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Ontario Geological Survey
Open File Report 5730

Carbonate Building Stone Resources of the Lake Simcoe – Kingston Area, Southeastern Ontario

1990

Ministry of
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ONTARIO GEOLOGICAL SURVEY

Open File Report 5730

Carbonate Building Stone Resources of the Lake Simcoe-Kingston Area, Southeastern Ontario

by

P.S. LeBaron and D.A. Williams

1990

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Ontario Geological Survey

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V.G. Milne, Director
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CONTENTS

List of Tables

List of Figures

List of Photographs

Map (back pocket)

Building Stone Resources of the Eastern Part of the Lake Ontario Lowland, scale 1:250,000

ABSTRACT

The Paleozoic limestones and dolostones of southern Ontario have been used as building stone since the early 1800's. Within the Lake Simcoe-Kingston area, rocks of the middle Ordovician Gull River and Bobcaygeon formations have been quarried extensively for the construction of dams, bridges, walls, and buildings. Current activity is limited to the production of flagstone, terrazzo chips, and rubble. Renewed interest in the use of natural stone for building purposes and in the restoration of historic stone buildings has created opportunities for the development of local building stone resources.

Lithographic limestone and red limestone/dolostone of the Gull River Formation and lithographic to fine crystalline limestone of the lower member of the Bobcaygeon Formation are the most favourable units with respect to colour, durability, bed thickness, and exposure. Bed thickness is not sufficient to allow the extraction of large mill blocks, but is suitable for the production of ashlar, flagstone, terrazzo, and possibly veneer. Bedrock exposure of the favourable formations, determined by recent geological mapping and quarry descriptions, and low overburden thickness are the criteria used in outlining areas of good building stone potential.

ACKNOWLEDGEMENTS

The authors would like to thank R. R. Wolf, consulting geologist, Toronto, for providing unpublished quarry descriptions and location maps. Keith Blades, consultant in the conservation of historic buildings, Ottawa, provided information on the current use of and demand for limestone for restoration work in Ontario. The authors also thank Michael Johnson, Acting Supervisor of the Paleozoic and Mesozoic Geology Subsection of the Engineering and Terrain Geology Section, for initiating the study and providing editorial comments, and Paul Kingston, Resident Geologist, Ministry of Northern Development and Mines, Tweed, for reviewing the final manuscript.

Paleozoic Carbonate Building Stone Resources of the Lake Simcoe-Kingston Area, Southern Ontario

by P.S. LeBaron[1] and D.A. Williams[1]

1.0 INTRODUCTION

The limestone building stone industry has contributed significantly to the development of southern Ontario, being a major source of construction material for commercial, residential, and public buildings as well as bridges, dams, and retaining walls from the early 1800's to the 1920's. Although the industry has been relatively dormant in southeastern and south-central Ontario since that time, a return to the use of natural stone in building styles, evident throughout North America in recent years, has created opportunities for the development of local building stone resources.

The use of Paleozoic rocks of southern Ontario as building stone has been briefly discussed in recent reports by the Ontario Ministry of Northern Development and Mines. Open File Report 5706, "Building Stone Potential in Eastern Ontario" (LeBaron et al 1989), deals primarily with Precambrian granite and marble but also includes a short discussion on the potential of Paleozoic rocks as sources of rough building stone and commercial marble. The three-volume report, "Limestone Industries of Ontario" (Derry Michener Booth and Wahl and Ontario Geological Survey 1989 a-c),

1Geologist, Ministry of Northern Development and Mines, Tweed.

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includes descriptions of several current building stone operations, and a report titled "An Evaluation of the Economic Potential of the Paleozoic Rocks in Southeastern Ontario" (Wolf and Williams, in prep.), describes the geology of and commodities produced from the entire range of Paleozoic rocks in southeastern Ontario.

This study was undertaken to complement the aforementioned reports by focussing on the potential for building stone production from Paleozoic rocks within the Kingston to Lake Simcoe area of south-central Ontario. More specifically, the study is confined to limestones and dolostones of Middle Ordovician age within the Ministry of Natural Resources districts of Napanee, Tweed, Lindsay, and Minden.

Development of the industry in this area will depend upon the successful promotion of stone from relatively small quarry operations for use in local markets. The relatively thin bedding and variable colour of the middle Ordovician strata preclude quarry development on the scale of the well-known Adair quarries, of Arriscraft Corporation near Wiarton, large dimension stone producers in the more uniform, thickly-bedded members of the middle Silurian formations exposed along the Niagara escarpment.

This report combines descriptions and locations of former building stone quarries with the results of recent geological mapping as a guide to exploration for Paleozoic building stone in south-central Ontario. High potential zones are outlined based upon the presence of favourable formations at bedrock surface in

areas of shallow overburden cover. Emphasis is given to the production of building stone blocks (ashlar) and veneer from thick-bedded units, but the use of more thinly-bedded sections for flagstone and crushed stone (used in the manufacture of terrazzo and agglomerated stone) is also considered.

1.1 PREVIOUS WORK

Descriptions of past and current producers of building stone from Paleozoic rocks are presented in reports by Miller (1904), Parks (1912), Goudge (1933, 1938), Verschuren et al (1985, 1986), LeBaron et al (1989), Derry Michener Booth and Wahl and OGS (1989 a, b, and c), Wolf (in prep.), and Wolf and Williams (in prep.).

1.2 METHODOLOGY

An inventory of inactive and active Paleozoic building stone quarries within the study area was obtained by reviewing previous reports, the most comprehensive of which are Parks (1912), Goudge (1938), Derry Michener Booth and Wahl and OGS (1989 a, b, and c), and Wolf (in prep.).

Quarry descriptions were obtained from previous reports and, in some cases, from recent re-mapping by D.A. Williams. The quarry locations were marked on a 1:250,000 scale geological map of the study area which shows fault blocks and contacts between Paleozoic formations as mapped and interpreted by D.A. Williams.

1.3 LOCATION OF STUDY AREA

The focus of this study is a wedge-shaped area of Paleozoic sedimentary rocks extending northward from Lake Ontario between the Kingston and Lake Simcoe areas (Figure 1). This area is

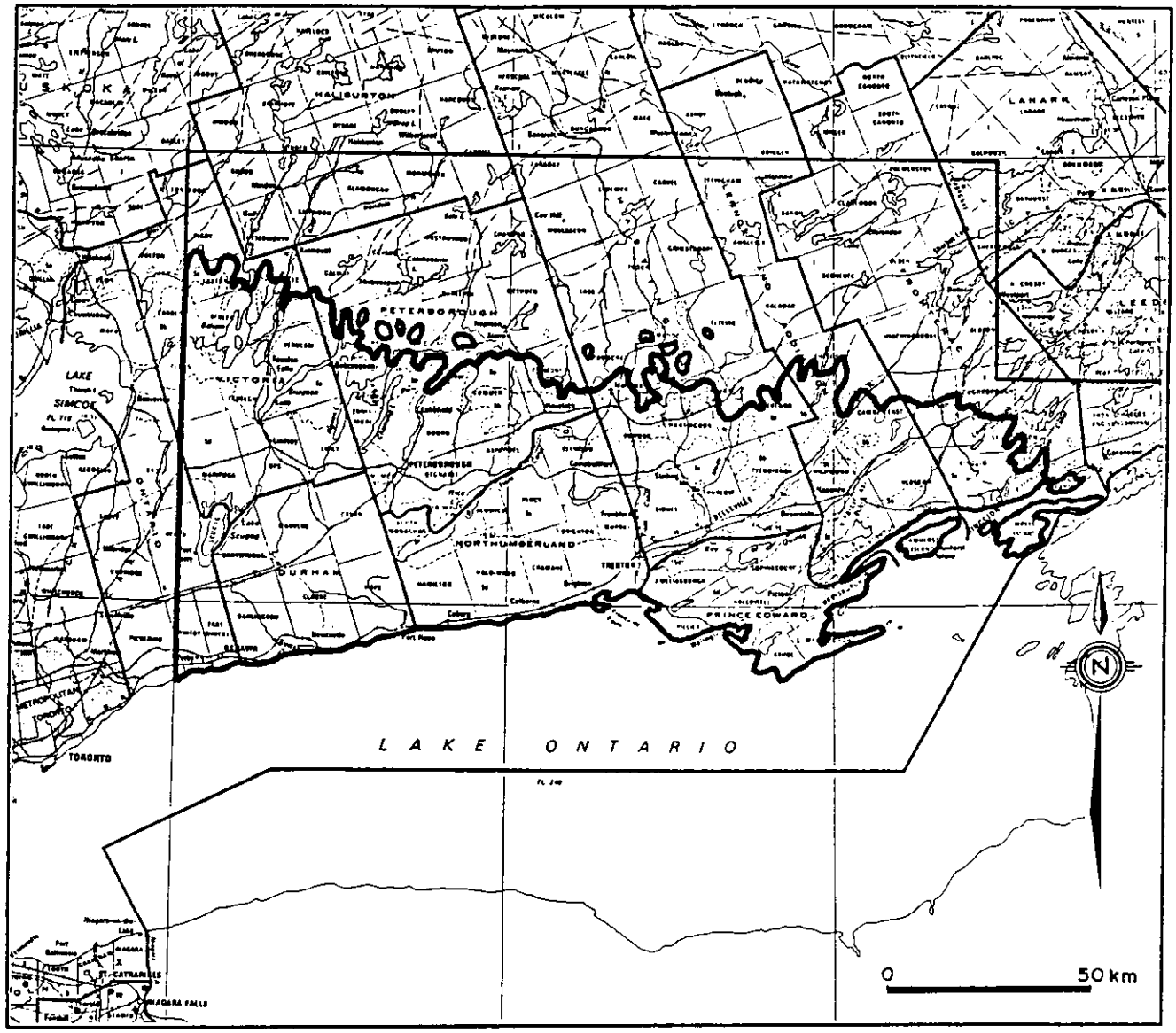

Figure 1. Location of the study area, showing the extent of middle Ordovician strata.

bounded by latitudes 43° 45′ N and 44° 45′ N and by longitudes 76° 00′ W and 79° 00′ W. Topographic coverage of the area is provided on 1:250,000 scale NTS sheets 31C (Kingston), 31D (Lake Simcoe), 30 M (Toronto), and 30 N (Rochester).

1.4 DEFINITIONS

The greatest potential for the development of Paleozoic building stone resources within the study area lies in the production of ashlar and, to a lesser extent, veneer, flagstone, terrazzo, and agglomerated stone. These terms, in addition to several others commonly used in the building stone industry, are defined below.

Agglomerated Stone. The solidified product of a mixture of dust to fist-sized stone and pigmented binder (resin). The mixture can be used to produce a molded object or a primary working block which is then cut and finished in the same manner as a quarried mill block.

Ashlar. Rectangular blocks of stone up to about 30 cm in length, and usually 10 to 30 cm in thickness, bounded by sawn, planed, or planar surfaces and used in walls or building facings. "Split-faced ashlar" has a natural rock face produced by splitting the stone in a guillotine (Photo 1). "Even-faced ashlar" uses blocks of equal height for each course, and "random-coursed ashlar" uses blocks of differing height and length.

Building stone. Building stone is classified as either mill blocks or dimension stone. "Mill blocks" are large, rectangular quarried blocks weighing up to 40 tonnes. "Dimension stone" or "cut stone" is stone cut or sawn into specific shapes and sizes,

including cut stone pannels, tiles, sills, steps, and ashlar.

Flagstone. Large, flat pieces of stone from 2 to 8 cm in thickness used for paths, steps, patios, etc. "Regular flagstone" is rectangular and "random flagstone" is irregular in shape.

