogs were being worked for horticultural uses. Only recently, as a possible fuel resource, has peat again aroused significant economic interest in Ontario.

For horticultural uses, undecomposed fibrous peat moss is preferred, and this is usually found to a greater or less extent in the top portions of peat bogs. Humified decomposed peat is commonly found at depth and is mainly of interest for fuel.

Only the Welland bog in the Regional Municipality of Niagara has been worked to any significant extent, operations here being more or less continuous for more than fifty years. Peat moss is recovered by a vacuum harvesting method and marketed mainly in the United States for horticultural uses. In 1980, Atkins and Durbrow Limited shipped 5,293 tonnes valued at $622,766, about the same volume as in each of the previous five years (Weatherson 1982, p.45). However, more than a dozen bogs in the Central Region have been worked or seriously investigated in past years. Details on some of these have been given by Haanel (1924, p.28-29) and Leverin (1946, p.64-71).

In 1981 the first stage of a major review of Ontario peat resources by the Ontario Government was published (Monenco 1981). The study goes into great detail on the potential use of peat as fuel and its mining and processing based largely on experience in Finland. A detailed inventory of peat resources is also planned. Such an



Scale :

0 km 50

Source :

Monenco Ontario Limited 1981, p.142, 147, 149.

FIGURE 9: PEAT BOGS IN SOUTH-CENTRAL ONTARIO

inventory should assess specific bogs for their horticultural value as well as for fuel. It should also address the serious environmental conflicts involved in the draining of peat wetlands.

Figure 9 has been prepared from maps in the Monenco (1981, p. 142-149) report; it shows the distrubution of peat bogs in the Central Region. Table 8 gives data on the size and reserves of peat in a dozen bogs of the Central Region, based on a number of reports summarized by Haanel (1924, p.28-29). Most of these are further described by Leverin (1946, p. 66-69) from which the following notes have been largely taken.

Amaranth Bog

Bog vegetation is mainly sphagnum and hypnum mosses, generally well-humified. About 80 hectares could be drained to the west, giving access to a moderate depth of peat.

Brampton Bog

A bog of 8 hectares near Brampton is reported (Leverin 1946, p.67) to have produced a few tons of moss annually for local greenhouses.

Branchton Bog

A small bog on the south half of lot 6, concession VII, North Dumfries Township in the Regional Municipality of Waterloo contains good quality sphagnum moss. It has been worked on a small scale for local horticultural uses (Leverin 1946, p.70).

TABLE 8 - SOME MAJOR PEAT BOGS OF THE CENTRAL REGION

Peat Bog	County or Regional Mun.	Area Hectares	Depth Metres	Total Volume Cubic Metres	Est. Workable Volume, CM	Fuel Reserves Tonnes *
Aberfoyle	Wellington	120	2		800,000	125,000
Amaranth	Dufferin	200	3	3,300,000	1,500,000	240,000
Beverly	Ham-Wentworth	700	1.5	1,553,000	207,000	245,000
Halton	Halton	195	1	1,183,000	158,000	190,000
Holland Marsh	York, Simcoe	5,930	5	94,424,000	47,100,000	7,450,000
Luther	Dufferin	1,980	5	55,880,000	42,650,000	6,750,000
Manilla	Victoria	300	3	5,050,000	2,280,000	360,000
Marsh Hill	Durham	2,070	5	69,690,000	55,130,000	8,400,000
Sunderland	Durham	235	3	3,820,000	2,090,000	330,000
Victoria Road	Victoria	27	5	490,000	300,000	50,000
Welland	Niagara	1,980	4	38,950,000	23,530,000	3,725,000
Westover	Ham-Wentworth	570	2	6,430,000	1,750,000	280,000

* At 25% Moisture

Reference: Haanel 1924, p.28-29.

Holland Marsh

Because of its high value for specialized farming, this bog is not considered a viable peat resource. In any event it has only a thin cover of unhumified fibrous peat.

Luther Bog

This large bog consists mainly of hypnum moss with minor sphagnum. It was worked experimentally for several years for the production of chemicals from a 2 m section of good-quality humified peat which underlies 0.5 m of fibrous peat (Leverin 1946, p.69).

Pefferlaw Bog

During the 1960's the writer visited a small peat operation southeast of Pefferlaw. Several horticultural products known as "Pegasus" and "Pefferlaw" brands were being produced by G.T. Strain.

Scarborough Junction Bog

Leverin (1946, p.67) refers to a small operation that supplied peat specifically for a local mushroom farm. The peat was mixed with manure to form a fertile soil.

Victoria Road Bog

A deposit of humified peat 1 or 2 km north of the hamlet of Victoria Road was worked at one time for peat fuel. About 0.6 m of well-humified peat is underlain by 2 m of partly humified sphagnum and hypnum moss. In 1940 the bog was worked on a small scale to produce top-moss, humus, and peat moss products. Humus from the top layer was dried, ground and sold as a dry powder. Peat moss was cut in sods 13 by 13 by 46 cm and left to dry on the bog, after which it was shredded and bagged. Leverin (1946, p. 66-67) says it was an inferior product [probably because it was partly humified] and the operation was short-lived.

Welland Bog

Brown fibrous peat moss of the sphagnum variety with minor sedge is 1 to 2 m thick over a large area. The Welland Bog has been the most continuously operated bog in Ontario, largely due to the superior quality of the moss and its proximity to a large U.S. market.

The bog was being worked in the 1940's by Erie Peat Limited. The moss was cut by hand into blocks, and air-dried before shredding and bagging for shipment (Leverin 1946, p. 68-69). Today the operation by Atkins & Durbrow Limited is more mechanized, using a vacuum harvesting method.

Westover Bog

This bog occupies lots 27 and 28, concession VII, in the former township of Beverly, now in Flamborough Township in the Regional Municipality of Hamilton - Wentworth. Sphagnum moss is scarce, the vegetation being mostly carex sedges and aquatic plants with minor hypnum moss. The peat is well-humified with a high ash content, and is of little value. However, in the 1940's it was being worked by Canadian Humus Products, and the peat was mixed with marl on which the peat layer rests. According to Leverin (1946, p. 67-68) a soil conditioner was being produced which had desirable proportions of humus and alkaline earths, and in which the limy marl neutralized the acidity of the peat. Test borings indicated a uniform thickness of 1.5 m of peat overlying 0.8 m of marl.

Environmental Considerations

There are few resources subject to as much potential environmental disturbance as peat extraction. The preservation and improvement of wetlands such as these are of major importance to the continued existence of certain wildlife and rare flora. In addition to conservation authorities and other government agencies, such international organizations as Ducks Unlimited have a major interest in the Region's wetlands, and all these interests must be carefully evaluated before a decision is made for the development of peat on a major scale.

SHALE

Ontario consumed 365 million bricks, worth about $46 million in 1978. More than 90% of these bricks were produced in Ontario, largely from shale; the rest were imported from the United States. In 1981 Ontario producers sold 384,213,814 bricks, 91 percent of which were destined for residential construction (Clay Brick Association of Canada). All were made from shale.

The total clay products industry (which includes brick, tile and sewerpipe) in Ontario in 1978 generated sales worth about $62 million, employed nearly 1,700 people, and paid more than $21 million in wages and salaries. Municipal, provincial, and federal taxes were about $1 million, $4 million, and $8 million respectively (Proctor & Redfern 1978, p.16).

Ontario produces and consumes more than 50% of all the bricks used in Canada. Its production is more than twice that of Quebec. All but one of Ontario's brick companies are located in the Central Region.

The historical record of brick-making in Ontario is marked by a number of major changes and trends. Originally characterized by a profusion of small family-owned and labour-intensive plants using surface clay, the industry today is dominated by a few large and highly-automated plants using shale. Continuous gas or oil-fired tunnel kilns have replaced the old coal or wood-fired beehive kilns.

The numbers of bricks produced today have only just caught up with the levels of production in the early years of this century, when multilayer brick walls were the principal structural style. Today's bricks are of much superior quality and are used almost exclusively in exposed wall surfaces.

Ontario's brick industry is concentrated in the area between Toronto and Hamilton, using shales of the Queenston and Georgian Bay Formations which are obtained by quarrying at the plant sites.

BRICK PRODUCERS

There are seven brick plants using shale in the Central Region. Shale is also used in the Region in the making of Portland cement, flowerpots, structural tiles and drainage tiles. Drainage tiles are also made from clay. These plants are briefly described in the following notes (see also the chapters on Cement and Clay).

Domtar Construction Materials Limited

Bricks have been continuously produced at this Mississauga site since 1911. The plant and quarry are located on lots 19 and 20, concession IS, in the former township of Toronto. Earlier descriptions of brickmaking on this site are given by Montgomery (1930 p. 144) and Guillet (1967 p. 39).

Ample reserves of grey Georgian Bay Shale remain in this large quarry, but the pressures of urbanization are being felt; residents in nearby apartment buildings overlook the entire operation, and complaints of unsightliness are frequent. Systematic backfilling of worked out areas is being done with fly ash from Hamilton steel mills.

Bricks are made in a large plant adjoining the quarry. Once a very diversified producer of bricks and tiles by various methods, the brick-making process is now almost entirely by the stiff-mud extrusion method and continuous tunnel kiln firing.

An expanded shale aggregate known as "Haydite" was produced in an adjoining plant from 1928 to the late 1970's. Bloating of the shale was accomplished in a rotary kiln at a temperature of about 1,175 ° C. Initially produced as a clinker crushed to various size fractions, a more desirable coated aggregate was produced from a pelletized feed in recent years. Bulk density of the product was in the medium weight category at about 600 kg per cubic metre.

This was the only commercial producer of expanded shale aggregate in Ontario. The only comparable product available today is a slag byproduct of the Hamilton steel plants.

Toronto Brick Company

Toronto Brick Company, the operating arm of United Ceramics Limited, is one of the most diverse and innovative brick producers in Ontario. Located on the west side of the Bayview Avenue Extension in the Don Valley just north of the Bloor Street viaduct in Toronto, brick-making at this site dates from 1889. Early descriptions of the operations here are given by Baker (1906 p.111), Keele (1924 p. 18), Montgomery (1930 p. 161) and Guillet (1967 p.47).

