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Open File Report 5662

Stratigraphy and Resource Potential of the Eramosa Member (Amabel Formation), Bruce Peninsula, Ontario

1988

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Ministry of
Northern Development
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MINES AND MINERALS DIVISION

ONTARIO GEOLOGICAL SURVEY

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STRATIGRAPHY AND RESOURCE POTENTIAL OF THE ERAMOSA MEMBER (AMABEL FORMATION), BRUCE PENINSULA, ONTARIO

by

D.K. Armstrong and J.R. Meadows

1988

This project is part of the Canada-Ontario Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

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Ontario Ministry of Northern Development and Mines

Sean Conway, Minister of Mines

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V.G. Milne, Director
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FOREWORD

Under the Canada-Ontario Mineral Development Agreement (COMDA) a study has been undertaken of the building stone resources of the province. Called the Mid-Ontario Building Stone Project, this study has been conducted jointly between the Paleozoic/Mesozoic Geology Subsection (Engineering and Terrain Geology Section) of the Ontario Geological Survey (OGS) and the Industrial Minerals Section of the Ministry of Northern Development and Mines. Investigations centred on two areas, the Bruce Peninsula and the Parry Sound area. This report presents the results of the field investigations undertaken by the OGS in the Bruce Peninsula area. The results of the Parry Sound study are the subject of a separate report.

Middle Silurian dolostones have been quarried on Bruce Peninsula for building stone since the turn of the century. Currently, thick- to massive-bedded dolostones of the Amabel Formation are being quarried to supply building stone for such projects as the new Canadian Chancery in Washington D.C. The Eramosa Member of the Amabel Formation, a thin-bedded dolostone unit which is quarried for a variety of building and landscaping stone products is the subject of this report. This study geologically defines the Eramosa Member, discusses geologic factors controlling quality of building stone extracted from this unit, and presents estimates of resource distribution and potential reserves.

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Ontario Geological Survey

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STRATIGRAPHY AND RESOURCE POTENTIAL OF THE ERAMOSA MEMBER (AMABEL FORMATION), BRUCE PENINSULA, ONTARIO

by

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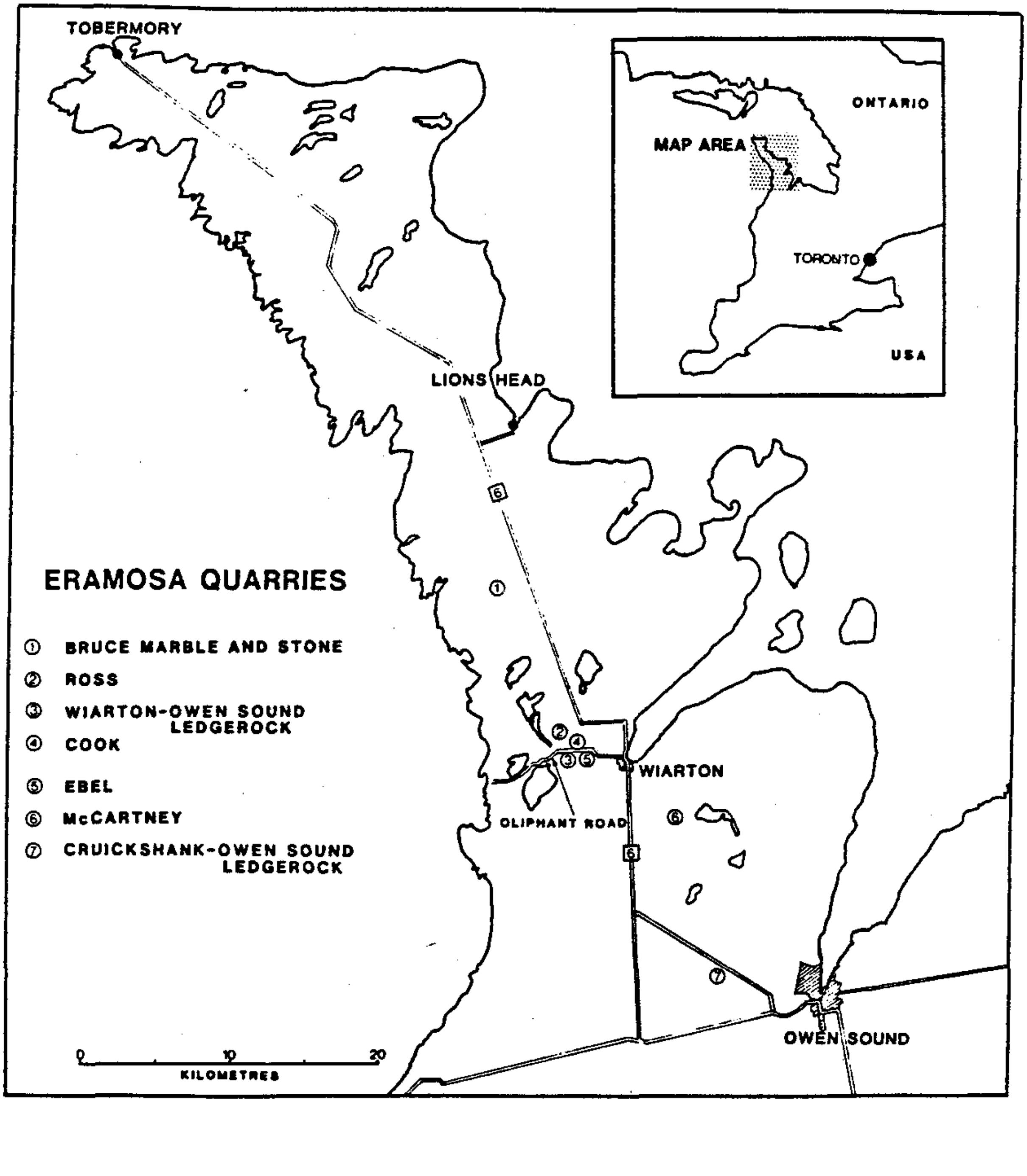
1.0 INTRODUCTION