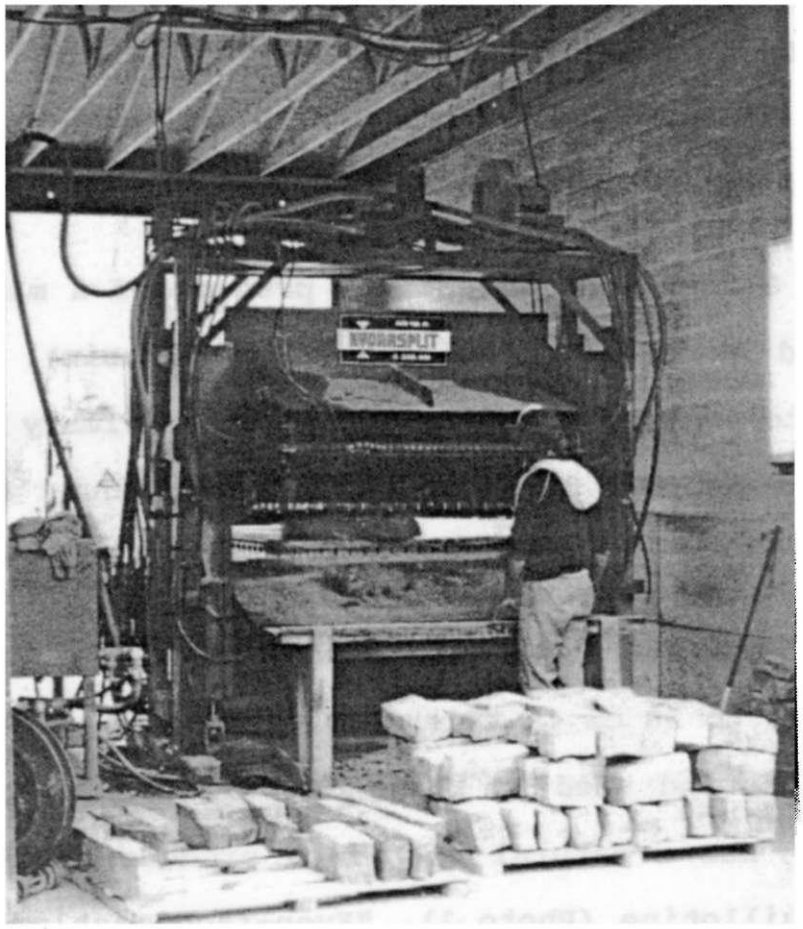

Photo 1. Hydraulic splitter (guillotine) used to produce ashlar, Owen Sound Ledgerock, Wiarton quarry.

Marble. Any carbonate rock that can be polished. Paleozoic carbonates which have been marketed as commercial marbles in Ontario include "Adair Marble", a dolostone produced by Arriscraft Corporation near Wiarton, and a black marble tile produced from Bobcaygeon Formation limestone by Karnuk Marble Industries at Cornwall. Serpentinites, whether of metasedimentary or meta-igneous origin, are also classified as commercial marbles.

Rubble. Building stones up to about 30 cm in length of irregular shape and size (not regularly rectangular) which produce uneven coursing.

Terrazzo. Marble and limestone chips of various sizes and colours bonded by a cementing matrix and usually cast in place as floors and window sills. After hardening, the surface is ground and polished with portable equipment.

Veneer. Thin slabs of stone 1.5 to 8 cm in thickness, irregular or regular in shape, used as facing stone for buildings and walls.

1.5 QUARRYING METHODS

Hand quarrying methods are employed at almost all small building stone quarries in Ontario which produce ashlar, flagstone, sills, coping, steps, etc. from Paleozoic rocks. Equipment consists of air compressors, drills, crowbars, wedges, plugs and feathers, and in some cases, hydraulic splitters and portable stone saws.

Photo 2 illustrates plug and feather quarrying in which the back

Photo 2. Plug and feather quarrying of a dolostone block, Don Ross quarry, Wiarton.

Photo 3. Quarrying a 55 cm thick dolostone bed using a pneumatic rock drill and forklift, Owen Sound Ledgerock, Wiarton quarry.

face has been split by a line of plugs and feathers, the sides are natural joints, and the block is being lifted by a wedge being driven along a bedding plane at the free face.

Fork lifts are commonly used to pry blocks from the quarry face (Photo 3), usually after vertical faces have been established by drilling, plug and feather splitting, or diamond saw cutting. In some cases, the fork lift is the only equipment used and slabs of less regular shape are extracted.

The stone may be cut and shaped by hand (hammer and chisel), diamond saw, or guillotine (hydraulic splitter, shown in Photo 1) at the quarry site.

1.6 HISTORY OF ONTARIO PALEOZOIC BUILDING STONE

Building stone production in southern Ontario developed into a significant industry between 1824 and 1832 during construction of the Welland and Rideau canals, which required extensive quarrying of limestone blocks for dams, locks, and retaining walls. Many of the stone masons who were hired from Great Britain and Europe for these projects remained in Ontario and continued using stone in the construction of commercial and residential buildings, bridges, and public works. The evenly-bedded Paleozoic limestones, being accessible, easily quarried, and easily dressed, were the most frequently used building stones.

In the early 1900's, concrete and cement blocks produced by the portland cement industry began to replace stone as construction material. Parks (1912) reports 137 active building stone quarries in Ontario's Paleozoic limestones and dolostones.

However, some others had already switched from building stone to crushed stone production for the cement industry and by 1933 there were only 14 active limestone quarries producing building stone (Goudge 1933).

In 1986, only 12 Ontario limestone quarries were producing building stone (Derry Michener Booth and Wahl and OGS 1989a). Most of these are located on the Bruce Peninsula near Wiarton and near Queenston on the Niagara Escarpment. Three are located within the Lake Simcoe-Kingston area, and one at Cornwall, east of the study area. The three producers within the study area are relatively small operations, producing rubble and flagstone from quarries in Harvey and Dummer townships, Peterborough County.

1.7 MARKET OPPORTUNITIES

The building stone industry has experienced substantial growth in recent years with a return to traditional building styles which make use of natural stone for reasons of aesthetics, low maintenance, and improved finishing/construction costs. The DPA Group Inc. (1987) report that, "discussions with many architects and developers based in central Canada indicate that there is a definite resurgence in the use of natural stone", with the primary markets being Toronto, Ottawa, and Montreal. The same report states that the Marble Institute of America reports "phenomenal growth" in the industry, and that this trend applies to the residential market as well as the commercial construction market.

With the current interest in conserving historical buildings, there is a demand for limestone ashlar which will closely match the original building stone. Because of the absence of local producers, most of the stone is imported from Quebec and the United States (Keith Blades, consultant in the conservation of historic buildings, Ottawa, personal communication 1990). Although the restoration market alone would not support a long-term quarry operation, promotion of the stone for residential construction could substantially increase the product demand.

Natural stone products face competition from manufactured building stone which may be preferred for its uniformity of colour and shape and for security of supply. However, advantages of natural stone include its uniqueness, durability, and easy maintenance which are proven in buildings showing little deterioration over periods of over 100 years, such as those of Queen's University and the Royal Military College in Kingston.

2.0 PALEOZOIC GEOLOGY OF THE STUDY AREA

The Paleozoic strata within the Kingston to Lake Simcoe area range in age from Cambro-Ordovician to Upper Ordovician (Figure 2). The stratigraphic nomenclature used in this report is based upon that of Liberty (1969) and Russell and Telford (1983), revised to a minor extent by Williams (in prep.). For a comparison of the stratigraphic subdivisions shown in Figure 2 with those of Liberty (1969), the reader is referred to Derry Michener Booth and Wahl and OGS (1989a).

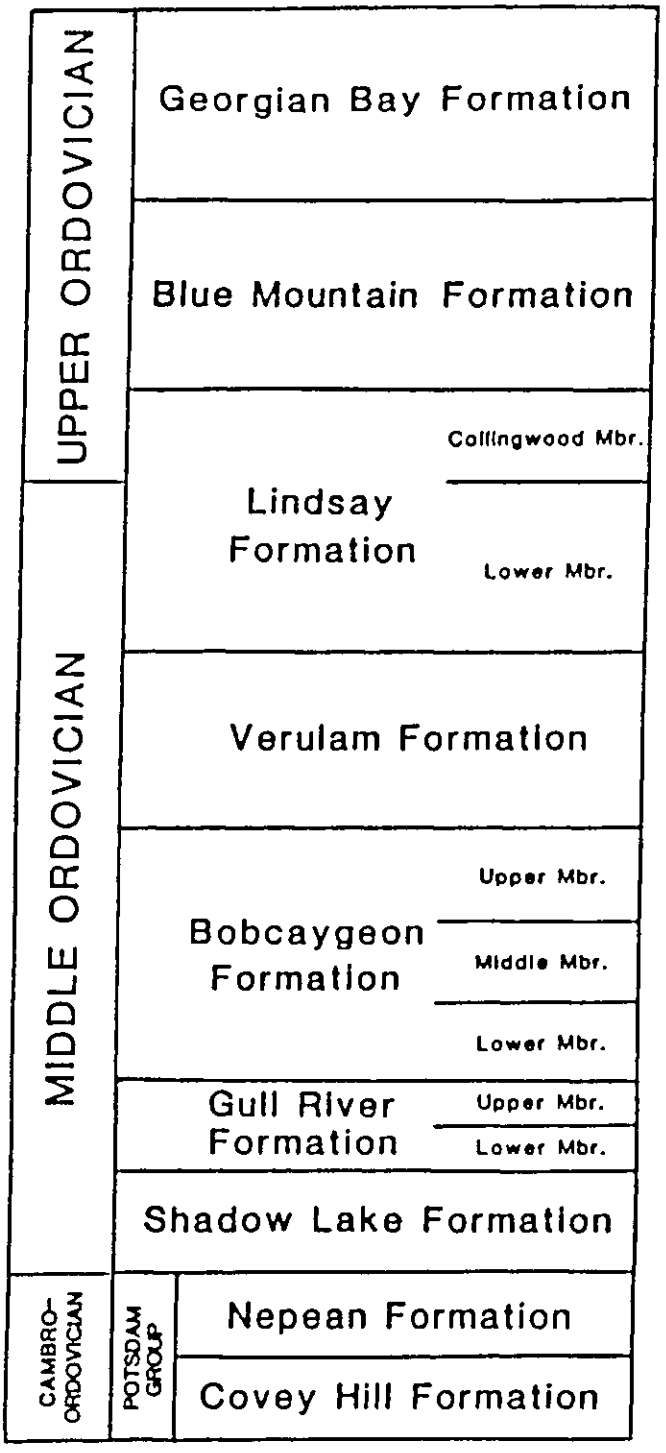

Figure 2. Stratigraphic column of Paleozoic strata in the Lake Simcoe-Kingston area.

The Paleozoic rocks of the study area display a shallow, southwestward regional dip which results in the exposure of successively younger strata from northeast to southwest. On the accompanying map (Building Stone Resources of the Eastern Part of the Lake Ontario Lowland, back pocket), the various formations have been grouped into map units according to age as follows: 1) Precambrian (undifferentiated metamorphic and igneous rocks); 2) Upper Cambrian-Lower Ordovician (Nepean Formation); 3) Middle Ordovician (Shadow Lake, Gull River, and Bobcaygeon Formations); 4) Middle-Upper Ordovician (Verulam and Lindsay Formations); and 5) Upper Ordovician (Blue Mountain and Georgian Bay Formations). The following descriptions of formations are summarized from Derry Michener Booth and Wahl and OGS (1989a).

2.1 DESCRIPTIONS OF FORMATIONS

2.1.1. Nepean Formation

The basal Paleozoic unit, exposed to the north and east of Kingston, is the Nepean Formation of the Potsdam Group, a sandstone of Cambrian to Lower Ordovician age which is quarried for building stone in the Kingston area.

2.1.2. Shadow Lake Formation

Overlying the Nepean Formation in the extreme eastern part of the study area and lying directly upon Precambrian basement rocks in the remaining parts is a sequence of conglomerates, sandstones and shales up to 12 m thick. These rocks comprise the Shadow Lake Formation and are generally not used as a source of building stone or industrial raw material.