Grey Georgian Bay Shale of Ordovician age is the major raw material used in brick-making, but blending with glacial varved clays to produce bricks in the lighter colour ranges is also done. The quarry not only exposes a deep section of the shale, but also an exceptional geological record in the clay and sand units which overlie the shale. The history of several stages in the advance and retreat of the glaciers during the past 100,000 years, is magnificently recorded in these Pleistocene sediments which have an international reputation as a result of the studies by Coleman (1933; 1941), Karrow (1967; 1969) and Freeman (1976).

The quarry is now 30 m deep in shale, overlain by an equal thickness of clays and sands. Floor of the quarry is well below the level of Lake Ontario. Confinement of the site through urbanization must ultimately result in closure of this operation through lack of accessible shale, unless shale is trucked in from another source. However, the maintaining of operations at this site ensures the accessibility of the unique geological record, preserving a "window" into Toronto's past which is nowhere else available. When mining is ultimately completed, the site should be made into a geological park in which historically significant clay and sand units are preserved behind glass accessible by elevated walkways against the steep slopes.

Also of some historical interest is the fact that bricks are still made here by the three principal brick-making processes: soft mud, pressed brick, and stiff-mud extrusion. While extrusion has become standard in the industry because it lends itself well to automation, it is interesting that there remains a continuing demand for bricks produced by the older methods because of certain colour and textural characteristics peculiar to them. Firing is accomplished in three tunnel kilns. Toronto Brick produces about 50 million bricks annually, and consumes 150,000 tons of shale in so doing.

The demand for grey-white sand lime bricks has declined, and Toronto Brick is the only company now producing them in Ontario. These bricks are pressed from mixtures of siliceous sand and lime, and are hardened by a steam autoclave process. Angelstone Limited at Cambridge produces a synthetic rock ashlar by a similar process. Harbour Brick Limited, formerly located on the Toronto waterfront, moved its sand lime brick plant to Barrie some years ago, but it is now believed to be closed.

Toronto Brick Company owns about 46 ha of red Queenston Shale on the southwest outskirts of Milton in lots 14 and 15, concession INS, in the former township of Trafalgar. A quarry was first opened here in 1911, and during the years 1919-1929 and 1956-1963 shale was quarried for the Don Valley plant. The lands are just within the Niagara Escarpment Planning Area and are presently unlicensed for quarrying. The terrain is flat and unattractive for other forms of development and should be preserved for quarrying. Environmental sensitivity is low; the site is effectively screened from the town of Milton by railroad embankments on two sides. A description of the 8 m shale section and its properties for brick-making is given by Guillet (1967 p.100).

Canada Brick Limited, Streetsville

One of the largest and most modern brick plants in Ontario is that of Canada Brick Limited in Streetsville. The Queenston Shale quarry and plant are in lot 6, concession V WHS, in the former township of Toronto. Brick-making commenced here in 1956. An earlier description of the plant and properties of the red shale are given by Guillet (1967 p.64).

Bricks are produced by auger extrusion equipment, and are fired in tunnel kilns. The operation is tidy and unobtrusive, and is a major economic asset to the community.

Canada Brick Limited, Burlington

The former Diamond Clay Products Limited is now owned by Canada Brick. The company started its operations on the north side of Highway 5 at Tansley in 1959. The plant and quarry are in lots 3 and 4, concession I NDS, in the former township of Nelson, now in the city of Burlington.

Queenston Shale is quarried on the site, but is also trucked from the National Sewer Pipe quarries on King Road in Burlinton. The latter shale gives a deeper red-fired colour than is possible from the company's own shale. Indeed, it was the buff and brown fired colours then much in fashion that attracted Diamond Clay to the Tansley site.

Burnstein Brick Limited

Burnstein Brick Limited of St. Catharines is the former St. Catharines Brick and Tile Company Limited (Guillet 1967, p.99-100), now owned by Canada Brick Limited. Bricks are made from shale quarried at St. Davids, one of the few places in this area where suitable shale is accessible.

F.B. McFarren

The F.B. McFarren company is located in Streetsville in lot 3, concession V WHS, in the former township of Toronto. The plant was built in 1913 and has been described by Keele (1924 p.22), Montgomery (1930 p. 148) and Guillet (1967 p.82). The company is now a division of Canada Brick Limited.

The plant uses mainly Queenston Shale and bricks are produced by the extrusion method. Firing is accomplished in rectangular downdraft kilns.

Brampton Brick Limited

Located on the east side of Highway 10 in lot 10, concession IE, in the former township of Chinguacousy, now the City of Brampton, brickmaking has been carried on at this site for nearly a century. Earlier descriptions are given by Baker (1906 p.89), Keele (1924 p.22), Montgomery (1930 p. 148) and Guillet (1967 p. 60).

Brampton's plant and quarry have all but been overtaken by urbanization, and accessible shale reserves are almost depleted. Although operations are continuing at the Brampton site, the company was successfull in negotiating for a shale resource at Cheltenham, and it plans to construct an all new plant at that site soon. The Cheltenham site was at one time worked by Domtar and is described by Guillet (1967 p. 76).

Hamilton Brick Limited

Located at 215 Kensington Avenue at the base of the Escarpment in Hamilton, bricks have been made here since 1907. Early descriptions are given by Montgomery (1930 p. 159) and Guillet (1967 p.80).

Although Queenston Shale exists in the face of the Escarpment behind the plant, and was formerly used, shale has been obtained from the National Sewer Pipe quarries in Burlington for some years. Bricks are made by extrusion and are fired in beehive kilns now rarely seen in the industry. The operation is critically dependent on the availability of shale from the National Sewer Pipe quarries. Urbanization has long since overtaken this old plant, and its continued existence speaks well for the company's efforts to be compatible with the community.

Halton Ceramics Limited

Halton Ceramics Limited is a producer of flowerpots and hollow structural tile for partitions. It also produces a wide variety of specialty tiles custom made to individual consumer specifications. The plant was built in 1910. It is located on the south side of

Hwy. 403 and the CNR, in lots 11-12, concession I, in the former township of East Flamboro, now the city of Burlington. Early references to tile-making on this site are given by Keele (1924 p. 96), Montgomery (1930 p.158) and Guillet (1967 p. 91).

The plant was originally located on this site to take advantage of an exceptionally good quality red clay used extensively at that time for sewer pipes, hollow tiles and flowerpots. This clay was derived from the eroding banks of Queenston Shale on the nearby lower slopes of the Niagara Escarpment, and it was deposited in two small areas in the cities of Hamilton and Burlington. Utilization and urbanization depleted the Hamilton deposit, and in due course the construction of Highway 403 eliminated the remnants of the Burlington deposit.

In the early years the plant used the red "Aldershot clay" exclusively, but as reserves diminished it was subsequently blended with Queenston Shale from a quarry on the same site. The shale from this site is inclined to be hard and more limy than desirable for tile-making when used by itself, so in 1953 when their clay was finally exhausted they continued for a few years with soft weathered shale trucked from a quarry at Milton. However, for more than twenty years now, the plant has depended exclusively on Queenston Shale from the National Sewer Pipe quarries on King Road in Burlinton. As with Hamilton Brick Limited this company is critically dependent on the continued availability of shale from this source.

Amos C. Martin Limited

Drainage tiles have been produced at this site near Wallenstein for nearly a century. The Martin family have owned the plant since 1919. It is located on lot 20, concession I, Peel Township, Wellington County. Early descriptions are given by Montgomery (1930 p.157) and Guillet (1967 p. 170). Drainage tiles are also produced across the road in the plant of N.S. Bauman Limited.

For many years both companies used local surface clay exclusively, but in recent years the Martin plant has used Queenston Shale from its own licensed quarry near Georgetown. The licensed area comprises 3.2 ha and is located in lot 23, concession VIII, in the former township of Esquesing, now the town of Halton Hills.

The quarry is small and exposes about 4.3 m of Queenston Shale. It is worked on a slope using a bulldozer and ripper, and the broken shale is allowed to take advantage of natural weathering before it is trucked to the plant. Weathering improves its plasticity and firing characteristics, which otherwise would not be adequate for tile-making. Two samples of the shale, one from the upper 2.3 m of soft weathered material, the other from the harder lower 2 m were analysed as follows:

TABLE 9 - QUEENSTON SHALE, A.C. MARTIN LTD.

	Lower 2m percent	Top 2.3 m percent
SiO_2	50.1	55.4
Al_2O_3	15.0	16.0
Fe_2O_3	6.96	7.50
CaO	7.85	4.36
MgO	4.21	3.50
Na_2O	0.20	0.21
K_2O	4.65	4.86

Analysed by X-Ray Assay Laboratories Ltd., Jan. 4, 1982.

National Sewer Pipe Limited

National Sewer Pipe ceased production at its Mississauga plant in 1979, and at its Hamilton plant some years previously. This company has been the sole supplier of clay sewer pipes in Ontario for many years, and its closing reflects increasing competition from concrete and asbestos pipes. Early descriptions of this company's operations are given by Baker (1906 p.116), Montgomery (1930 p.168) and Guillet (1967 p. 175).

While the company actually used little Queenston Shale itself, it used to own about 160 ha of shale lands in the vicinity of King Road, north of Highway 403, in Burlington. It still owns some of these lands, but large portions have been consumed for landfill and most, if not all, will likely be ultimately lost for ceramic use.

The making of sewer pipes was originally founded on the excellent "Aldershot clay", a small shallow deposit of red clay peculiar to the Burlington-Hamilton area. With the eventual exhaustion of this clay the company purchased land on the nearby bare eroding slopes of Queenston Shale, from which they scraped away the soft weathered shale and blended it with fireclay imported from Pennsylvania. Eventually they used imported clays entirely, so that the Burlington shale lands were superfluous to their needs.