During the summer and fall of 1986, field investigations were conducted on the Bruce Peninsula in southwestern Ontario (Figure 1) in an effort to determine the resource potential of the Eramosa Member (Amabel Formation). This project is part of the Mid-Ontario Building Stone Project, which is funded by the Canada-Ontario Mineral Development Agreement 1985 (COMDA).

The Eramosa Member is a thin-bedded dolostone which has been quarried on the Bruce Peninsula since at least the turn of the century for a wide variety of building and landscaping stone products. The main objectives of this project were to (1) geologically define the Eramosa Member, and (2) determine its regional potential as a building stone resource. Currently, a few quarries produce added-value products, such as polished tile, on a custom basis, from certain portions of the Eramosa Member. This study focussed on this unit and its potential to sustain future high-volume production of such added-value products.

Currently, there are six active quarries and at least one abandoned quarry which expose the Eramosa Member on the Bruce Peninsula. The locations of these seven quarries, herein referred to as the Eramosa quarries, are plotted on the map in Figure 1 and on the 1:100,000 scale geological resource map (in back pocket). The Bruce Peninsula can be reached by Highway 6, via Owen Sound and Wiarton. Highway 6

Figure 1: Bruce Peninsula field area, showing location of Eramosa quarries.



continues north along the Peninsula to Tobermory. Details of the individual quarry locations and access are provided in Appendix I.

Field work was divided into two parts: (1) detailed mapping of active and abandoned quarries of the Eramosa Member to identify and delineate immediately accessible resources; and (2) reconnaissance mapping of the Bruce Peninsula to investigate the regional extent of the resource. As the detail of mapping decreases away from any given quarry exposure, the certainty of interpretation decreases similarly.

In addition to mapping of the strata exposed in each quarry, ten shallow drillholes were cored in all but one of the quarries. Drilling was conducted with a portable "Winkie" drill, generously loaned by Mr. Harold Stobbe of Owen Sound Ledgerock Quarries Ltd. The "Winkie" drill produces a 2 centimetre diameter core sample to a maximum depth of 7 metres. These drillholes are collectively referred to in this report as the "shallow drilling program".

Small polished slabs (5 x 7.5 cm) and standard thin sections were made of hand samples representative of the various lithofacies and units encountered in the field investigations. In addition, a group of representative samples were analysed for a suite of major, minor and trace elements by the Geoscience Laboratories of the Ontario Geological Survey (77 Grenville St., Toronto). The complete geochemical data set, including duplicate analyses, are presented in Appendix II. These laboratory investigations were conducted in an effort to determine the factors controlling the quality of stone quarried from the Eramosa Member.