2.1.3. Gull River Formation

The Gull River Formation, formerly subdivided into three members in the Lake Simcoe area (Liberty 1969) and four members in the Kingston area (Liberty 1971 a-e), is now considered to consist of only two members (Williams, in prep.).

The lower member of the Gull River Formation consists of alternating units of limestone and dolostone. The limestones are dominantly microcrystalline, commonly with a lithographic texture, and are interbedded with rare thin-bedded, fine-crystalline intervals. The fine-crystalline dolostones commonly contain small amounts of terrigenous material that ranges from mud to sand sized. This member thickens from 15 m in the west to 40 m in the Kingston area.

The redefined upper member of the Gull River Formation consists of thin-bedded limestones, commonly containing thin shale partings between the beds, and thickens from 5 m in the west to 20 m in the east.

The Gull River Formation has been quarried for many years, especially around Lake Simcoe and Kingston. The stone has been used for aggregate, lime, cement and building purposes, including bridges, town halls and churches throughout central Ontario. Aggregate producers currently utilize most of the rock which is quarried from the Gull River Formation in central Ontario, especially the lower member. The major areas of production are east and west of Lake Simcoe and around the city of Kingston.

2.1.4 Bobcaygeon Formation

In the Lake Simcoe area the Bobcaygeon Formation had been subdivided into three members by Liberty (1969), whereas in the east only a two-fold subdivision was used (Liberty 1963, 1971a-e). The Bobcaygeon Formation can now be subdivided into three members across all of central Ontario, and is approximately 25 m thick. The primary distinction between the members is the presence of numerous thin shale partings between the limestone beds in the middle member, while the lower and upper members are virtually shale-free.

The lower member of the Bobcaygeon Formation consists of thick-bedded limestones, with beds usually over 1 m in thickness. The microcrystalline to fine-crystalline limestones are usually intermixed with medium-to coarse-grained calcarenites, and commonly contain nodules of hard, black chert.

The middle and upper members of the Bobcaygeon Formation are similar to the lower member, except for the higher shale content in the middle member. The thin-to medium-bedded, very fine-to medium-crystalline limestone beds of these members are interbedded with medium-to coarse-grained calcarenites. The upper member may also display a distinctive blue-grey weathered surface.

Outcrops of the middle and upper Bobcaygeon Formation are rare, relative to the Gull River Formation, and lower Bobcaygeon Formation, which is often exposed as a caprock in quarries. Where the formation is accessible, the unit is utilized primarily

by the aggregate industry. In the past some building stone operations have used material from the lower member.

2.1.5 Verulam Formation

The term Verulam Formation was applied by Liberty (1969) to a sequence of interbedded limestone and shale which overlies the Bobcaygeon Formation. The Verulam Formation is approximately 65 m thick; exposures, however, are isolated because of the thick glacial deposits over most of the area where the formation occurs.

The interbedded nature of the limestone and shale lithologies also makes the formation easily erodable and few natural outcrops remain, although the formation can be examined in quarries and roadcut exposures. The carbonate lithologies vary from very fine-crystalline limestones, virtually fossil-free, to coarse-crystalline, bioclastic limestones. The limestone beds rarely exceed 10 cm in thickness and the 1-5 cm thick interbeds of shale are commonly calcareous and burrowed extensively.

The Verulam Formation is not used as building stone and is rarely utilized by the limestone industry because of its high shale content, but in an outcrop area between Belleville and Kingston it is used as a source of aggregate and for cement manufacture.

2.1.6 Lindsay Formation

The Lindsay Formation, as used in this report, can be subdivided into two members: the lower member, a nodular limestone (Liberty's Lindsay Formation), and the upper Collingwood Member, black calcareous shale (Liberty's lower member, Whitby

Formation). The lower member ranges from very fine-to coarse-crystalline and fossiliferous. On weathered surfaces these thin-bedded limestones commonly exhibit a nodular texture because of very thin, undulating shale partings. The black shales of the overlying Collingwood member may either overlie the limestones with a minor disconformity, or may be interbedded with the limestones over a thickness of several metres. This member is characterized by black, petroliferous, very calcareous shale which contains a rich fossil assemblage. The Middle-Upper Ordovician boundary occurs near the contact between the lower and upper members of the Lindsay Formation.

The limestones of the lower member range in thickness from 60 m in the west to over 100 m in Prince Edward County, south of the City of Belleville. The black shales of the Collingwood Member maintain a uniform thickness of about 10 m across central Ontario.

The limestones of the Lindsay Formation are used primarily as raw material for the manufacture of cement.

2.1.7 Blue Mountain Formation

The Upper Ordovician Blue Mountain Formation (Russell and Telford 1983) includes the middle and upper members of the Whitby Formation of Liberty (1969). The blue-grey shales of the Blue Mountain Formation outcrop only rarely in the western part of central Ontario and are not used by the building stone industry.

2.1.8 Georgian Bay Formation

The Georgian Bay Formation (Liberty 1969) is rarely exposed in central Ontario, and where it is exposed the formation consists of interbedded limestone (rarely dolostone) and shale. The formation averages 100 m in thickness and has been subdivided several times into members by various workers (see Liberty 1969 for a summary). Thick glacial overburden, limited exposures, and a high shale content preclude its use as a source of building stone. St. Lawrence Cement Inc. has quarried the rock at its Mississauga plant for use in cement manufacture, and rock from the formation is used in the Toronto area as a raw material for brick manufacturing.

2.2 STRUCTURAL GEOLOGY

The Paleozoic sedimentary rocks within the study area are nearly flat-lying, dipping at a very low angle to the southwest. They have been subjected to post-Paleozoic faulting which has produced a number of normal fault blocks showing displacements commonly in the order of 10 to 40 m and, more rarely, up to 100 m.

The faults trend parallel to four major rift systems: 1) the Ottawa valley system (east-southeast), 2) the Lake Ontario-St. Lawrence valley system (east-northeast), 3) the Timiskaming valley system (south-southeast), and 4) the Champlain valley system (north-northeast). They generally show a topographic expression such as a linear depression (river, creek, or swamp) or escarpment.

3.0 PAST AND PRESENT PALEOZOIC BUILDING STONE PRODUCERS

A total of 39 past and present producers of building stone from Paleozoic carbonate rocks within the Lake Simcoe-Kingston area have been identified and are listed in Table 1 according to formations present within the quarry section. The quarry numbers and names are those used by Derry Michener Booth and Wahl and OGS (1989 a-c) and Wolf (in prep.). Quarries are designated with respect to Ministry of Natural Resources district by the letters L (Lindsay/Minden), NP (Napanee), and TW (Tweed). Quarry locations are shown on the accompanying map (back pocket). Quarry locations and descriptions are found in the appendix to this report.

Three additional quarries are listed in Table 1. Quarry TW-1, the Marmoraton Mining Company open pit iron mine (inactive), produced no building stone but exposes a Paleozoic section from the Shadow Lake to Bobcaygeon formations. The Lower Bobcaygeon member is exposed at the surface of the quarry and has potential for building stone production. Quarries H-6 and H-26 (Huronia District) lie just west of the study area and are former producers of building stone from both the Gull River (upper member) and Bobcaygeon (lower member) formations.

Of the 39 building stone quarries within the study area, only 3 are current producers and one produces terrazzo chips intermittently. It is likely that there are more than 36 former producers, however; many of the abandoned quarries and active aggregate quarries have no record of early production.

Table 1. Past and present building stone quarries by formation and member (L-lower, M-middle, U-upper)

Formation (member)						
Shadow Lake	Gull River		Bobcaygeon			Verulam	Lindsay
	(L)	(U)	(L)	(M)	(U)		
	L-5		L-38				NP-212
	L-6*		L-43				
	L-8*		NP-5				
	L-9*	NP-15	NP-15				
	L-26	NP-64	NP-59				
	NP-212	NP-141	NP-60				
	NP-214	NP-146					
	NP-221	NP-169					
	NP-266	NP-170					
	NP-276	NP-171					
	NP-277	NP-172					
	NP-291	NP-178					
	NP-299	NP-261	NP-261				
		NP-263	NP-314				
		NP-264					
TW-1	TW-1	TW-1	TW-1				
	TW-2						
TW-3	TW-3		TW-4				
	TW-21	TW-34	TW-34				
	TW-23						
	TW-28						
		H-6	H-6				
		H-26	H-26				

*Active building stone quarry

The Blue Mountain and Georgian Bay formations are not included in Table 1, having no historical building stone production and little potential for future production because of their high shale content and poor exposure. Similarly, the Verulam and Lindsay formations have little building stone potential due to high shale content and/or thin bedding. The only quarry listed in the Lindsay Formation (NP-112) produced blocks of thinly-bedded limestone and shale which were used as foundation stone in the early 1900's (Parks 1912). The Shadow Lake Formation, consisting primarily of conglomerates, sandstones, and shales, is also not a potential source of building stone. Quarry TW-3 extends into the Shadow Lake Formation but produces limestone chips only from the overlying Gull River Formation (Derry Michener Booth and Wahl and OGS 1989b).

Therefore, the only formations of interest as potential sources of building stone within the study area are the Gull River and Bobcaygeon. Typical examples of building stone produced from quarries within the various members of these formations are described below.

3.1 GULL RIVER FORMATION, LOWER MEMBER

The lower member of the Gull River Formation hosts the only current producers of building stone within the study area as well as many important former producers. The two primary types of stone produced are very light-weathering lithographic limestone which has been used extensively in building construction and

reddish grey dolostone used less widely as ashlar, flagstone, and terrazzo chips.

The lithographic stone is best represented in the Kingston area and can be seen in many municipal buildings and in the buildings of Queen's University and the Royal Military College. The stone is light grey to dark brown on the fresh surface, with a smooth, lithographic texture marked by stylolites, shaly partings and patches of small calcite crystals ("birdseye" texture). The most outstanding feature of this stone is its white to pale grey weathered surface which develops after several years of exposure. It occurs in beds up to 50 cm thick with thin shale interbeds over a stratigraphic interval of up to 6 m, occasionally with interbeds of yellowish-weathering dolomitic limestone. Photo 4 shows thick bedded, light grey lithographic limestone interbedded with brownish grey dolostone at the Petworth Quarry in Portland Township, northwest of Kingston (quarry NP-212). Stone from this quarry has recently been used in the construction of a McDonald's restaurant in Kingston.

Similar stone to that of the Kingston area quarries is also seen in the Marmora area (quarries TW-21, TW-23). Here, the lithographic stone occurs in beds up to 35 cm thick over a stratigraphic interval of about 3 m. Photo 5 shows a 60 cm-thick bed of light grey, lithographic limestone overlain by brownish grey, silty dolostone in a cliff along the west side of the Crowe River at Marmora, near quarry TW-23.