Queenston Shale varies slightly in composition from place to place, and hence varies also in its ceramic properties. It happens that the Burlington lands of National Sewer Pipe contain good red-burning shale not readily available elsewhere, and hence quarrying was commenced on these lands in the 1950's and 1960's by several other companies under lease agreements with National. At the present time three companies are dependent on this source of shale: the Burlington plant of Canada Brick Limited, Halton Ceramics Limited, and Hamilton Brick Limited.

The preservation of some of these lands for the continued use of its shale by these companies is a matter of major importance. One and possibly two of these companies cannot survive without it. Compared to the adjoining landfill sites, and the original "badlands" topography, a quarry operation with suitable landscaping and vegetative screening need not be environmentally detrimental.

EXPANDED AGGREGATE

Medium-weight expanded aggregate, produced by bloating Georgian Bay Shale in a rotary kiln, has recently been discontinued after being in commercial production in Ontario for many years. Known as "Haydite", the product was made by Domtar Construction Materials Limited in a plant adjoining the Company's Cooksville brick plant.

As a replacement for sand and gravel or crushed stone, expanded aggregate offers significant weight saving, better insulating qualities, and reduced load-bearing requirements for structural steel in building construction. It finds particular application in lighter weight concrete blocks and precast concrete panels.

Shales of the Whitby and Cabot Head formations also show promise for expanded aggregate.

SHALE RESOURCES

The Central Region enjoys the greatest abundance and variety of shale resources in the province. The Paleozoic sequence in southern Ontario includes at least fourteen shale units, many of which however are compositionally unsuitable for brick-making, and most are limited in their outcrop extent and are difficult of access. Their principal characteristics are outlined by Guillet (1977). The four shale formations of major interest are briefly described on the following pages.

Queenston Shale

Shale of the Queenston Formation is the major raw material for six brick plants in the Central Region: two in Mississauga and one each in Brampton, Burlington, Hamilton and St. Catharines. It is also used in making structural tile and flowerpots in Burlington and drainage tiles at Wallenstein.

The Queenston Formation outcrops along the base and lower terraces of the Niagara Escarpment. It forms the shoreline of Lake Ontario from Niagara to Oakville and parallels the Escarpment northward through Owen Sound and Cape Croker. It reaches its maximum extent in the regional municipalities of Halton and Peel where it forms the bedrock over a width of 20 km. Its overall thickness in this area is 150 m, but it thins northward to about half this amount at Owen Sound.

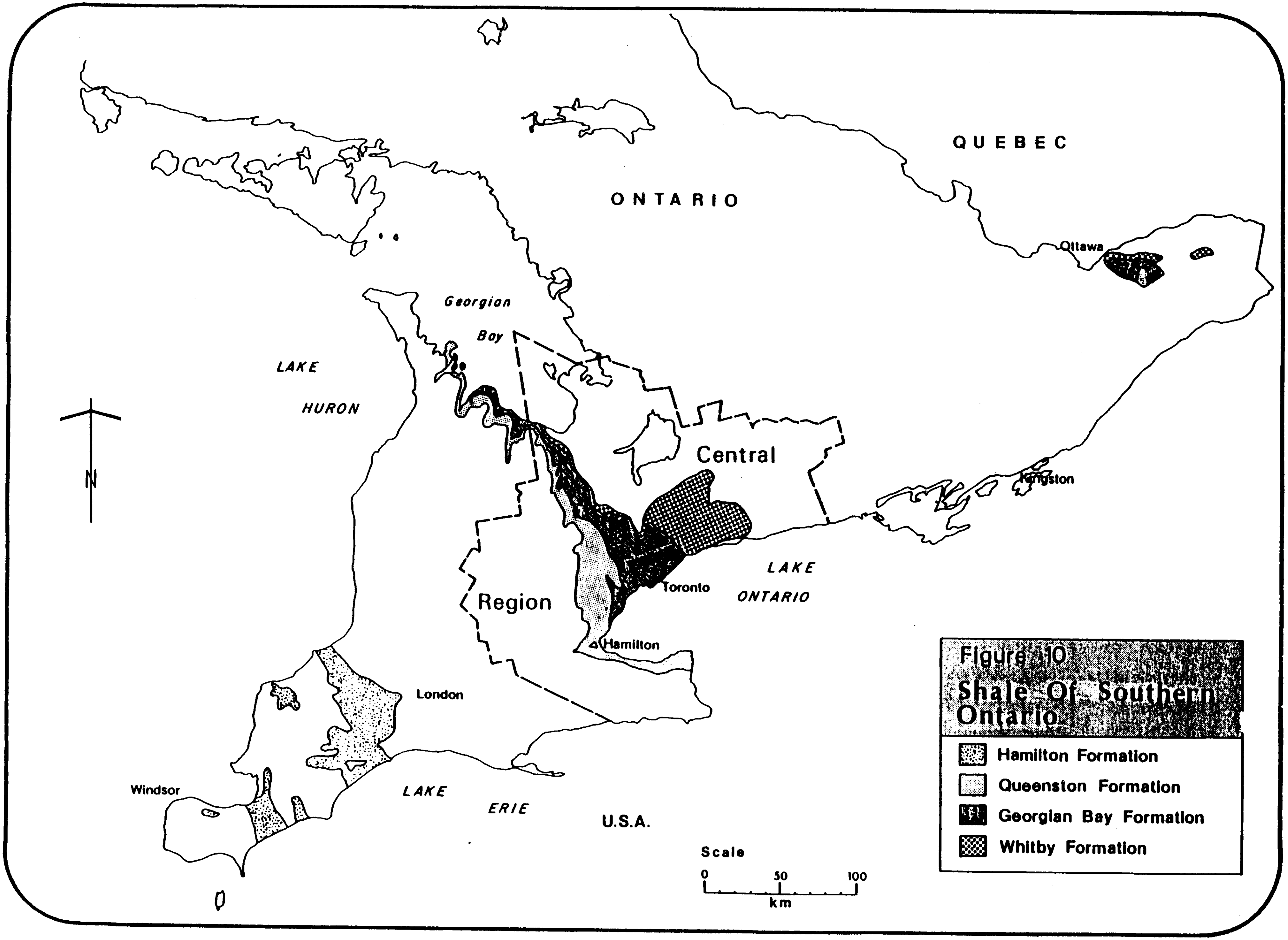


Figure 10
Shale Of Southern Ontario
Hamilton Formation
Queenston Formation
Georgian Bay Formation
Whitby Formation
QUEBEC
ONTARIO
Ottawa
Kingston
Georgian
Bay
LAKE
HURON
Central
Region
Toronto
Hamilton
LAKE
ONTARIO
London
Windsor
LAKE
ERIE
U.S.A.
Scale
0
50
100
km
N

The Queenston Formation occupies a position at the top of the Ordovician system in Ontario. The shale is characteristically red, mottled with green, and thin to medium bedded. It breaks down readily to a red clay soil which is a conspicuous feature wherever the bedrock is near surface.

While Queenston Shale is the most widely used, its suitability for making bricks may be restricted by local concentrations of gypsum and other soluble salts, excessive lime content, and unusual hardness. The effect of these characteristics are respectively the increased likelihood of scum formation or efflorescence on the finished brick, increased porosity and weakened fired colour, and lower or insufficient plasticity.

Nevertheless, Queenston Shale and the underlying Georgian Bay Shale are the major resources for Ontario's brick industry, and at least some of their outcropping areas must be preserved to meet future industry needs. Areas where these resources are available beneath not more that 7.5 m of overburden are plotted on accompanying maps. Only the major resource areas are reproduced here; a complete inventory is available in Proctor & Redfern (1978).

Georgian Bay Shale

Shale of the Georgian Bay Formation is the principal raw material for two brick plants in Ontario. Formerly known by the names Meaford and Dundas, the shale typically is soft with platy lamination, medium grey in colour, and interbedded with hard limy and sandy layers. The few areas where Georgian Bay Shale occurs within 7.5m of the surface are shown on accompanying maps (Proctor & Redfern 1978). These maps do not attempt to distinguish Queenston Shale from Georgian Bay Shale, but economically significant resources of the latter are restricted to the townships of Trafalgar, Toronto and Toronto Gore.

Stratigraphically, the Georgian Bay Formation underlies the Queenston Formation and is also of Ordovician age. It reaches its maximum extent in the Toronto area, where it forms the shoreline of Lake Ontario between Oakville and West Hill, extending to the north with diminishing width, and finally disappearing beneath Georgian Bay north of Meaford. Thickness of the formation in the Toronto area is about 175 metres; thinner to the north.

Exposures of Georgian Bay Shale are few and practically confined to the Toronto area, where they may be seen on the lower reaches of the Humber and Credit Rivers and Mimico and Etobicoke Creeks.

Like Queenston Shale, Georgian Bay Shale has barely sufficient plasticity for the extrusion machines used for brick making. While it does not suffer as much as Queenston Shale in respect to an erratic distribution of gypsum, the frequency of hard limy and sandy layers contributes not only to handling problems in the quarry but also to reduced plasticity and a weakened red-fired colour. The frequency of these hard brittle layers, which average perhaps 10 to 20% of the total formation, increases markedly in the upper part of the formation with the result that certain locations in the Streetsville and Woodbridge areas may not be acceptable for economic utilization.

As with Queenston Shale, Georgian Bay Shale is a most important resource for brick making; it is also a component of Portland cement and was formerly used for making expanded aggregate in Mississauga. Brick plants are located in Mississauga and in Toronto's Don Valley north of the Bloor Street viaduct. Accessibility of future resources is hindered by limited natural extent, heavy overburden, and urban development.

Whitby Shale

Shale of the Whitby Formation has not been utilized in Ontario, and although it shows some promise for expanded aggregate, it is accessible only in the more densely developed southern portion of the Region of Durham where other development interests and market forces are likely to limit the opportunities for its utilization.

Although carbonate content was higher in the shale than desired, testwork with which the writer was associated indicated that finely ground pelletised shale bloated well in a rotary kiln and produced coated pellets with a bulk density of 335 kg per cubic metre; and with the addition of 4 percent iron oxide, a 17 percent reduction in bulk density was possible.

Whitby Shale is of Ordovician age, and it underlies Georgian Bay Shale. It varies from blue to grey to black and lacks the hard limy and sandy layers of the Georgian Bay Shale. The darker units are slightly petroliferous and carbon-bearing.