This report first reviews the general stratigraphic setting of the Eramosa Member as presented in previous geological studies. The results of this investigation are then presented in three sections: firstly, description of the lithology of the Eramosa Member; secondly, discussion of the stratigraphic relationships, both within the Member, and with respect to its bounding formations, with comments on its regional distribution; and lastly, aspects of its resource potential as a building stone, including geologic factors effecting its potential distribution and quality. A 1:100,000 scale resource distribution map, based in large part on the reconnaissance mapping, is included in the map pocket, and resource estimate calculations are presented.

1.1 Acknowledgments

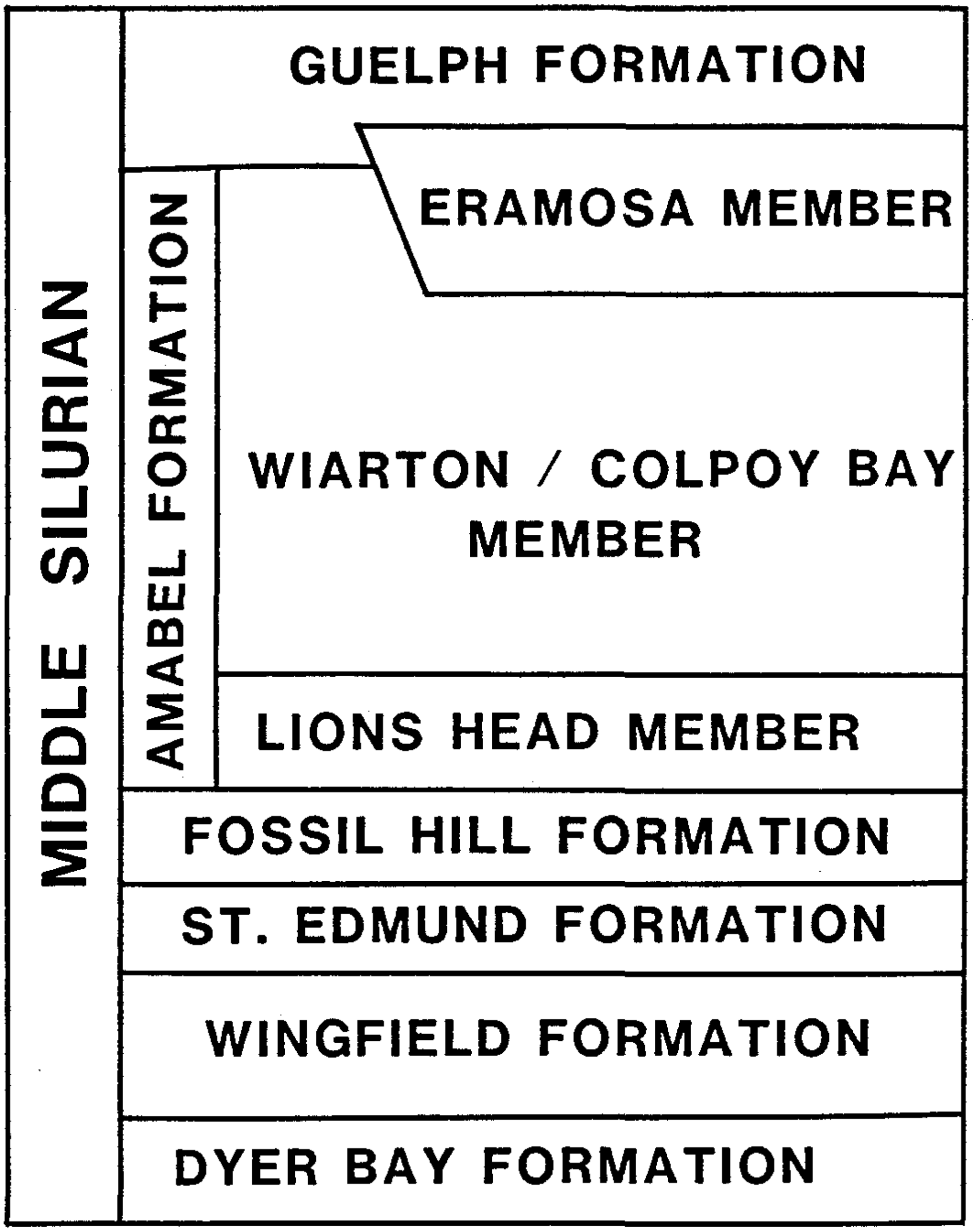
The authors gratefully acknowledge the following quarry operators and workers whose assistance during the 1986 field season was invaluable to this study: R.G. Ebel, C. McCartney, B. McKendrick, D. McKinnon, D. Ross, H. Stobbe, and T. Stobbe. A significant portion of the data presented in this report was afforded through drillcore obtained with a "Winkie" drill loaned to the field party by H. Stobbe, of Owen Sound Ledgerock Quarries.