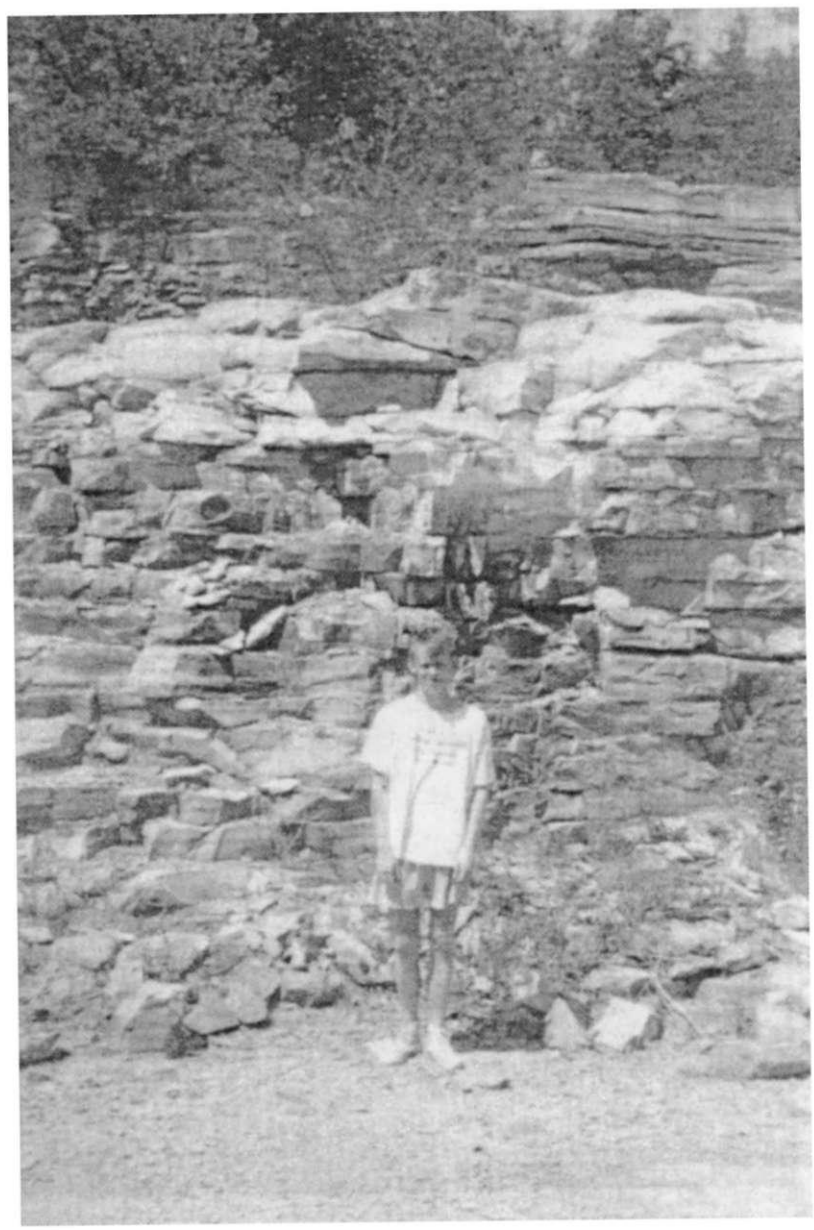

Photo 4. Lower lift of the Petworth Quarry (NP-212), Portland Township, showing interbedded light grey lithographic limestone and brownish grey dolostone of the lower member, Gull River Formation.

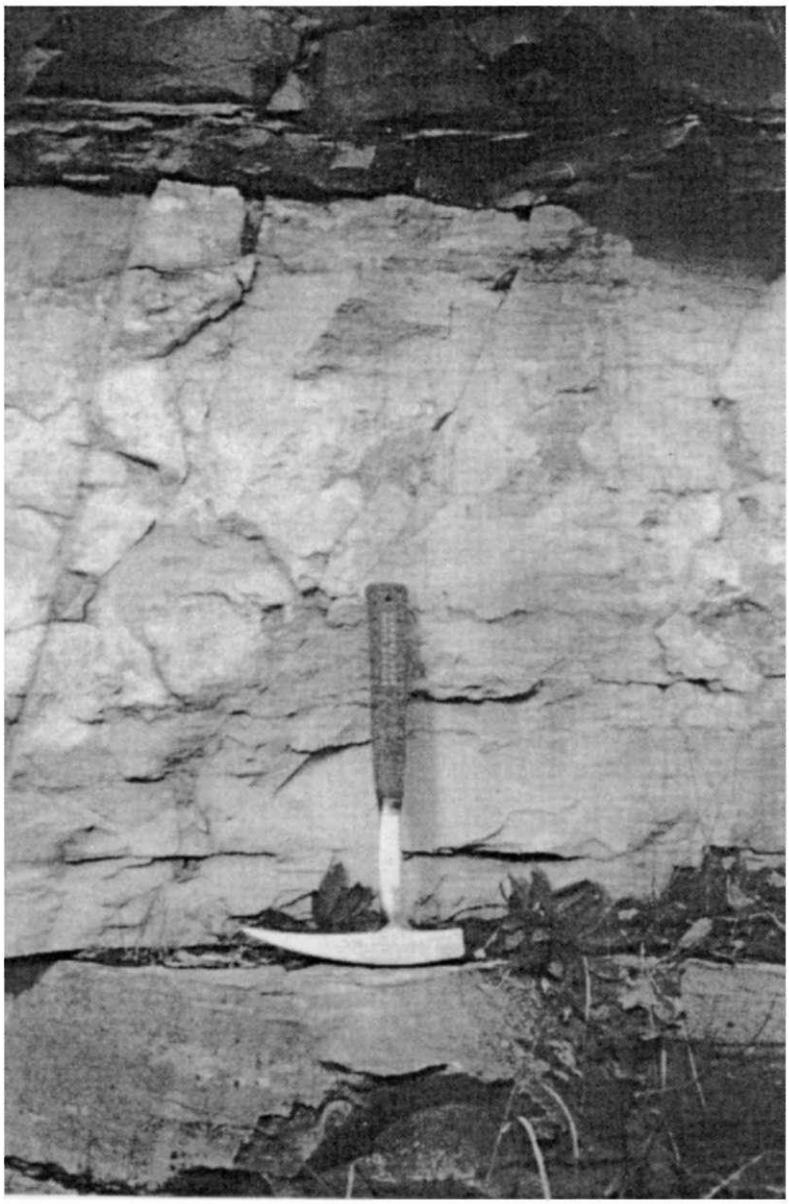

Photo 5. Light grey, lithographic limestone bed 60 cm thick overlain by brownish grey dolostone; Crowe River near quarry TW-23.

A study of the physical characteristics of several limestones used for building purposes (Sharp 1960) indicates that the Kingston area stone is one of the most durable Paleozoic building stones available in eastern North America. In a comparison with stone from Indiana (Bedford limestone), Queenston (Silurian-age dolomitic limestone from the Niagara Escarpment, southwestern Ontario), Manitoba (Tyndall limestone, Upper Ordovician), and Minnesota (Mankato dolomitic limestone, Upper Cambrian), the Kingston stone from the lower member, Gull River Formation exhibited the highest compressive and transverse strength and the lowest porosity.

Reddish grey dolostone beds situated stratigraphically below the lithographic limestone beds, near the base of the Gull River Formation, have been quarried as a source of building stone (ashlar and flagstone) in the western part of the study area (quarries L-5, L-6, L-26) and for the production of terrazzo chips near Madoc (quarry TW-3). This rock, known as "Red Pamelia" stone in the building stone trade, is a fine crystalline, medium bedded dolostone or dolomitic limestone, locally containing scattered quartz grains. Parks (1912) stated that, when polished, the stone is similar in appearance to Tennessee red marble and should be regarded as a decorative material of considerable value.

The "Red Pamelia" stone is not uniformly present throughout the study area. The beds may vary in colour from red to green, maroon, and grey over a thickness of up to 3 m and the rock may vary in composition from dolostone to limestone.

In the western area, the red beds are overlain by light grey, thick-bedded, lithographic limestone which is also currently quarried for the production of flagstone and retaining wall stone (quarries L-8, L-9).

Although the lower unit (Red Pamelia) may contain interbeds of sandy and/or shaly limestone and the upper (lithographic) unit contains shaly interbeds, both are suited to the quarrying of multiple beds over stratigraphic thicknesses of 1 to 6 m.

3.2 GULL RIVER FORMATION, UPPER MEMBER

Within the study area, only thick bedded limestone of the upper member, Gull River Formation has been quarried extensively as building stone. About 25 km west of the study area, however, dolostone of this member has produced large mill blocks for construction purposes.

The limestone is generally medium to dark grey or brownish grey, less commonly light grey, and is lithographic to fine crystalline in texture. It weathers to a darker colour than the lithographic stone from the lower member, commonly dark blue-grey, light grey brown or light grey. Most of the former producers of this stone are situated close to the Napanee River between Napanee and Yarker. Several others are located in the Collins Bay area west of Kingston, and one at Lonsdale, west of Napanee.

Quarry NP-141 (Pybus Quarry) in Richmond Township, north of Napanee, produced stone from a "white" bed 50 cm thick as well as

from two "blue" beds 25 and 60 cm thick (Parks 1912). The white stone, not reported in any other quarries within this member, was a valued building material used in construction of many buildings in Napanee. With this exception, the limestone from the upper member of the Gull River Formation appears to have produced a less attractive stone than that of the lower member and was used less extensively. The reported thicknesses of good building stone range from 1.5 to 3.7 m, usually bounded above and below by thin bedded, shaly limestone.

Dolostone of this member was quarried west of the study area in Rama Township from the 1930's until some time before 1960 (quarries H-6 and H-26). Known as "Rama" stone, it was used as both structural blocks and as polished interior trim in buildings throughout Ontario. The stone is a brown-weathering, light grey-brown to light green-brown, fine crystalline, thick bedded dolostone. The unit is about 3.5 m thick and contains one 30 cm thick bed of greenish grey, shaly dolostone in addition to minor shale leafs and carbonate-filled vugs. It is overlain and underlain by shaly limestone. The presence of these beds within 10 m of surface in Rama Township suggests that there is potential for bedrock exposure of the unit in the western part of the study area.

3.3 BOBCAYGEON FORMATION, LOWER MEMBER

The massive bedded limestones of the lower member, Bobcaygeon Formation have been quarried for use as building stone in all parts of the study area. The stone is most commonly dark grey to brown-grey, weathering grey, brown, or blue-grey, and varies in

texture from lithographic to medium grained. Less commonly, the weathered surface is light grey (quarries NP-15, NP-314) and in one case, the fresh surface is described as being white (quarry NP-5). Beds are commonly over 1 m in thickness over stratigraphic intervals of up to 5 m in which the massive beds are separated by sharp, stylolitic contacts. The limestone locally contains shaly partings, patches of small calcite crystals ("birdseye" texture), and black chert nodules. Photo 6 shows massive bedded, grey limestone in the walls of the H.J. McFarland Construction Co. quarry at Crookston (TW-4).

Although this stone can be extracted in very large blocks, it has not been marketed as cut dimension stone because of the predominantly dark colour of both the fresh and weathered surfaces. However, it has been used extensively as structural blocks in large construction projects. Quarries L-38 and L-43 in Dummer Township supplied limestone from this member for construction of the Trent Canal and quarry TW-4 in Huntingdon Township provided blocks used in the construction of the South Shore and Victoria Bridges in Montreal (Goudge 1938).

Light-coloured beds are also present in the lower member of the Bobcaygeon Formation, and have been used in the construction of local buildings. Quarries at Point Anne (NP-5, NP-59, NP-60) east of Belleville produced both blue-grey and white limestone. The latter was used in the construction of St. Thomas Anglican Church and Albert College in Belleville. Quarry NP-314 on Wolfe Island provided stone for buildings in Marysville from a 4-meter

Photo 6. Thick bedded limestone of the lower member, Bobcaygeon Formation; H.J. McFarland Construction Co., Crookston quarry (TW-4).

section of thick bedded (greater than 1 m), pale grey-brown, pale grey weathering, lithographic limestone of this member.

West of the study area, quarries H-6 and H-26 in Rama Township produced a white-weathering limestone known as "Longford" stone from the lower member of the Bobcaygeon Formation between the late 1800's and the 1930's. The "Longford" stone beds lie about 5 m stratigraphically above the "Rama" stone beds (upper member of the Gull River Formation, described above), and extend over a thickness of about 2 m. The stone is very pale grey, lithographic, and thick-bedded. It was used in many construction projects in Ontario, including the Parliament Buildings and old city hall in Toronto. These beds may also be exposed at or near bedrock surface in the western part of the study area.

3.4 BOBCAYGEON FORMATION, MIDDLE MEMBER

The middle member of the Bobcaygeon Formation has a higher shale content than both the upper and lower members and is not considered to be a potential source of building stone.