Several small outcrops are known in the banks of Duffin Creek in the Town of Pickering. Two areas in Pickering of very limited size contain generally less than 15 m overburden but preservation of these lands for their shale resources may not be warranted because of other land use pressures.

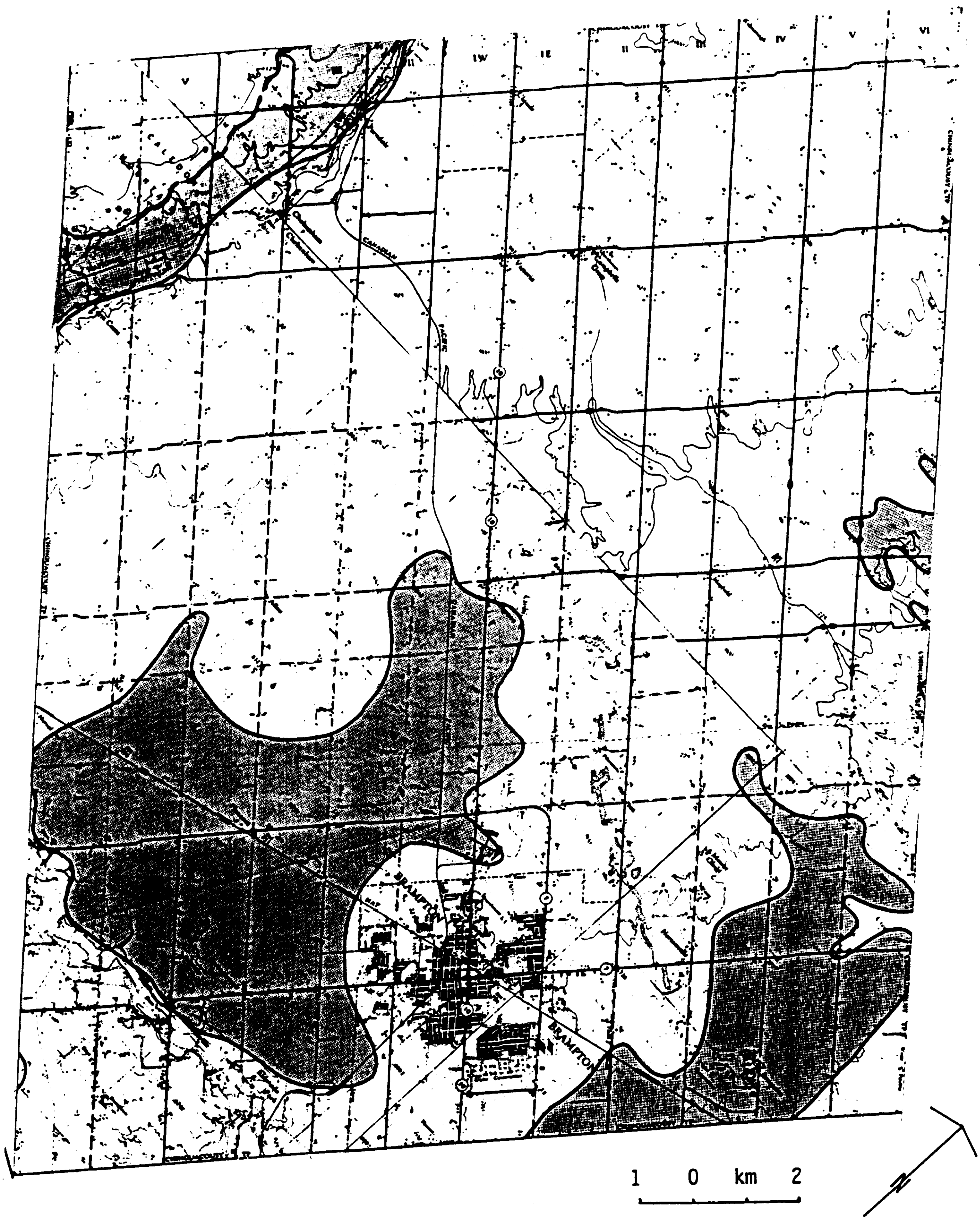


FIGURE 11 : SHALE RESOURCES OF CHINGUACOUSY TOWNSHIP

(Ref: Proctor & Redfern 1978)

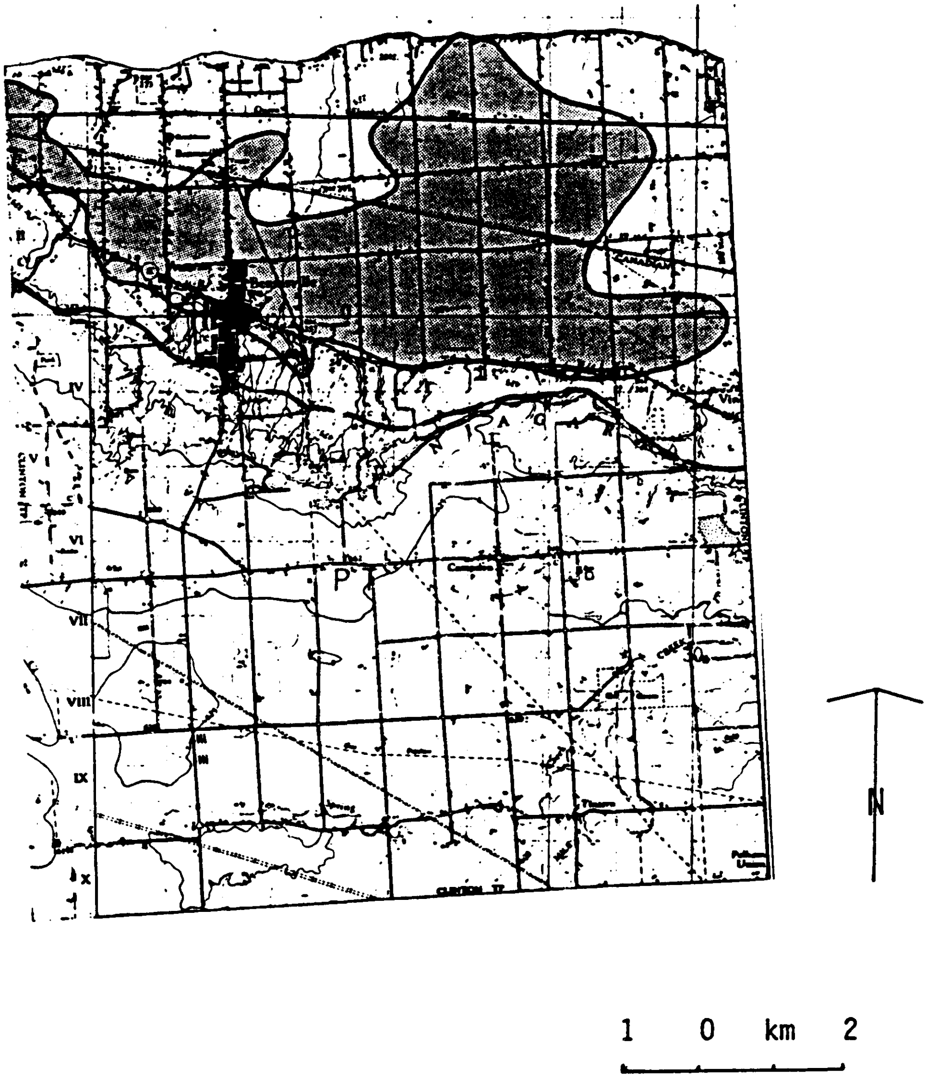
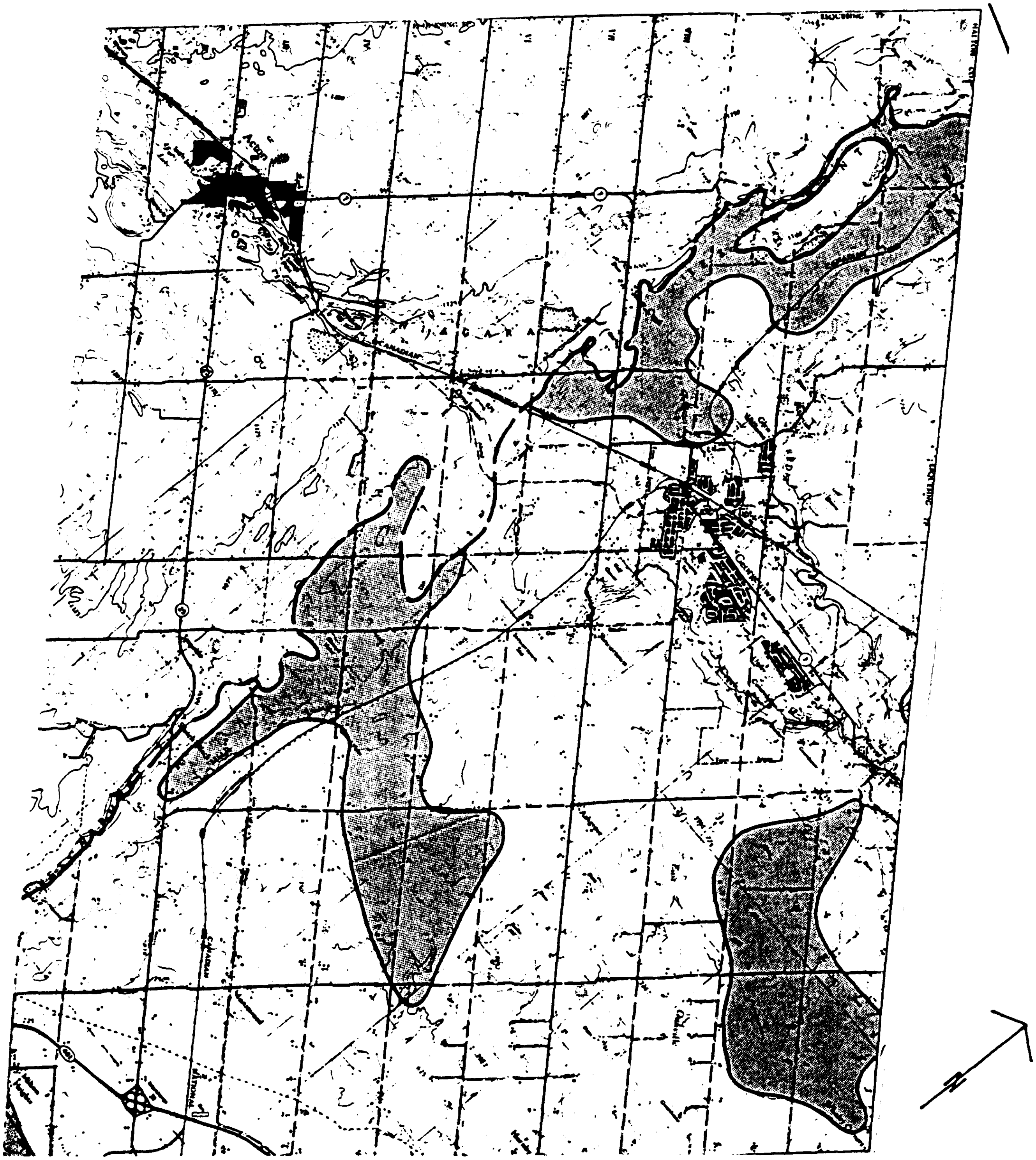