The assistance of B. Feenstra, M.N.D.M. Resident Geologist for Southwestern Ontario, whose efforts initiated this study, is also greatly appreciated. The authors also acknowledge the assistance of C. Fouts and G. Kiritsis during the 1986 field season.

2.0 REGIONAL AND HISTORICAL SETTING

The term "Eramosa" was first applied by Williams (1915) to the bituminous dolostones which occur at the top of the Middle Silurian age Lockport Formation along the Eramosa River near Guelph, Ontario. The name Amabel Formation has now replaced the name Lockport Formation in this area and farther north; the latter name is used only south of Waterdown (near Hamilton) and on the Niagara Peninsula (Bolton 1953, 1957). Sanford (1969), working predominantly with subsurface information in southwestern Ontario, assigned the Eramosa Member strata to the overlying Guelph Formation. This uncertainty in the stratigraphic placement of the Eramosa strata has been noted by other workers (eg. Telford, 1978) and is reflected in the Middle Silurian stratigraphic chart for the Bruce Peninsula presented in Figure 2. In this chart, Bolton's (1957) two middle members of the Amabel Formation, the Wiarton and Colpoy Bay Members, are combined (following Liberty and Bolton, 1971) into the single Wiarton/Colpoy Bay Member (Member 3b of Liberty and Bolton, 1971). For the purposes of this report the Eramosa Member is considered to be a part of the Amabel Formation (after Liberty and Bolton, 1971), however, as will be apparent in subsequent discussions (below), a re-evaluation of this assignment is required, especially on the Bruce Peninsula.

Figure 2: Stratigraphic nomenclature for Middle Silurian strata exposed on the Bruce Peninsula (modified after Bolton, 1957; Sanford, 1969; and Liberty and Bolton, 1971).



In general, the Eramosa Member consists of thin-bedded, grey to dark grey and brown to dark brown, fine-crystalline, bituminous dolostone, interbedded with thin-bedded non-bituminous dolostone (Bolton, 1953, 1957; Liberty and Bolton, 1971). It has been interpreted to be an inter-biohermal facies associated with Amabel Formation bioherms of the Wiarton/Colpoy Bay Member (Bolton, 1957) and in part with the lower Guelph Formation bioherms (Liberty and Bolton, 1971), or associated predominantly with Guelph Formation bioherms (Sanford, 1969). Because of its inter-biohermal position, the Eramosa Member is not present, for instance, where Amabel bioherms pass upward into Guelph bioherms (Bolton, 1957; Liberty and Bolton, 1971). This possibility is indicated schematically in Figure 2, where the Guelph Formation directly overlies the Wiarton/Colpoy Bay Member of the Amabel Formation.

On the Bruce Peninsula, the contact of the Eramosa Member with the overlying Guelph Formation was reported by Bolton (1957) to be at the base of thick (1 to 1.5 metre) beds of brown, fine-crystalline dolostone exposed in the Cook Quarry near Wiarton and outcropping at Sky Lake. The lower contact with the Wiarton/Colpoy Bay Member (Amabel Formation) is less well exposed and defined; Eramosa Member strata are, however, reported draping over Amabel Formation bioherms along Highway 6 south of Edenhurst (Liberty and Bolton, 1971).

Although previous geologic mapping on the Bruce Peninsula (Williams, 1919; Caley, 1945; Liberty 1966; and Liberty and Bolton, 1971) has only delineated formational contacts, occurrences of bituminous Eramosa Member strata are reported on the Bruce Peninsula from Shallow Lake in the south to Flower Pot Island in the north (Williams, 1919; Goudge, 1938; Bolton, 1957; Liberty and Bolton, 1971). None of these occurrences, however, exposes the complete Eramosa Member interval. Bolton (1957) assigned 15.5 metres of "covered interval" in the roadcut immediately north of Wiarton to the Eramosa Member. Liberty and Bolton (1971) assigned 9 metres of the Sky Lake roadcut (location on map in pocket) to the Eramosa Member and reported a number of other smaller occurrences as far north on the Bruce Peninsula as Brinkman's Corners (north of Lion's Head).