3.5 BOBCAYGEON FORMATION, UPPER MEMBER

The upper member of the Bobcaygeon Formation is very similar to the lower member and includes limestone beds suitable for building stone. The apparent absence of building stone production from this member probably reflects its poor exposure.

4.0 BUILDING STONE DEPOSIT CRITERIA

Some of the major considerations in evaluating the potential of a

building stone prospect, particularly with respect to Paleozoic rocks within the study area, are discussed below.

4.1 PHYSICAL PROPERTIES OF THE STONE

Colour and texture control the price and marketability of a stone. Of particular importance are uniformity of colour and a knowledge of what changes, if any, will occur in the colour as the stone weathers. Pale colours are generally the most marketable. However, some dark grey limestones such as those of the lower member of the Gull River Formation used in many of the Kingston area buildings weather to a white to pale grey colour after several years. This attractive feature should be an important consideration in evaluating the market potential of the stone.

The chemical and mineralogical composition of the stone may affect the weathering characteristics. It is important to note the presence of any deleterious minerals such as pyrite and soluble salts.

Absorption and porosity of the rock influence the resistance to freeze-thaw cycles and to staining and efflorescence caused by solution and salt migration within the rock.

General durability and soundness must be demonstrated by a series of physical property tests designed by the American Society for Testing and Materials (ASTM). Testing procedures and minimum specifications are provided for properties such as absorption and bulk specific gravity, compressive and transverse strength, resistance to temperature cycles and wash salt solutions, and

abrasion resistance. They are available from the ASTM (1916 Race Street, Philadelphia, PA 19103, USA).

4.2 SUITABILITY FOR QUARRY DEVELOPMENT

A number of features are required in a building stone prospect in order to facilitate quarrying. These include low thickness of drift and bedrock cover above the desired beds; large surface area available for quarry development; favourable joint pattern and bed thickness; ease of access; and ability to utilize quarry waste.

Photo 7 shows a site which is ideal for quarry development. Removal of a thin cover of vegetation and soil has exposed a large area exhibiting widely-spaced, regular joints. Photo 8 illustrates a quarrying operation on a similar site. Unlike granite or marble dimension stone quarries which exploit relatively large, homogeneous deposits to considerable depths, quarries in Paleozoic rock may exploit only a single bed or a series of beds over a 1 to 2 m stratigraphic interval. Consequently, long-term production of Paleozoic building stone requires a large quarry area. The quarry shown in Photo 3 is about 1 m deep and 7 ha in area. Large producers are generally licensed for quarry areas in the order of 10 to 40 ha.

Transportation costs in the stone industry represent a high proportion of the product price. Therefore, access to a deposit from major transportation routes affects the economic viability. Quarries are not usually developed more than 2 km from existing roads (Verschuren et al 1989).

Photo 7. Limestone pavement showing widely spaced joints, J.S. Cook quarry, Wiarton.

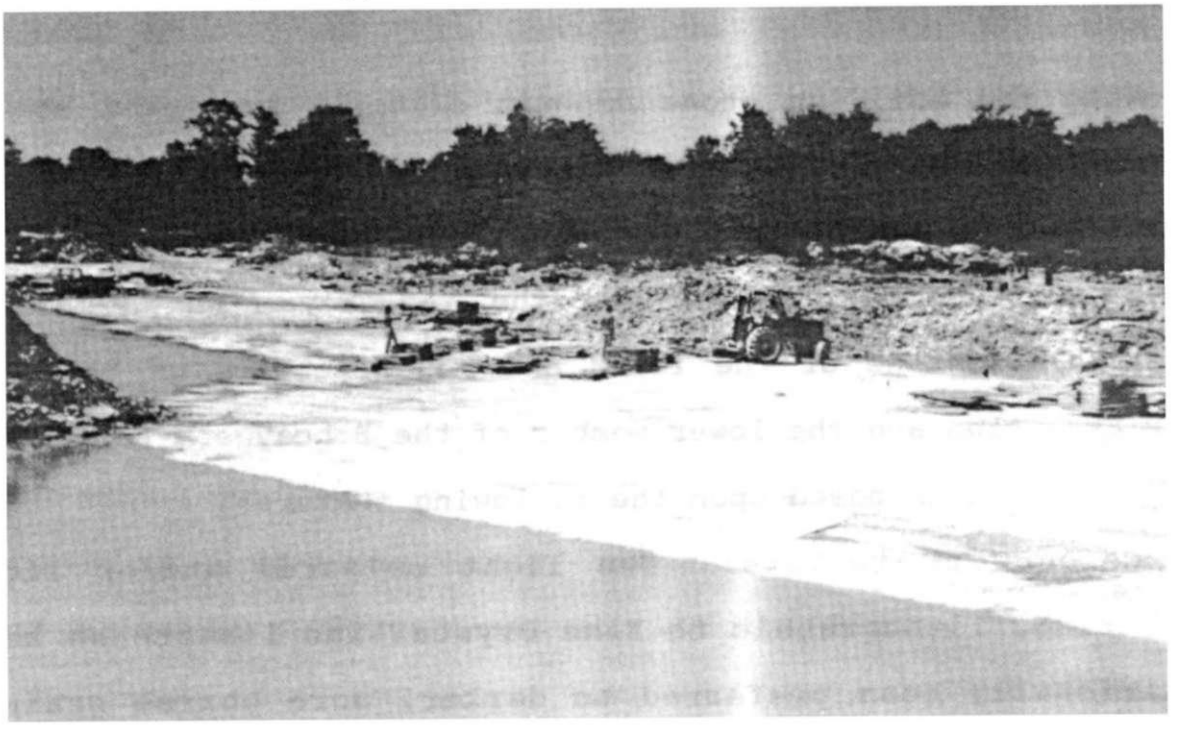

Photo 8. A Paleozoic building stone operation showing shallow depth (1 m) and large surface area of the quarry; Owen Sound Ledgerock, Cruickshank quarry, Owen Sound.

The utilization of quarry waste is also an important factor in the economic feasibility of a Paleozoic building stone quarry. Because of the narrow widths and large areas involved, a small thickness of unsuitable rock overlying the building stone beds may produce an unacceptable waste rock to production stone ratio. The ability to market the waste rock as aggregate, chips for agglomerated stone or terrazzo, random flagstone, or rubble greatly enhances the economic potential of the operation.

5.0 BUILDING STONE POTENTIAL

On the accompanying map (back pocket), areas of good potential for Paleozoic building stone development have been outlined based upon the criteria of favourable Paleozoic strata and low overburden thickness.

Following the building stone deposit criteria presented above, the most favourable strata for building stone development within the study area are the medium to thick bedded, lithographic to fine crystalline limestone and the red-grey ("Red Pamelia") limestone/dolostone of the lower and upper members of the Gull River Formation and the lower member of the Bobcaygeon Formation. This selection is based upon the following features:

1) Colour and texture: The light coloured and/or light weathering, lithographic to fine crystalline limestones have traditionally been preferred to darker, more coarse grained limestone as a building stone. A unique stone such as the "Red Pamelia" may have a wider market potential than a grey stone with

respect to product type (veneer, ashlar, flagstone, terrazzo) and market area.

2) Chemical/mineralogical composition: The selected members contain beds with very low content of deleterious minerals (pyrite, soluble salts) and shale.

3) Durability: Building stone from these members has shown little deterioration in buildings over 100 years old. Tests have shown the lithographic limestones to have considerably higher compressive and transverse strength and lower porosity than several other North American limestones used for building purposes (Sharp 1960).

4) Suitability for quarry development: Thick sections (up to 6 m) of medium to thick bedded limestone and/or dolostone with only minor shale content as shaly partings or shale interbeds within these members are amenable to quarrying and to the production of ashlar, which requires a minimum bed thickness of 10 cm (preferably 30 cm). The ability to quarry multiple beds allows production over a smaller surface area, requiring less stripping of waste material. The low shale content is also conducive to the utilization of quarry waste as flagstone, random ashlar, terrazzo chips, or aggregate.

The criteria of wide joint spacing, accessibility, and large surface area were not considered in determining the areas of good building stone potential. Jointing is generally sufficiently regular and widely spaced to allow extraction of large quarry blocks in the Paleozoic rocks of the study area. Similarly,

access to all parts of the study area is good, and the availability of a large surface area depends upon land zoning, land ownership, etc. and is beyond the scope of this study.

The zones of good building stone potential, therefore, are considered to be those in which the Gull River and Bobcaygeon formations occur at bedrock surface in areas of low overburden thickness. The latter were determined from the outline of limestone plains shown on physiographic maps of southern Ontario (Chapman and Putnam 1972 a, b), and from the distribution of abandoned quarries indicated by Wolf (in prep.).

The main zones of good building stone potential lie within an area bounded by Marmora, Belleville and Kingston to the west and south, and by Precambrian rocks to the north and east. Smaller zones extend westward along the Precambrian/Paleozoic contact to another relatively large zone in the northwest corner of the study area.

Many of the former building stone quarries are situated at the Precambrian/Paleozoic contact and along escarpments (river valleys, lake shores) where vertical sections of Paleozoic strata are exposed and natural quarry sites are available. Similar sites may be present in the vicinity of the fault lines shown on the accompanying map.

6.0 CONCLUSIONS

1) Based upon the criteria of colour, texture, durability, and suitability for quarrying, the Paleozoic rocks with the greatest

potential for building stone development are lithographic to fine crystalline limestones of the Gull River Formation and of the lower member, Bobcaygeon Formation. Red-grey limestone/dolostone of the lower member, Gull River Formation ("Red Pamelia" stone) also has good potential for various building stone applications.

2) Exploration for potential quarry sites within the favourable formations should be concentrated within areas of low overburden thickness north and east of the Marmora-Belleville-Kingston areas and within a narrow strip along the Precambrian/Paleozoic contact in the western part of the map area. The best exposures of Paleozoic strata are in the vicinity of fault scarps, river valleys, lake shores, and the Precambrian/Paleozoic contact. Abandoned quarries within the high potential areas should also be investigated. A complete inventory of abandoned quarries in southern Ontario (in addition to those documented in this report) has been compiled by Wolf (in prep.).

3) Potential applications of the stone include ashlar, veneer, flagstone, and limestone chips (terrazzo and agglomerated stone). The utilization of quarry waste is essential to the economic viability of the operation. Potential markets include the restoration of historic buildings and residential construction. The availability of locally-produced natural stone may create an increase in demand for the products.

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APPENDIX

Descriptions of Abandoned and Active Building Stone Quarries in the Lake Simcoe-Kingston Area

Unless otherwise noted, the geological sections are from recent mapping by D.A. Williams (1984-1989). Units are described in the order in which they occur in the quarry from top to bottom. Quarry descriptions are listed in numerical order by district (L-Lindsay/Minden, NP-Napanee, TW-Tweed, and H-Huronia).

L-5 BRITNELL QUARRY

Location: lot 13, con. 6, Somerville Tp., Victoria County

Production: Abandoned; produced building stone in the early 1900's; primarily ashlar from reddish-grey dolostone ("Red Pamelia" stone), but also some dimension stone 1.1 by 1.1 m (Parks 1912).

Geological Section:

	Thickness
Gull River Formation, lower member	
Unit 3	4.5m
Limestone: lithographic to finely crystalline; light to medium grey to brownish grey; light bluish grey weathering; thinly to thickly bedded (3-70 cm).	
Unit 2	0.4m
Interbedded shale and sandy limestone: alternating red and green; very thinly bedded.	
Unit 1	2.8m
Dolostone and dolomitic limestone: red to reddish grey ("Red Pamelia" stone); finely crystalline; medium bedded.	
Total thickness:	7.3m

References: Parks 1912 p. 225-227

Goudge 1938 p.201

DMBW and OGS 1989c p.13-14

L-6 NELSON WINDOVER-NICHOLS (FLYNNS TURN) QUARRY

Location: lot 21, con. 13, Harvey Tp., Peterborough County

Production: Active (operator N. Windover); produces small amounts of flagstone.