FIGURE 12 : SHALE RESOURCES OF CLINTON TOWNSHIP

(Ref: Proctor & Redfern 1978)



1 0 km 2

FIGURE 13 : SHALE RESOURCES OF ESQUESING TOWNSHIP

(Ref: Proctor & Redfern 1978)

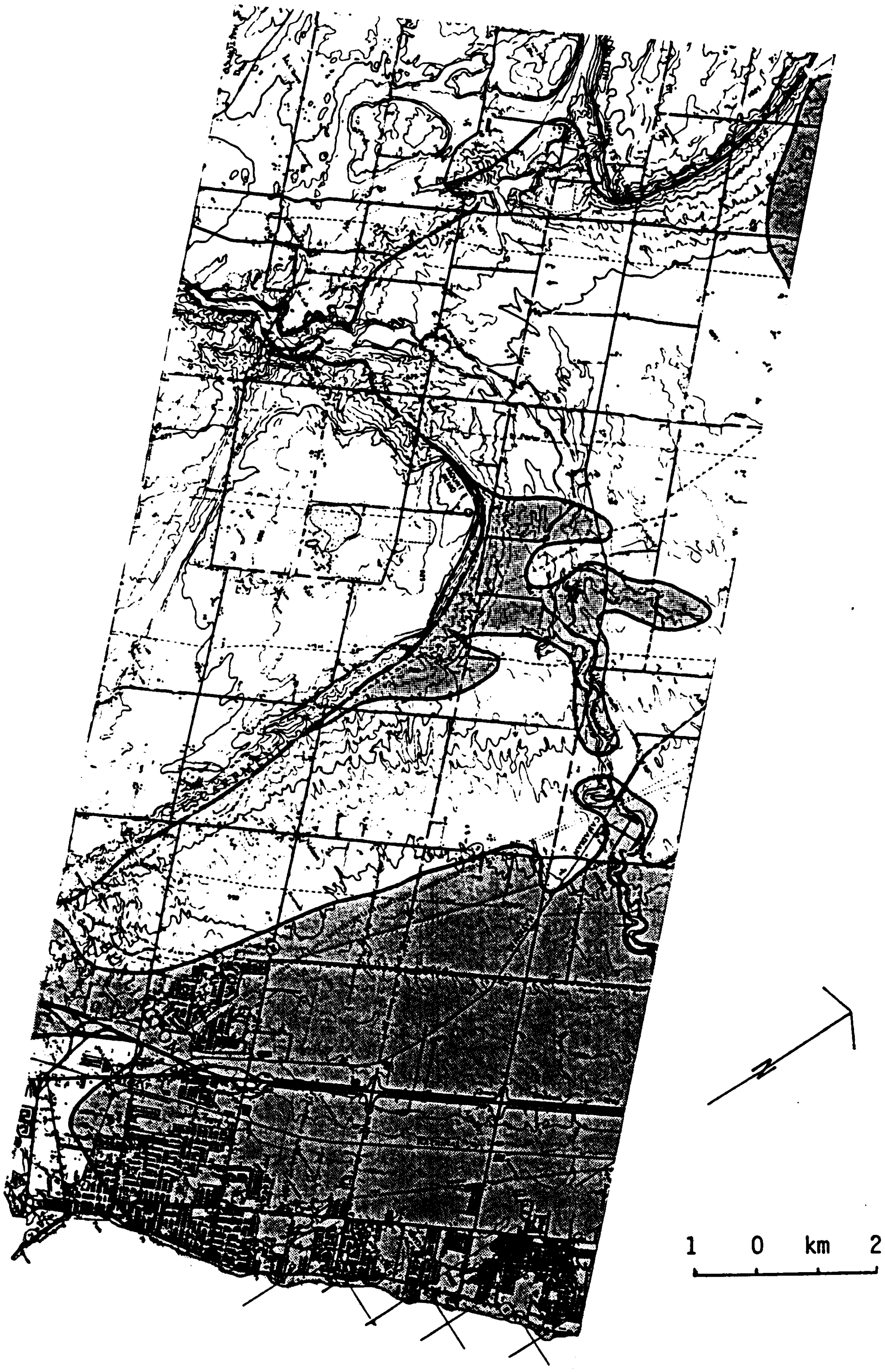


FIGURE 14 : SHALE RESOURCES OF NELSON TOWNSHIP

(Ref: Proctor & Redfern 1978)

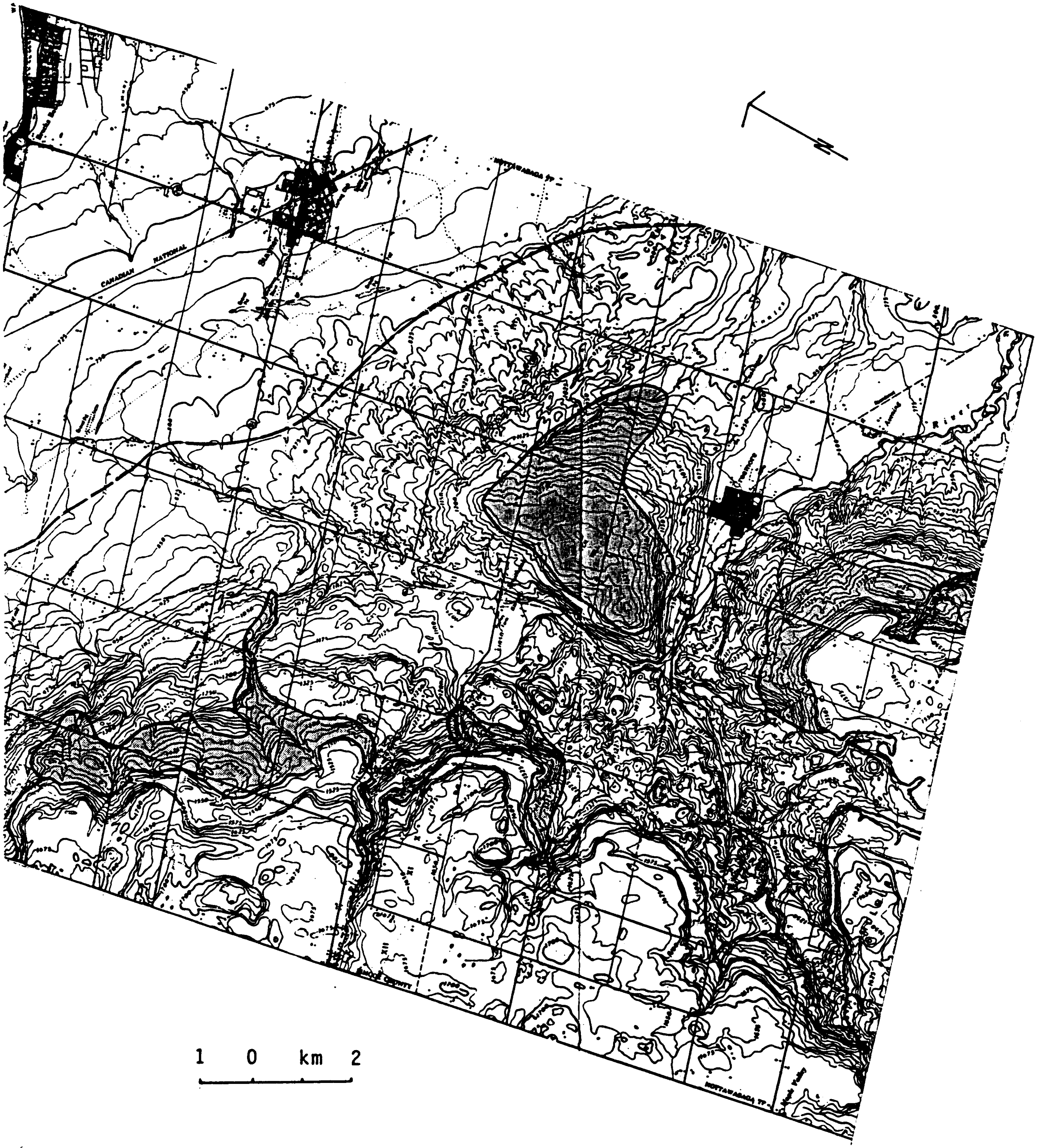


FIGURE 15 : SHALE RESOURCES OF NOTTAWASAGA TOWNSHIP (SOUTH PART)

(Ref: Proctor & Redfern 1978)

FIGURE 16 : SHALE RESOURCES OF TORONTO TOWNSHIP

(Ref: Proctor & Redfern 1978)