Determination of the full regional extent of the Eramosa Member on the Bruce Peninsula is complicated by: (1) the lack of a completely exposed Eramosa Member interval; (2) the uncertainty of its relationship with both the Amabel and Guelph Formations; and (3) the lack of previous mapping delineating its distribution.

3.0 LITHOLOGY OF THE ERAMOSA MEMBER

In general, the Eramosa Member is a grey-brown to black, laminated, bituminous, thin-bedded, very fine- to fine-crystalline dolostone. It has subordinate beds of light brown, non-laminated, non-bituminous, thin- to thick-bedded, fine- to medium-crystalline dolostone. On the Bruce Peninsula, the Eramosa Member consists of three basic lithofacies: (1) a light grey-brown to black, laminated, bituminous dolostone; (2) a light brown, non-laminated, slightly bituminous dolostone; and (3) a light to dark brown, bituminous, poor- to well-laminated dolostone, transitional between (1) and (2). The essential distinguishing factors among these lithofacies are the degree of lamination, the related pattern of stylolitization (explained below), and the colour. The last factor is in part related to the organic matter content, which, for the Eramosa Member is considered to be bituminous in nature owing to the petroliferous odour emitted from freshly broken rock surfaces. Lithofacies 1 is further subdivided into lithofacies 1a and 1b, based primarily on colour and the related organic matter content. The characteristics of the Eramosa Member lithofacies are summarized in Table 1 and discussed in detail below.

Table 1: Lithologic properties of the Eramosa Member lithofacies.

LITHO-FACIES	LAMINATION	COLOUR	BEDDING	CRYSTALLINITY	ORGANIC CONTENT	STYLOLITES	FOSSILS	OTHER
1a	yes	light to dark grey brown	thin	very fine to fine	moderate	very abundant microstylolites	stromatolites	vugs with calcite, pyrite, sphalerite, fluorite
1b	yes	dark brown to black	thin	very fine to fine	high	abundant microstylolite networks	graptolites	chert, pyrite, sphalerite, calcite
2	no	light brown to grey brown	thin to thick	fine to medium	slight	local microstylolites and single stylolites	brachiopods echinoderms corals, stromatoporoids	vugs with calcite, dolomite, pyrite
3	variable	light to dark brown	thin to medium	fine to medium	variable	microstylolite networks and single stylolites	brachiopods stromatoporoids, corals	chert, pyrite, sphalerite

3.1 Lithofacies 1a

Lithofacies 1a, informally and locally termed the "marble", consists of thin-bedded, light to dark grey-brown, very fine- to fine-crystalline, moderately bituminous, laminated dolostone (Plates 1 - 5). Abundant planar to low amplitude wavy (< 1cm) or micro-crenulated (< 2mm), dark brown to black, organic-rich (i.e. bituminous), paper-thin planes occur throughout, oriented parallel to sub-parallel to the lamination (Plates 1 - 3). These planes are stylolites, formed by post-depositional pressure-solution processes which dissolved some of the original carbonate minerals and concentrated insoluble material such as clays, quartz, and organic matter. Stylolites are generally considered to be planes of structural weakness and sites of preferential weathering, and their abundance and planar form in this lithofacies results in the relatively high frequency of horizontal partings or separations.

Petrographic examination shows that lamination in lithofacies 1a is primarily imparted by grain size variation of the dolomite matrix and is enhanced by stylolite development (Plates 1 - 3). Minor minerals including quartz, feldspar, and clays are scattered throughout the dolomite matrix, but are more commonly associated with (i.e. concentrated in) stylolites.

Sedimentary structures such as convolute laminae and ripple-like forms are commonly bounded by stylolites and were probably modified by pressure solution processes. This makes positive identification of these structures more difficult. At the Bruce Marble and Stone Quarry (see Figure 1), very small irregular ripple-like forms occurring on bedding planes are similar to structures termed adhesion ripples (or "runzel" marks) which have been interpreted (deVries Klein, 1977) to be indicative of subaerial exposure.