Geological Section (DMBW and OGS 1989c):

	Thickness
Gull River Formation, lower member	
Unit 1	1.0m
Limestone and sandy dolomitic limestone: red to reddish brown and green; fine to medium crystalline with coarse, rounded quartz grains; beds up to 30 cm thick.	
Total thickness:	1.0m

References: DMBW and OGS 1989c p. 14

L-8 NELSON WINDOVER-HOME (BUCKHORN) QUARRY

Location: lot 12, con. 9, Harvey Tp., Peterborough County

Production: Active (operator N. Windover); produces small amounts of flagstone, retaining wall stone.

Geological Section (DMBW and OGS 1989c):

	Thickness
Gull River Formation, lower member	
Unit 2	1.0m
Limestone: light to medium grey, weathers same; lithographic texture; single bed with numerous stylolites; abundant burrows filled with greenish brown dolomitic limestone.	
Unit 1	0.9m
Limestone: medium grey-brown, weathers same; fine to medium crystalline; thick bedded (40-	

45 cm), splits into thin slabs 3-6 cm thick; some large vugs filled with calcite, pyrite, or gypsum.

Total thickness: 1.9m

References: DMBW and OGS 1989c p. 16

L-9 ELDRED PAYNE-WARSAW QUARRY

Location: E 1/2 lot 21, con. 4, Dummer Tp., Peterborough County

Production: Active (operator E. Payne); produces flagstone, retaining wall stone.

Geological Section (DMBW and OGS 1989c):

Thickness

Gull River Formation, lower member

Unit 1: 0.6m

Limestone: light grey-brown, weathers light grey; lithographic texture; single bed which splits into two; at the top is a thin layer of light brown, silty dolostone.

Total thickness: 0.6m

References: DMBW and OGS 1989c p. 17

L-26 VOLTURNO LAKE QUARRY

Location: lot 30, con. 13, Harvey Tp., Peterborough County

Production: Abandoned; produced ashlar and flagstone from lithographic limestone and "Red Pamelia" dolostone in the early 1900's.

Geological Section (Wolf, in prep.):

Gull River Formation, lower member

Thickness

Unit 2 2.2m

Limestone: cream to light grey, weathers same; lithographic texture; thick bedded.

Unit 1 0.7m

Dolostone: reddish brown, weathers same ("Red Pamelia" stone); fine crystalline with scattered coarse quartz grains; thin bedded

Total thickness: 2.9m

References: Wolf (in prep.)

L-38 WARSAW QUARRY #3

Location: lot 14, con. 2, Dummer Tp., Peterborough County

Production: Abandoned; limestone blocks quarried in the 1800's for construction of bridges and locks on the Trent canal.

Geological Description:

The quarry is about 2 m deep, within limestone of the lower member of the Bobcaygeon Formation. Two beds were quarried, the upper being 1.4 m thick and the lower 0.6 m thick. The stone is dark brownish grey, fine grained, and contains a number of thin shale seams. The lower bed contains nodules of black chert. Widely spaced joints permit the extraction of very large blocks and soil cover is only a few centimeters deep for a distance of about 130 m from the quarry (Goudge 1938).

References: Goudge 1938 p. 148-150

L-43 ARMSTRONG QUARRY

Location: lot 29, con. 12, Dummer Tp., Peterborough County

Production: Abandoned; produced limestone blocks for construction of the Trent canal in the 1800's; more recently quarried for crushed stone used in local road construction.

Geological Section (Wolf, in prep.):

Thickness

Bobcaygeon Formation, lower member

Unit 1 5.1 m

Limestone: grey to dark brown, weathers grey and brown; lithographic texture; massive bedded with stylolites; patches of small calcite crystals ("birdseye" texture) are common; abundant fossils and burrows.

Total Thickness: 5.1 m

References: Wolf (in prep.)

NP-5 POINT ANNE QUARRY

Location: lots 16-27, Broken Front and con. 1, Thurlow Tp., Hastings County

Production: Intermittently active (H.J. McFarland Construction Co., Belleville); Parks (1912) reported production in the 1800's from two 0.5 m beds of blue limestone used for canal construction and from a white upper bed used for buildings in Belleville (Anglican Church and Albert College). A very large quarry has been developed, primarily for stone used in manufacturing cement.

Geological Section:

Thickness

Bobcaygeon Formation, lower member (upper sub-member)

Unit 5 5.2 m

Limestone: light grey to medium brownish grey, weathers light bluish to brownish grey; lithographic to coarse crystalline; beds 2-30 cm thick, some cross-bedding.

Unit 4 2.6 m

Limestone: light to medium bluish grey, weathers same as unit 5; lithographic to fine crystalline; beds 20-65 cm thick.

Unit 3 4.1 m

Limestone: light to medium brownish grey, weathers same as unit 5; sub-lithographic to coarse crystalline; beds 2-60 cm thick, some cross-bedding.

Bobcaygeon Formation, lower member (lower sub-member)

Unit 2 3.5 m

Limestone: medium brownish grey, weathers bluish grey; sub-lithographic to fine crystalline; beds 5 to 105 cm thick with shaly partings.

Unit 1 0.1 m

Limestone: light grey, weathers light bluish grey; lithographic texture; single bed.

Total thickness: 15.5 m

References: Parks 1912 p. 218
DMBW and OGS 1989b p. 108-109

NP-15 CAMDEN EAST (AYLESWORTH) QUARRY

Location: lot 26, con. 2, Camden East Tp., Lennox and Addington County.

Production: Intermittently active (operated for crushed stone by the Township of Camden East); quarried for building stone prior to 1912. Parks (1912) reported that 3 beds of pale grey, microcrystalline limestone were quarried, each about 30 cm thick.

Geological Section (DMBW and OGS 1989b):

Thickness

Bobcaygeon Formation, lower member

Unit 3 1.0 m

Limestone: light to medium grey, weathers light grey; microcrystalline; thick bedded (50 cm) with sharp stylolitic contacts; small patches of calcite crystals ("birdseye" texture).

Gull River Formation, upper member

Unit 2 1.8 m

Limestone: light grey-brown to light brown, weathers medium brown; very fine to fine crystalline; thin bedded (5-10 cm).

Unit 1 4.2 m

Limestone: dark grey, weathers medium grey; microcrystalline to fine crystalline; thin bedded (5-10 cm); fossiliferous, small patches of birdseye texture and rare pyrite crystals.

Total thickness: 7.0 m

References: Parks 1912 p. 214-215
DMBW and OGS 1989b p. 121

NP-59 POINT ANNE QUARRY #2 (J. MACDONALD)

Location: lot 20, Broken Front, Thurlow Tp., Hastings County

Production: Abandoned; building stone was produced by J. Macdonald in the early 1900's from three beds of light to dark, blue-grey limestone about 40, 50, and 60 cm thick for use as bases, sills, and veranda caps. Pieces up to 3 m long are reported to have been extracted (Parks 1912).

Geological Section:

	Thickness
Bobcaygeon Formation, lower member	
Unit 1	7.45 m

Limestone: light grey to medium brownish grey, weathers light bluish to brownish grey; lithographic to coarse crystalline; thick bedded; upper 2.35 m contain shaly partings.

References: Parks 1912 p. 216-217

NP-60 POINT ANNE QUARRY #1 (A. MACDONALD)

Location: W 1/2 lot 20, Broken Front, Thurlow Tp., Hastings County

Production: Abandoned; quarry operated by A. Macdonald in the early 1900's. Parks (1912) reported that the same beds as those exposed in J. Macdonald's quarry were worked, as well as two additional beds 15 and 50 cm thick.

Geological Description:

Bobcaygeon Formation (lower member); see geological section for quarry NP-59.

References: Parks 1912 p. 217

NP-64 LONSDALE QUARRY

Location: lot 31, con. 3, Tyendinaga Tp., Hastings County

Production: Abandoned; building stone was produced in the early 1900's and used in the construction of several buildings in Lonsdale and the Roman Catholic church at Marysville.

Geological Description:

The quarry is in limestone of the upper member, Gull River Formation. Goudge (1938) described the stone as, "dense-textured, dove-grey in colour" and occurring in beds 9 to 23 cm thick.

References: Goudge 1938 p. 93

NP-112 BEDBOROUGH QUARRY

Location: lot 23, con. 3 Military Tract, Hallowell Tp., Prince Edward County

Production: Abandoned; rough building stone produced in the early 1900's for foundations.

Geological Description:

Thinly bedded limestone and shale of the Lindsay Formation were quarried. Parks (1912) described the stone as "a rough, grey, highly fossiliferous limestone of no promise as a building material".

References: Parks 1912 p. 241
Goudge 1938 p. 158

NP-141 PYBUS QUARRY

Location: lot 30, con. 1 Gore, Richmond Tp., Lennox and Addington County.

Production: Abandoned; limestone quarried in the early 1900's was used as foundation stone and trim for many buildings in Napanee. Parks (1912) reports production from two blue limestone beds, 25 and 60 cm thick, and a white bed 50 cm thick which was used in the Court House, a church, and several business buildings in Napanee.

Geological Section (Wolf, in prep.):

Thickness

Gull River Formation, upper member

Unit 1 3.5 m

Limestone: grey brown to brown, weathers light grey to grey-brown; lithographic to very fine crystalline; thin to medium bedded with rare thicker beds; shale partings and patches of "birdseye texture" (calcite crystals) are common.

Total thickness: 3.5 m

References: Parks 1912 213-214
Wolf (in prep.)

NP 146 KINKLEY QUARRY

Location: lot 19, con. 7, North Fredericksburgh Tp., Lennox and Addington County.

Production: Abandoned; quarried in the early 1900's for building stone, crushed stone, and lime. Goudge (1938) reported that a 9 ft. (2.7 m) section of brownish grey limestone in beds up to 7 inches (18 cm) thick in the lower part of the quarry was the source of the building stone.

Geological Section (Wolf, in prep.)

Thickness

Gull River Formation, upper member

Unit 5 1.0 m

Limestone: dark grey, weathers light grey; lithographic with small patches of calcite crystals ("birdseye" texture); single bed.

Unit 4 1.5 m

Limestone: dark grey, weathers light grey-brown; very fine crystalline; thin bedded (2-3 cm) with thin shale partings.

Unit 3 2.5 m

Limestone: dark grey, weathers light grey; lithographic with patches of "birdseye" tex-

ture; thin bedded (1-8 cm) with shale partings; fossiliferous.

Unit 2 0.8 m

Limestone: dark grey, weathers light grey; lithographic with patches of "birdseye" texture thick bedded; fossiliferous.

Unit 1 3.0 m

Limestone: dark grey, weathers light grey; microcrystalline to very fine crystalline; thin bedded (3-10 cm) with thin shale partings; scattered small pyrite crystals and fossils.

Total thickness: 8.8 m

References: Goudge 1938 p. 126
Wolf (in prep.)

NP-169 STRATHCONA QUARRY (PEARSON AND SHELTOR)
NP-170 STRATHCONA QUARRY (NAPANEE CEMENT COMPANY)
NP-171 STRATHCONA QUARRY #3
NP-172 NEWBURGH QUARRY #1

Location: the 4 quarries listed above are located, respectively, in lot 11, con. 1, lot 10, con. 1, lot 14, con. 1, and lot 16, con. 2, Camden East Tp., Lennox and Addington County.

Production: Abandoned; minor building stone production in the late 1800's to early 1900's for use in local buildings. The Napanee Cement Company quarried shaly limestone for the manufacture of cement from 1867 to 1891.

Geological Description:

Goudge (1938) describes the rocks of the Strathcona and Newburgh area quarries as fine-grained to dense-textured (lithographic), brownish grey limestone in beds up to 20 cm thick interbedded with shale and shaly limestone. These rocks comprise part of the upper member of the Gull River Formation.

References: Goudge 1938 p. 127

NP-178 YARKER QUARRY #1

Location: lot 43, con. 2, Camden East Tp., Lennox and Addington County.