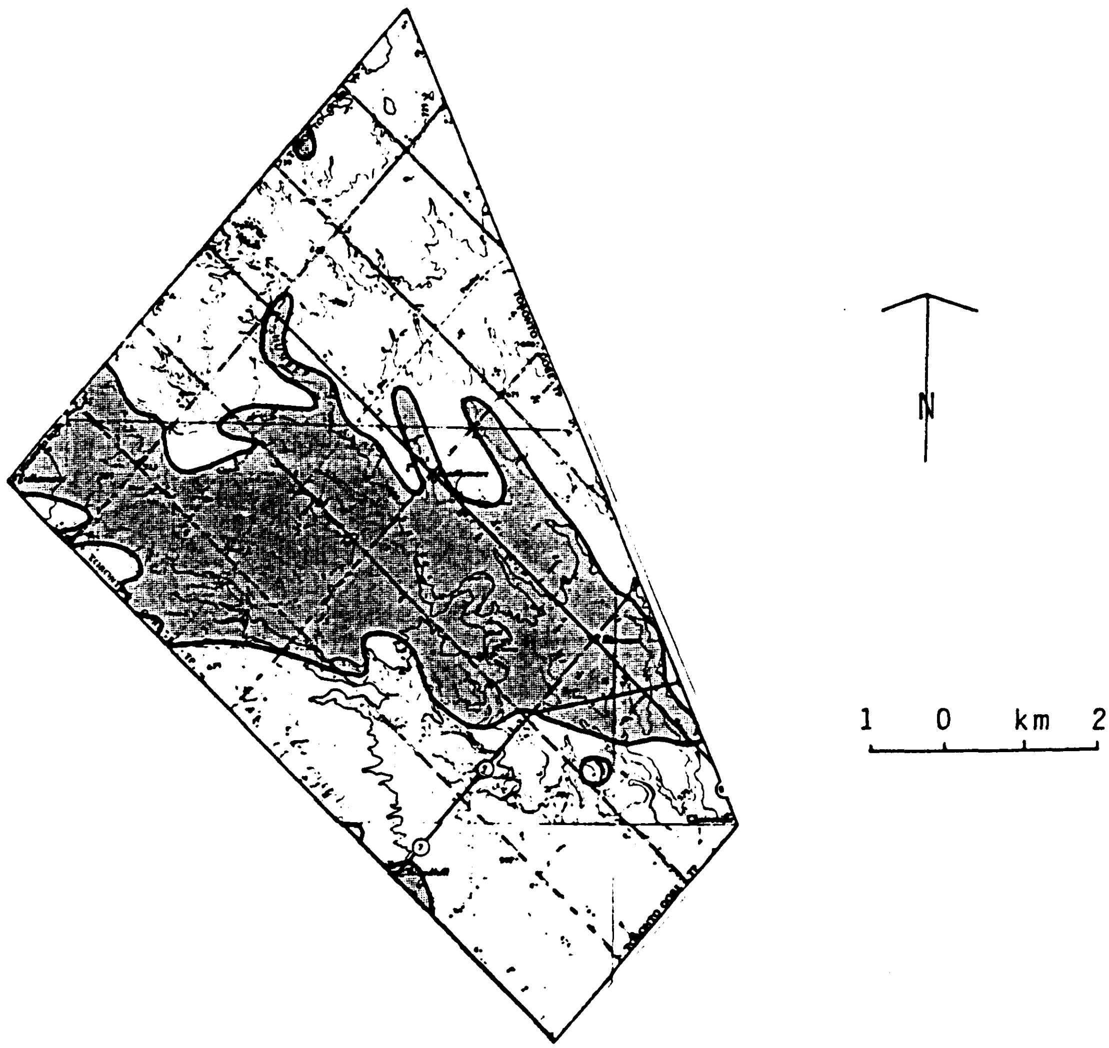


FIGURE 17 : SHALE RESOURCES OF TORONTO GORE TOWNSHIP

(Ref: Proctor & Redfern 1978)

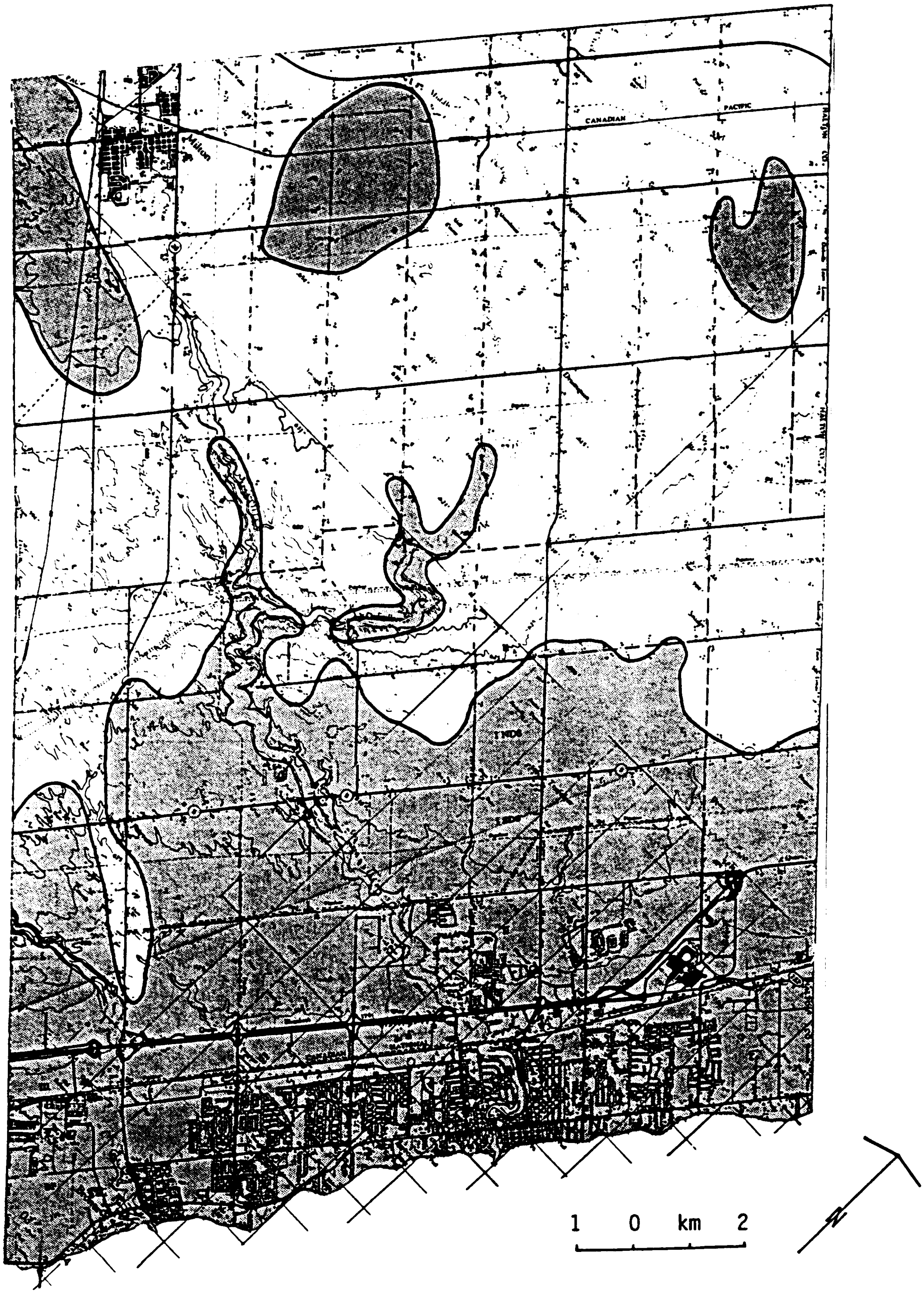


FIGURE 18 : SHALE RESOURCES OF TRAFALGAR TOWNSHIP

(Ref: Proctor & Redfern 1978)

SILICA

There is presently a strong demand for silica in the Central and Southwestern Regions, mainly for glass-making and foundry use. Much of this demand results from the high cost of imported silica, a cost which reflects escalating transportation charges. Nearest domestic commercial sources are operated by Indusmin Limited with producing plants at Midland, Ontario, and St. Canut, Quebec.

Finely-ground silica has many uses, but the major uses are in glass, where it forms the bulk of the batch, and in moulds to prevent sticking when casting molten iron and steel. For glass sand, high chemical purity is necessary, and uniformity from shipment to shipment is essential; iron and alumina should be less than 0.03% (as Fe_2O_3) and 0.5% respectively, and other metals such as titanium, chromium and cobalt should not exceed a few parts per million. For foundry sand, high chemical purity is also necessary, and rounded quartz grains are preferred.

In the Central Region, silica for glass is shipped from the Midland plant which grinds quartzite from a source in northern Georgian Bay. A small area of Oriskany Sandstone in the Town of Haldimand may have potential to fill some of the glass sand needs of the Region. Medina (Whirlpool) Sandstone in the Niagara Escarpment, described in the Building Stone section of this report, has been used to a minor extent as a silica flux.

Midland Silica

Indusmin Limited quarries high-purity quartzite from Badgeley Island at the north end of Georgian Bay. Lump quartzite is shipped for use in the manufacture of ferrosilicon, and only the finer fragments unavoidably produced in the crushing process are used by the Midland grinding plant. The plant process includes drying, grinding, screening and air-classifying, and the product is shipped mainly for glass-making in the Central Region.

Oriskany Sandstone

The only exposure of Oriskany Sandstone in Ontario outcrops in an area of several square kilometres in the former Oneida and North Cayuga townships, now the Town of Haldimand. The occurrence was the subject of much environmental concern in public hearings that preceded the opening of Genstar's Oneida crushed aggregate quarry in 1979. Although that quarry uses only the underlying Bertie-Akron Dolomite, it stockpiles the sandstone that is stripped from the quarry area.

Typically a thickness of 1 to 3 m of sandstone is available in the immediate area of the Oneida Quarry, but as much as 6 m may be available elsewhere. The stone is buff to grey, medium-grained, thin to thick bedded, and in places rusty stained. Because of a variable content of calcium and magnesium carbonates up to about 6 percent, acting as a natural cement for the subrounded quartz grains, the stone varies from compact to friable.