Production: Abandoned; in the early 1900's, a small amount of

limestone was quarried as building stone for the construction of bridges and houses.

Geological Description: Goudge (1938) described the quarry as follows: "The stone utilized was 5 feet (1.5 m) of dense-textured, dove-grey limestone in regular beds 3 to 10 inches (1.2 to 4 cm) thick, with 4 feet (1.2 m) of shaly, thin-bedded stone and 4 feet (1.2 m) of soil overlying it." These strata are part of the upper member of the Gull River Formation.

References: Goudge 1938 p. 128

NP-212 PETWORTH QUARRY

Location: lot 16, con. 6, Portland Tp., Frontenac County

Production: Abandoned; origin of the quarry is unknown; however, in recent years building stone (ashlar and sills) has been produced, primarily from previously broken and loose rock for construction and restoration work in the Kingston area. The stone can be seen in walls of the McDonald's restaurant on Division Street in Kingston.

Geological Section:

	Thickness
Gull River Formation, lower member	
Unit 1 Limestone with dolostone interbeds: limestone-light grey to dark brownish grey, weathers bluish grey; lithographic to sublithographic with shaley partings; thin to thick bedded. dolostone - light brownish grey, weathers light brown; finely crystalline and silty with calcite-filled vugs; dolomitic beds at 0.25-0.60, 1.30-2.40, 4.50-5.35, and 5.55-5.70m (measured from the base of the quarry).	7.5 m
Total thickness:	7.5 m

References: none

NP-214 WOLFE'S SWAMP QUARRY

Location: lot 11, con. 5, Portland Tp., Frontenac County

Production: Abandoned; quarried in the early 1900's for local road metal and building construction.

Geological Description:

Limestone and shale of the lower member, Gull River Formation are exposed in this small quarry. Goudge (1938) reported 2.1 m of very fine-grained, dark brownish-grey limestone in the top part of the quarry, underlain by shale and impure limestone.

References: Goudge 1938 p. 69

NP-221 ROSEDALE QUARRY

Location: lot 7, con. 7, Loughborough Tp., Frontenac County

Production: Intermittently active; the quarry was once worked for building stone; recent intermittent production of crushed stone.

Geological Section (Wolf, in prep.):

	Thickness
Gull River Formation, lower member	
Unit 1	9.1 m
Interbedded limestone and dolostone: limestone - light grey, weathers same; lithographic, medium bedded, sparsely fossiliferous. dolostone - light brown to light greenish grey, weathers light green-grey; fine crystalline with minor silt and fine sand; medium bedded.	
Total thickness:	9.1 m

References: Wolf (in prep.)

NP-261 COLLINS BAY QUARRY (BENNETT PAVING)

Location: lot 5, con. 1, Kingston Tp., Frontenac County

Production: Abandoned; produced building stone in early 1900's and crushed stone from mid 1960's to 1970's.

Geological Section (Wolf, in prep.)

	Thickness
Bobcaygeon Formation, lower member	
Unit 2	3.4 m
Limestone: light grey, weathers dark grey;	

lithographic with some medium grained calcarenite interbeds; thick bedded (40-50 cm) with sharp stylolitic contacts; scattered large, calcite-filled vugs and patches of small calcite crystals ("birdseye" texture); fossiliferous

Gull River Formation, upper member

Unit 1 3.1 m

Limestone: medium to dark grey, weathers dark grey; lithographic to fine crystalline; thin to medium bedded (2-15 cm) with thin shale partings and interbeds up to 2 cm thick; patches of "birdseye" texture, fossiliferous.

Total thickness: 6.5 m

References: Goudge 1938 p. 68
Wolf (in prep.)

NP 263 COLLINS BAY PENITENTIARY QUARRY #1
NP 264 COLLINS BAY PENITENTIARY QUARRY #2

Location: two quarries located in con. 1, Kingston Tp., Frontenac County, south of Hwy. 33.

Production: Abandoned; worked for crushed stone and building stone for construction of the Collins Bay penitentiary in the early 1900's.

Geological Description:

The quarries expose beds of the upper member, Gull River Formation. Goudge (1938) reported 4.3 m of shaly limestone above 3.7 m of dense-textured, brittle (lithographic) limestone in beds 13 to 36 cm thick.

References: Goudge 1938 p. 68

NP-266 KIRKPATRICK QUARRY

Location: lot 16, con. 2, Kingston Tp., Frontenac County (about 370 m N. of Bath Road, east side of Cataraqui Creek).

Production: Abandoned; produced building stone during late 1800's and early 1900's.

Geological Description: A 4.6-m thickness of dark bluish to brownish grey, lithographic limestone of the lower member, Gull River Formation was quarried. Bedding thickness is 15 to 33 cm, with some shaly interbeds.

References: Goudge 1938 p. 65

NP-276 WEHMAN QUARRY
NP-277 RODDY QUARRY

Location: two quarries in lot 25, con. 1, Kingston Tp., Frontenac County. The quarries were located on opposite sides of Division Street, Kingston.

Production: Abandoned; building stone and crushed stone production in the 1800's to early 1900's.

Geological Description:

The Wehman quarry, which was developed in an east-facing escarpment on the west side of Division Street in Kingston, exposed a 9-m section of the lower member, Gull River Formation which includes the entire thickness of the building stone beds quarried in the Kingston area at that time. The upper 3-m section consists of shale, shaly limestone, and one 30-cm bed of brown, dolomitic limestone. The underlying 6-m section consists of dark brown, lithographic limestone that weathers almost white, in smooth, regular beds 8 to 35 cm thick with some shaly interbeds up to 15 cm thick. Small crystals of secondary calcite are scattered throughout. This limestone unit is representative of all the Kingston area building stone quarries.

References: Parks 1912 p. 209-212
Goudge 1938 p. 61-64

NP-291 RIDEAU STATION QUARRY

Location: lot D, con. 2, Pittsburgh Tp., Frontenac County (east side of Hwy. 15).

Production: Abandoned; probably worked for building stone prior to 1938

Geological Description:

About 7.5 m of interbedded dark brownish grey, lithographic limestone and dolomitic limestone of the lower member, Gull River Formation, are exposed.

References: Goudge 1938 p. 67

NP-299 BARRIEFIELD QUARRY

Location: near the southwest corner of Pittsburgh Tp., Frontenac County; the quarry is at the top of the Barriefield hill, east of Hwy. 15 at its junction with Hwy. 2.

Production: Abandoned; building stone and crushed stone were produced in the early 1900's. The building stone was used in the construction of the Royal Military College at Kingston.

Geological Description:

The building stone beds are typical of the limestones of the lower member, Gull River Formation, quarried in the Kingston area. They are lithographic, dark brownish grey limestones which weather almost white. Fine crystals of calcite are scattered throughout. Beds range in thickness from 8 to 45 cm over a 3-m interval containing some shaly interbeds. Overlying the building stone beds are about 1.5 m of thinly bedded limestone and one 30-cm bed of yellow-weathering dolomitic limestone.

Goudge (1938) reported that jointing is widely spaced and that blocks 8 ft (2.4 m) square were removed. The quarry was worked by hand drills, plugs and feathers, and crowbars. Quarry waste was crushed to provide concrete aggregate.

References: Goudge 1938 p. 65-67

NP-314 WOLFE ISLAND LANDFILL

Location: lot 3, con. 8 North, Wolfe Island Tp., Frontenac County (0.5 km east of Marysville).

Production: Current site of Wolfe Island landfill operation; produced building stone in the late 1800's and early 1900's for construction in Marysville (village of Wolfe Island).

Geological Section (Wolf, in prep.):

	Thickness
Bobcaygeon Formation, lower member	
Unit 1	4.0 m
Limestone: light grey to light brown, weathers light grey; lithographic to fine crystalline; very thick bedded (>1 m); sparsely fossiliferous with numerous burrows.	
Total thickness:	4.0 m

References: Wolf (in prep.)

TW-1 MARMORATON MINING COMPANY (MARMORA PIT)

Location: lots 4 and 5, con. 5 and 6, Marmora Tp., Hastings County.

Production: Inactive; former open pit iron ore mine; a 55-m section of Paleozoic strata is exposed at the top of the pit; 20 million tonnes of limestone were stripped from above the Precambrian magnetite-rich skarn, and the waste limestone has been worked for aggregate by Armbro Materials and Construction Ltd., the current owners of the property. The pit is about 800 m long, 400 m wide, and 220 m deep.

Geological Section:

	Thickness
Bobcaygeon Formation, lower member	
Unit 10	13.3 m
Limestone: lithographic to fine crystalline; thin to massive bedded with shaly partings; "birdseye" texture common; black chert nodules occur in a 2-m thick interval about 10 m above the base of the unit.	
Gull River Formation, upper member	
Unit 9	2.74 m
Dolomitic limestone: buff weathering; lower 10 cm shaly.	
Unit 8	4.45 m
Limestone: lithographic to fine crystalline; thin to medium bedded with shaly partings.	
Gull River Formation, lower member	
Unit 7	0.36 m
Dolostone: fine crystalline; silty to sandy	
Unit 6	8.2 m
Dolomitic limestone: brownish grey, weathers buff; sub-lithographic to fine crystalline with shaly partings and interbeds of lithographic to	

sub-lithographic limestone containing stylolites; calcareous quartz sandstone from 0.22 to 1.43 m above base of unit, and oolitic limestone in lower 0.22 m.

Unit 5 — 1.47 m

Limestone: light grey, weathers white; lithographic with stylolites; main lithographic bed of lower Gull River Fm.

Unit 4 — 1.72 m

Dolomitic limestone: brownish grey, weathers buff; sublithographic to fine crystalline; silty.

Unit 3 — 1.16 m

Sandstone: light green; fine to medium grained, calcareous quartz sandstone.

Unit 2 — 5.51m

Interbedded limestone and dolostone.

Shadow Lake Formation

Unit 1 — 7.69 m

Sandstone and dolomitic limestone.

Total thickness: 49.60 m

References: DMBW and OGS 1989b p. 150-152

TW-2 STOKLOSAR MARBLE QUARRIES LIMITED (JARVIS LAKE QUARRY)

Location: lot 11, con. 1, Madoc Tp., Hastings County.

Production: Inactive; quarried intermittently for limestone terrazzo chips and ornamental stone until recently.

Geological Section:

Thickness

Gull River Formation, lower member

Unit 2 — 0.1 m

Sandstone: green, medium to coarse grained, calcareous quartzo-feldspathic sandstone.

Unit 1 5.0 m

Limestone: light to dark reddish brown, weathers reddish brown to light bluish grey; some light green colour along bedding planes; lithographic to fine crystalline; thin to thick bedded with stylolites and some disseminated coarse quartz grains.

Total thickness: 5.1 m

References: DMBW and OGS 1989b p. 152

TW-3 STOKLOSAR MARBLE QUARRIES LIMITED (MADOC MARBLE QUARRY)

Location: two quarries on lot 10, con. 4, Madoc Tp., Hastings County; one quarry north of the road and one south of the road.

Production: Intermittently active; Stoklosar Marble Quarries Limited produces terrazzo chips from limestone.

Geological Section:

North Quarry

Thickness

Gull River Formation, lower member

Unit 2 1.75 m

Limestone: light to dark reddish brown to light green, weathers reddish brown to light bluish grey; lithographic to fine crystalline; thin to medium bedded.

Shadow Lake Formation

Unit 1 2.25 m

Sandstone: reddish brown to light green, weathers reddish brown; fine to coarse grained quartz sandstone; contains Precambrian cobbles and pebbles adjacent to contact with underlying Precambrian rocks; medium to thick bedded.

Total thickness: 4.0 m

South Quarry

Thickness

Gull River Formation, lower member

Unit 1 7.0 m

Limestone: light to dark reddish brown to light green, weathers reddish brown to light bluish grey; lithographic to fine crystalline; thin to thick bedded; interbeds of fine to coarse light green to reddish brown calcareous quartz sandstone in lower 1.35 m of section.