A number of small quarries have been opened in the sandstone from time to time (Figure 19) and in 1962 two quarries were operated intermittently by William R. Barnes Company and by Cayuga Quarries Limited (Hewitt 1963, p.27). Until 1981 the Barnes company continued to ship small amounts of the sandstone for use in the manufacture of rock wool insulation.

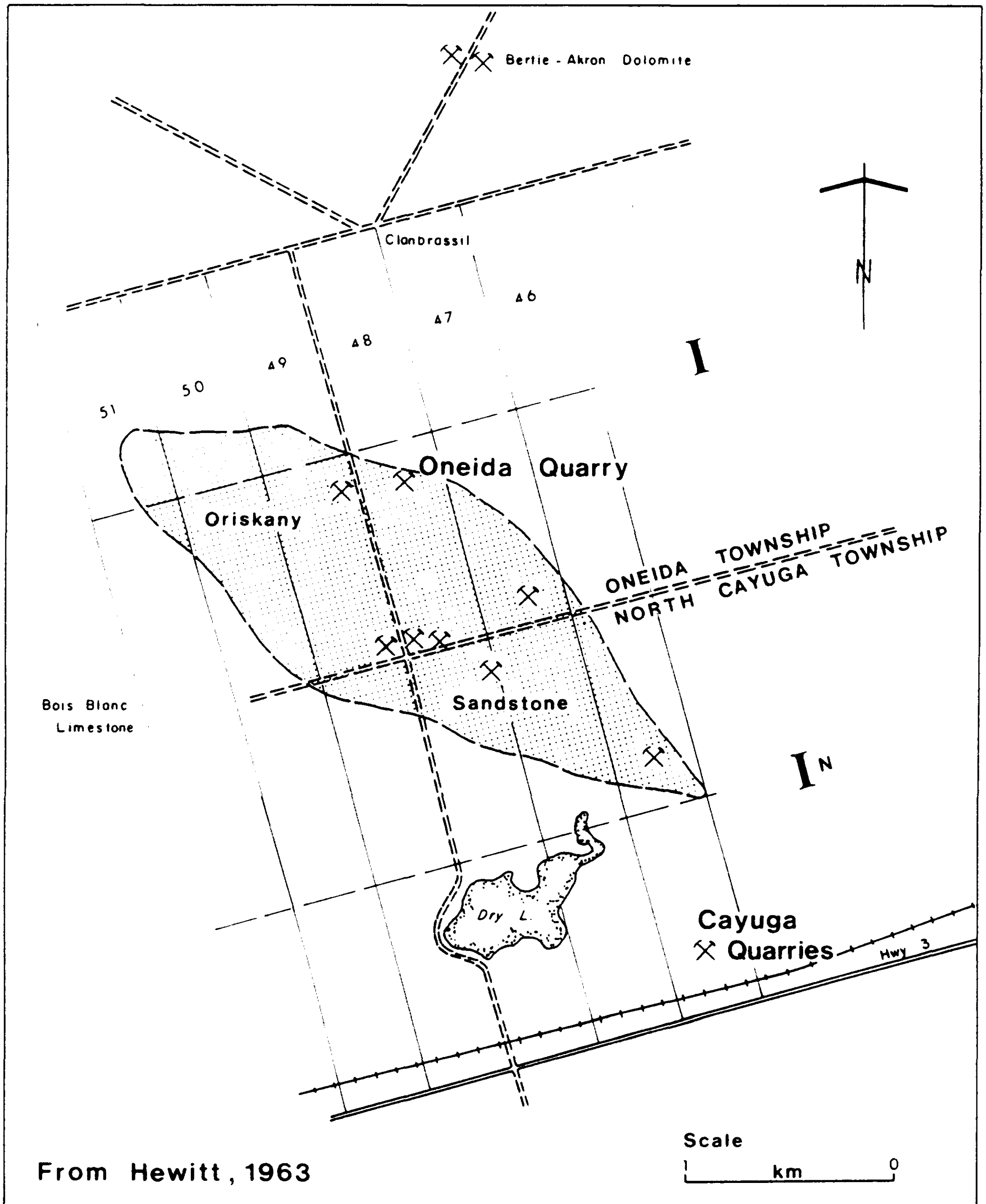


Figure 19

Oriskany Sandstone Area
Oneida & North Cayuga Townships

The most active period of development was 1912-1918 when Oneida Lime Company, Pilkington Brothers, and Consolidated Plate Glass Company held portions of the sandstone lands. Oneida Lime Company produced glass sand and foundry sand during this period from a quarry in the south part of lot 49, concession I, Oneida Township. Pilkington Brothers also produced a small amount of glass sand from a nearby quarry in lot 48.

Although the iron and lime contents are much too high in the crude sandstone, private laboratory studies are presently underway to determine if an acceptable glass-grade product can be produced for today's more demanding market.

Medina Sandstone

The Whirlpool Member of the Medina Sandstone is an important building stone, as elsewhere described in this report. It has also been used to a small extent as a source of silica for rock wool and as a flux or refractory in Hamilton steel plants (Hewitt 1963, p.25). William R. Barnes Company has operated intermittently for this purpose on the west half of lot 19, concession

V, in the former Esquesing Township, now the Town of Halton Hills. The working face is only a metre thick beneath 3 m of overburden. Whirlpool Sandstone here and elsewhere is really too thin and impure to be an important source of silica on a significant scale.

TRAPROCK

Metagabbro intrusives and associated diorites and metabasalts are important sources of traprock in Belmont Township. The only producer of roofing granules in Canada is 3M Canada Inc., located just north of Highway 7 about 5 km east of Havelock. Other occurrences northeast of this location, near the Crowe River, have been shown to be suitable for traprock asphalt aggregate (HLI) for surface courses on heavily travelled roads.

3M Canada Incorporated

This company operates a large quarry in fine-grained metagabbro in the west part of lot 7, concession V, Belmont Township. The rock is a uniform, dense, hard, green, massive stone that tends to break into equidimensional (cubic) fragments as desired for roofing granule use. The stone is practically free of sulphide minerals, a feature also necessary for roofing granules to avoid unsightly rusty staining on shingled surfaces. The plant and quarry employ 100 to 125 people, and the operation is a major economic feature of the area.

Originally started in 1907 by Ontario Rock Limited to produce crushed aggregate for road surfacing, the operation was taken over in 1948 by Building Products Canada Limited to produce principally roofing granules, artificially coloured. In 1960 the operation was purchased by Minnesota Minerals which in 1973 became 3M Canada Inc. As a result of a fire in 1962 a new mill was erected, and a major expansion program in 1979 substantially increased its productive capacity. The company supplies most of the Canadian market for roofing granules and makes minor shipments to Belgium and France.

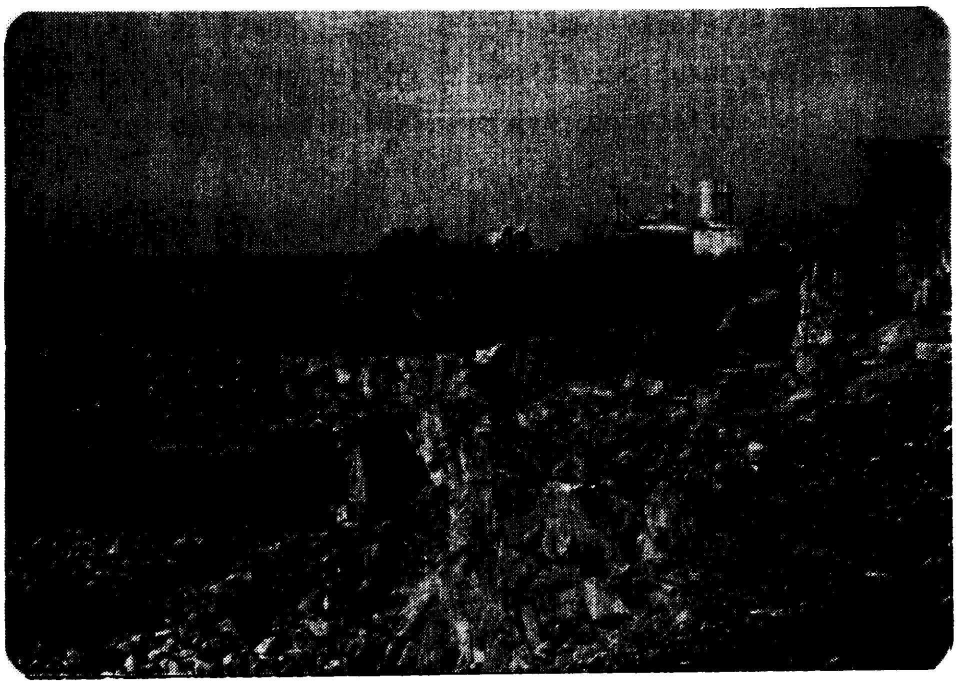


PHOTO 11 : TRAPROCK QUARRY, 3M CANADA INC.

The quarry occupies an area of 250 m by 500 m and since 1971 has been worked on a second lift 12 to 15 m high. Blasthole drilling is accomplished with a Gardner Denver PR66 machine which drills 10 cm holes on a 3 m grid pattern. Twenty holes are blasted about once a week, and secondary breaking is accomplished by a dropball. Two shovels (a Marion 3 yd. and a Northwest 2.5 yd) are used for loading two Terek trucks of 22 tonne capacity and for overburden removal. Broken stone is transported out of the quarry to the primary crusher, an Allis Chalmers jaw with an opening of 1.5 by 1.2 m, discharging at minus 15 cm.

About 630,000 tonnes are quarried annually. Minor slabby or soft slips and sulphide zones are wasted. The rest is crushed and screened to produce a granule in the -10+35 mesh range, the principal size demanded by the roofing granule market. The annual production of granules is about 270,000 tonnes, about half of the total rock milled. Some of the finer product is sold for asphalt filler in the -65+200 mesh range, but substantial amounts of fine material are stockpiled for lack of a market. Markets for coarser products for road surfacing and poultry grit are not sought because of low prices.

Surface colouring dyes, which are actually ceramic coatings, are applied to the granules in any of 14 principal colours depending on market demand. Products are shipped to asphalt shingle manufacturers throughout Canada primarily by train; lesser amounts are shipped by truck.

This company has a large investment in its Havelock facilities in terms of dollars and technology. Its major problem is that it has essentially a single product that is dependent solely on the residential construction market. In the interest of conserving its raw material it chooses not to seek other granular markets such as poultry grit, decorative aggregate, and traprock aggregate for the surface asphalt coat on high-traffic roadways, because it finds these markets relatively unprofitable. However, it does have finely ground waste products which are unavoidably produced in the grinding process, and for which a byproduct use is needed.

Crowe River Deposit

Medium to coarse grained metagabbro occupies much of lots 13 and 14, concession I, Belmont Township. The property is owned by C.R. Young of Havelock and is zoned for extractive purposes.

In 1974 Mr. Young submitted a sample to the Ministry of Transportation and Communications for an assessment of its suitability as a crushed aggregate, with the following results (C.R. Young, personal communication). The limiting quality specifications for HL1 (traprock) hot mix asphalt aggregate is shown for comparison.

	Crowe River Traprock	HL1 Maximum limits
Petrographic number	100.2	100
Magnesium sulphate soundness, % loss	1.5	5
Absorption, percent	0.36	1.0
Los angeles abrasion, % loss	11.5	15
Bulk specific gravity	3.038	

Crowe River traprock would undoubtedly make a good crushed aggregate for HL1 uses and other specialty granular markets. At present there is no suitable long term source of this material available for the Central and Southwestern Regions of the province. The principal problem with the commercial utilization of this resource is its distance from much of the market area and the high transportation costs that would be involved.

Although the Crowe River site may be environmentally sensitive because of sporadic cottage development and water quality concerns, the site is relatively high and dry and well-wooded, and should be able to be worked with minimum impact. Road access would have to be improved and perhaps rerouted to avoid cottage communities.

There is a continuing market for traprock aggregate in Central and Southwestern Ontario, and a lack of a suitable commercial source. There would seem to be an opportunity for the economic development of the Crowe River resource.

URANIUM

Radioactive pegmatite dikes and sills in Harvey Township, especially in metasediments and metavolcanics west of the Burleigh gneiss dome, may have potential for uranium mineralization. According to Bright (1980, p. 69) the overlapping Paleozoic strata should also be considered:

> "The flat-lying Paleozoic strata which unconformably overlie the southern part of the Bancroft uranium belt in Harvey Township should be considered as a potential target for uranium concentrations analogous to the Ordovician South March uranium deposit in March Township near Ottawa (see Grasty 1973).
>
> The basal unit of the Paleozoic strata in Harvey Township is conglomeratic feldspathic sandstone of the Ordovician Shadow Lake Formation (Liberty 1955). A reconnaissance scintillometer survey of this permeable clastic unit by the writer indicated no anomalous radioactivity."

The likelihood of finding economic occurrences of uranium in the Central Region is not considered great, but exploration should be encouraged. Uranium mining is likely to be an underground operation with minimal disturbance to the surface environment.

UNDERGROUND RESOURCES

The multiplicity of pit and quarry operations in the Central Region has been a continuing social and environmental problem inspite of site enhancement and rehabilitation requirements which have been imposed by regulatory authorities. Also,competition for land use and sterilization of resources through urbanization have put a premium price on remaining resource lands. In consequence, more remote sources are being developed inspite of escalating haulage costs.

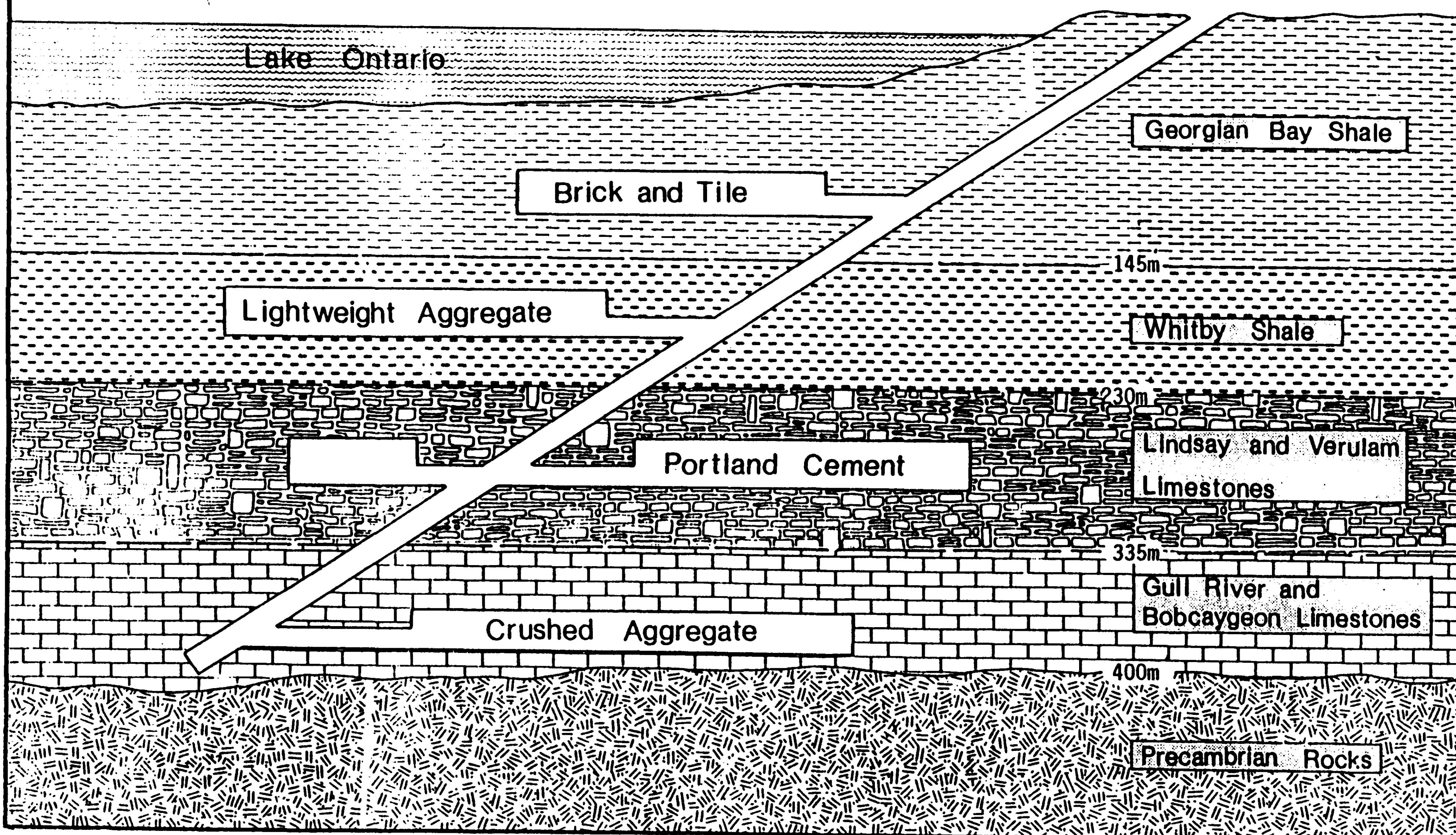
As these factors assume increasing significance in the final delivered price of a wide variety of industrial mineral commodities, few alternatives are available. However, one alternative that is receiving increasing interest is underground mining in the Toronto area.

Underground mining could provide much of the Region's requirements for crushed aggregate, cement and brick shale. It might also encourage renewed production of expanded shale aggregate and chemical lime, and provide access to oil shale resources.

A sequence of horizontal Ordovician shales and limestones 300 to 500 m thick underlies the Toronto area. Near the base, on top of the Precambrian rocks, are limestones of the Simcoe Group: The relatively pure and sometimes high-calcium limestones of the Gull River and Bobcaygeon formations are generally suitable for crushed aggregate and may also be a source of chemical limestone. The shaly limestones of the Verulam and Lindsay formations are ideally suited for Portland cement. Shales of the Whitby Formation show promise for expanded medium-weight aggregate and in places are petroliferous. Shale of the Georgian Bay Formation is used in brick-making and cement.

Figure 20

The Potential for Underground Mining at Toronto



We believe an inclined shaft from the Toronto shoreline to give access to these resources beneath Lake Ontario offers the best situation in respect to legal, economic, and environmental concerns. Advantages of such a development are:

1. Mineral rights vested solely with the Ontario Government.

2. Closest accessible site to the market centre.

3. Eliminates social concerns (largely unwarranted) for subsidence.

4. Facilitates use of deepest mined-out space for surge electric power generation.

5. Ready access to expressway road system for truck distribution of products.

A large integrated mining and development complex could be created from a single inclined shaft having a number of working levels developed in the most suitable strata. To minimize the impact of the operation on local social systems, all processing and stockpiling could be underground. Multi-deck, highspeed, belt conveyors could transport materials to surface as required, and truck traffic could be fed directly into the Region's excellent arterial road system to minimize local disturbance.

Mining beneath Lake Ontario has the combined advantages of minimizing local concern for subsidence, as well as avoiding the multiplicity of mineral ownership. It also offers the potential for valuable secondary use of part of the mined-out space for surge electric power generation. Other uses for parts of the mined-out space include hydrocarbon storage, storage of business or institutional records, and disposal of solid waste. With adequate development planning all of these uses could take place simultaneously in various parts of the underground workings, while mining continued in other parts.

Escalating haulage cost from existing sources within the Region is the major economic factor that encourages consideration of underground mining near the market centre. In the final analysis it will be a trade-off of transportation costs versus underground mining costs that will make the decision. But the economics of underground mining for low-priced mineral commodities must also be enhanced by the diversity of mineral products available, the variety of secondary uses for the mined-out space, and the improved surface environment from pits and quarries no longer needed.

As a preliminary, we believe a single vertical hole should be drilled on the lakeshore to the Precambrian surface, and the drillcore carefully logged and evaluated for its chemical and physical suitability for a variety of mineral products.

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