Total thickness: 7.0 m

References: DMBW and OGS 1989b p. 153-154

TW-4 H.J. MCFARLAND CONSTRUCTION CO. (CROOKSTON QUARRY)

Location: lot 10, con. 9, Huntingdon Tp., Hastings County.

Production: Inactive; produced building stone intermittently from 1890 to 1927 from two adjacent quarries known as the Gibson quarry and the Quinlan and Robertson quarry. The quarries produced ashlar, monument bases and large dimension stone, some of which was used in construction of the South Shore and Victoria bridges at Montreal. The area is now licensed to H.J. McFarland Construction Co. who have not yet extracted any significant amount of rock.

The best stone is reported to have come from a 1-m bed of brownish grey, compact limestone (Parks 1912).

Geological Section:

Thickness

Bobcaygeon Formation, lower member

Unit 1 8.35 m

Limestone: brownish grey, weathers bluish grey; sub-lithographic to fine crystalline; thin to massive bedded with thin, undulating shaly partings; shaly interbeds at 4.15-4.35 and 5.7-5.9 m above base of quarry; nodules and lenses of dark to light chert in upper 1.35 m of section; fossiliferous, some beds with very large corals.

Total thickness: 8.35 m

References: Parks 1912 p. 218-220
Goudge 1938 p. 94
DMBW and OGS 1989b p. 154-155

TW-21 MARMORA QUARRY (BONTER)

Location: lot 8, con. 3, Marmora Tp., Hastings County (south side of Crowe Lake).

Production: Abandoned; stone for lithographic use was produced from 1895-1898 by the American Lithographic and Asbestos Co. (Parks 1912). It is similar to that from the Pearce quarry (TW-23) which was used in the construction of several buildings in Marmora.

Geological Section:

Thickness

Gull River Formation, lower member

Unit 1 3.0 m

Interbedded limestone and dolomitic limestone: limestone is lithographic to sub-lithographic; dolomitic limestone is sub-lithographic to fine crystalline and silty; brownish grey to medium grey, weathers light brown to bluish grey; thin to thick bedded; thin shaly interbeds in upper part of section.

Total thickness: 3.0 m

References: Parks 1912 p. 224-225

TW-23 PEARCE QUARRY

Location: lot 7, con. 4, Marmora Tp., Hastings County (west side of Crowe R., north of Hwy. 7).

Production: Abandoned; produced building stone intermittently from the early 1800's to early 1900's. Parks (1912) reported that the brownish grey, lithographic limestone produced a hard, durable building stone from 12 to 35 cm in thickness. It was used in the construction of several buildings in Marmora in the early 1800's and can be seen in the present Roman Catholic Church, constructed in 1904. The quarry exposed an interval of about 4 m, the upper 3 m of

which provided most of the building stone. The following geological section describes rocks exposed in a cliff on the west side of the Crowe River, Marmora, in the area of the old quarry site.

Geological Section:

	Thickness
Gull River Formation, lower member	
Unit 3	0.7 m
Limestone: light brownish grey, weathers light bluish grey; lithographic texture; medium to thick bedded.	
Unit 2	1.1 m
Dolostone: light to medium brown, weathers yellowish brown; fine crystalline, silty; thin to thick bedded.	
Unit 1	1.2 m
Limestone: light brownish grey, weathers light bluish grey; lithographic texture; medium to thick bedded.	
Total thickness:	3.0 m

References: Parks 1912 p. 222-223

TW-28 MADOC QUARRY #1

Location: lot 8, con. 5, Madoc Tp., Hastings County.

Production: Abandoned; Goudge (1938) reported production of building stone from several small quarries in this area, most of which was used locally and some of which was used in Belleville. The stone is described as being dense-textured and brown, weathering to a light grey.

Geological Description:

Two shallow quarries in this area have been examined, both exposing about 1.5 m of lithographic limestone above light greenish grey, buff-weathering, fine to medium crystalline, silty dolostone. The limestone is light brownish grey, weathering light bluish grey, and is thinly to thickly bedded. These rocks are part of the lower member, Gull River Formation.

References: Goudge 1938 p. 97

TW-34 TWEED QUARRY

Location: lot 12, con. 11, Hungerford Tp., Hastings County (about 1.6 km north of Tweed).

Production: Abandoned; building stone was produced in the early 1900's from the upper, 1-m thick bed in this quarry. The stone was used primarily for buildings in Tweed and for monument bases (Parks 1912).

Geological Section:

	Thickness
Bobcaygeon Formation, lower member	
Unit 2	4.5 m
Limestone: brownish grey, weathers bluish grey; sub-lithographic to finely crystalline; thin to massive bedded with thin, undulating shaly partings; fossiliferous.	
Gull River Formation, upper member	
Unit 1	2.8 m
Limestone: colour and texture same as unit 2; thin to thick bedded with abundant shaly partings.	
Total thickness:	7.3 m

References: Parks 1912 p. 220-221
Goudge 1938 p. 95
Wolf (in prep.)

H-6 WOODS (LONGFORD) QUARRY-FOWLER CONSTRUCTION CO. LTD.
H-26 LONGFORD QUARRIES

Location: lots 26-29 (WOODS) and lots 24-26 (LONGFORD), Broken Front concession, Rama Tp., Simcoe County.

Production: The Woods Quarry is active, producing crushed stone (Fowler Construction Co. Ltd.). The Longford quarries to the south are abandoned and overgrown. All of these quarries were important producers of building stone, the history of which is described by Wolf (in prep.) as follows:

"Known by the trade names of "Rama" stone and "Longford" stone, they were used in many buildings throughout Ontario, including the Roman Catholic church in North Bay, a school in Orillia, the post office, library, and churches in Orillia, in the head office of the Imperial Bank at Toronto, and as trim in several post offices in the Toronto area. In addition polished Rama stone was used as interior trim in the post offices at Montreal, Thunder Bay, and Guelph, as well as a number of buildings in Toronto (Parks 1912; Goudge 1938). Miller (1904) also reported that Longford stone was used in the construction of the Queen and King Street subways in Toronto, in the foundations of the Parliament Buildings and (old) city hall in Toronto, in the Hamilton tunnel of the Toronto, Hamilton, and Buffalo Railway, and by the Grand Trunk Railway in bridge construction. Stone not used for building purposes was used as flux in the Midland blast furnace, or it was burned in a lime kiln adjacent to the quarries, producing a white lime (Miller 1904).

These quarries, originally operated by hand, were opened in 1883 by individual operators, who consolidated in 1901 to form the Longford Quarry Company, Limited. Until the early 1930's only the Longford stone was quarried, when in 1933 the property was acquired by Lake St. John Quarry Company, Limited, who then in 1936 sold it to Longford Quarries Limited. The company quarried the Rama stone, which was marketed as "Rama Mottled Dove", and shipped most of it to the Toronto market. The Longford stone was no longer quarried as it was too brittle to be worked by mechanical methods. The quarries had ceased operations some time before 1960. These quarries are now very overgrown, with vegetation obscuring most of the old excavations. Quarries which had been worked below the lake level are also now filled with water."

The "Longford" stone, from the upper part of the quarries, is a white weathering, very pale grey, lithographic, thick-bedded limestone of the lower member of the Bobcaygeon Formation (formerly assigned to the middle member, Gull River Formation as defined by Liberty 1969). The "Rama" stone, from the lower part of the quarries, is a brown-weathering, light grey-brown to light green-brown, fine crystalline, thick bedded dolostone of the upper member of the Gull River Formation (formerly assigned to Liberty's lower member, Gull River Formation).

The following geological section describes the rocks intersected in a diamond drill hole drilled adjacent to the Woods Quarry in 1987 by Fowler Construction Co. Ltd.

Geological Section:

Thickness

Bobcaygeon Formation, lower member

Unit 13 — 3.14 m

Limestone: medium grey to pale yellow-brown; medium to thin bedded with undulating shaly seams; calcisiltite to calcarenite; calcarenite bed from 1.32 to 1.77 m below top of unit.

Unit 12 — 1.94 m

Limestone ("Longford" stone beds): very light grey; lithographic; thick bedded with stylolites; bentonite bed from 0.89 to 0.96 m below top of unit; "birdseye" texture in lower 20 cm of unit.

Unit 11 — 1.52 m

Limestone: pale yellow brown; lithographic; medium bedded with occasional shaly seams; upper 10 cm very shaly.

Unit 10 — 0.47 m

Limestone: same as unit 12; minor pyrite.

Unit 9 — 2.94 m

Limestone: light grey to pale yellow-brown; medium to thick bedded; calcisiltite to calcilutite; lower 50 cm shaly.

Gull River Formation, upper member

Unit 8 — 3.69 m

Dolostone ("Rama" stone beds): light greenish grey to light brownish grey; thick bedded; dolosiltite; local shale leafs, calcite-and strontianite-filled vugs (2-3 mm); shaley greenish grey dolostone from 1.27 to 1.57 m below top of unit.

Unit 7 — 1.16 m

Dolomitic limestone: mottled light grey to light brownish grey; thick bedded; calcisiltite to calcarenite.

Unit 6 — 1.29 m

Shaly limestone: medium grey; glauconite; shale interbeds up to 3 cm thick.

Unit 5 — 2.41 m

Interbedded dolomitic limestone and shaly limestone.

Gull River Formation, lower member

Unit 4 — 0.49 m

Dolostone: greenish grey; shaly and sandy.

Unit 3 — 1.35 m

Dolostone: alternating thick beds of light greenish grey and light brownish grey dolosiltite to doloarenite.

Unit 2 — 3.10 m

Dolomitic limestone to calcitic dolostone: alternating light greenish grey and light brownish grey; thick bedded; occasional shale seams; doloarenite, becoming less calcitic with depth.

Shadow Lake Formation

Unit 1 — 7.55 m

Shaly to sandy dolostone: light to dark greenish grey, shaly dolostone with occasional sandy beds; thick bedded; becomes dark red, shaly and sandy 2 m above base of unit, and arkosic to conglomeratic green and red shaly sandstone within 1 m of base.

Total thickness: 31.05 m

Precambrian: Granite gneiss

References:
Miller 1904 p. 90-91
Parks 1912 p. 229-231
Goudge 1938 p. 135-138
Wolf (in prep.)

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BUILDING STONE RESOURCES OF THE EASTERN PART OF THE LAKE ONTARIO LOWLAND

LEGEND

PALEOZOIC

UPPER ORDOVICIAN

5 Blue Mountain and Georgian Bay Formations: dark blue-grey to brown-grey shale with laminations of calcareous siltstone; interbedded dark grey shale, fossiliferous calcareous siltstone, and silty bioclastic limestone.

MIDDLE-UPPER ORDOVICIAN

4 Verulam and Lindsay Formations: interbedded thin to medium bedded, sublithographic to coarse crystalline limestone and shale; sublithographic to coarse crystalline limestone, nodular in part, with interbeds of shale.

MIDDLE ORDOVICIAN

3 Shadow lake, Gull River and Bobcaygeon Formations: red and green conglomerate, sandstone and mudstone; thin to medium bedded, lithographic to fine crystalline limestone, with interbeds of dolostone and sandstone; thin to massive bedded lithographic to coarse crystalline limestone.

UPPER CAMBRIAN-LOWER ORDOVICIAN

2 Nepean Formation: fine to coarse grained quartz sandstone, partially calcareous in upper part.

PRECAMBRIAN

1 Undifferentiated metamorphic and igneous rocks.

SYMBOLS

- Geological boundary (for zero overburden thickness)
- Normal fault
- ■ Active building stone quarry
- ● Inactive building stone quarry
- ▨ Area of good building stone potential

Geology by D.A. Williams, 1984-1990

Quarry locations from R.R. Wolf (in prep.), "An Inventory of Inactive Quarries in the Paleozoic Limestone and Dolostone Strata of Ontario", Ontario Geological Survey.