The predominant fossils found in lithofacies 1a are stromatolites which occur sporadically throughout as thin stromatolitic beds or laminae and locally in stromatolitic zones up to 0.5 m thick (Plates 3 - 5). Rare eurypterids have also been reported from this unit (H. Stobbe, pers. comm., 1986). The stromatolites exhibit relatively little internal structure except for local faint cream to light brown colour lamination. Secondary porosity after fenestral porosity is common in these stromatolitic zones. Very thin stromatolitic beds or laminae (Plate 3) generally exhibit a laterally linked hemispherical morphology (classification after Logan et al., 1964) with generally low amplitudes (averaging 2 cm). Acicular-mold porosity (resulting from the leaching of primary anhydrite) occurs scattered throughout this lithofacies, sometimes associated with stromatolites, and commonly concentrated in lenses (generally less than 5 cm long) with associated disturbed bedding. Vuggy porosity is also locally developed in this lithofacies, often in stromatolitic zones. Vugs (up to 5 cm in diameter) are commonly mineralized with coarse calcite and dolomite, pyrite, sphalerite, and locally fluorite (especially at the Bruce Marble Quarry).

3.2 Lithofacies 1b

Lithofacies 1b consists of thin-bedded, dark brown to black, very fine- to fine-crystalline, bituminous, laminated dolostone (Plate 6), and is informally and locally termed the "black marble". Its higher content of organic matter, and related darker colouration are the main factors which distinguish it from lithofacies 1a. The relatively high organic matter content and laminated nature (accentuated by stylolites) imparts a shaly fissility to lithofacies 1b upon weathering. Petrographic examination reveals that the darkest laminae are composed of networks of anastomosing organic-rich micro-stylolites. Wavy bedding, soft sediment deformation structures, and apparent ripples occur commonly in this lithofacies.

Chert nodules and beds occur locally and sometimes contain silicified fossils. Sulphide mineralization, primarily pyrite, occurs disseminated throughout and as small nodules in this lithofacies, especially in association with chert. This lithofacies contains few fossils (rare graptolites). Unlike lithofacies 1a, stromatolites are not known to occur in lithofacies 1b. However, a stromatolitic body occurs in outcrop north of the Owen Sound Ledgerock Wiarton Quarry at a roughly equivalent stratigraphic horizon (discussed below).

3.3 Lithofacies 2

Lithofacies 2 is a light brown to grey-brown, fine- to medium-crystalline, slightly-bituminous, non-laminated, locally vug-rich, thin- to thick-bedded dolostone (Plates 7 - 9). Small dark brown concentrations of anastomosing micro-stylolites (Plate 8), here termed "horsetails", occur scattered throughout. Bedding (up to 20 cm thick) is commonly imparted by thin (2 cm) planar networks of anastomosing micro-stylolites. This lithofacies is similar in character to the inter-biohermal bedded lithofacies of the overlying Guelph Formation (Liberty and Bolton, 1971).

Vugs, commonly 4 to 8 cm in diameter and often lined with calcite, dolomite, and/or pyrite (and other sulphides ?), are locally abundant and tend to be concentrated in beds. These vugs may represent leached fossils, such as pentamerid brachiopods or corals. Vug-rich beds also occur in strata assigned to the Guelph Formation at the top of the Wiarton roadcut (Bolton, 1957; Liberty and Bolton, 1971).

Rare corals and stromatoporoids, in some cases silicified, occur in both disoriented and life-position in the dolostone matrix. Rare cephalopods and eurypterids are also found in this lithofacies. Other fine fossil debris (such as crinoidal fragments) are scattered throughout. Small brachiopods are sometimes concentrated in thin beds similar to those in lithofacies 3 (see below).

3.4 Lithofacies 3

Lithofacies 3, informally termed the "brown marble", consists of light to dark brown, fine- to medium-crystalline, bituminous, non- to moderately well-laminated, thin- to medium-bedded dolostone (Plate 10). It is transitional in lithologic character between lithofacies 1b and 2. Lithofacies 3 lacks the well-developed lamination of 1b, and is darker and more bituminous than 2. Dark brown, bituminous, anastomosing micro-stylolites are commonly concentrated in thin (< 3 cm thick) bands which are more abundant than in lithofacies 2 and impart this lithofacies's thin-bedded nature (Plate 15).

This lithofacies contains small brachiopods which in some beds are locally abundant enough to constitute a coquina (informally termed "shelly beds"). These small thin-walled shells commonly appear to be in life-position. Bitumen commonly, and sphalerite rarely, infill associated moldic porosity. Burrows and trails are found on some bedding planes (Plate 11). Corals and stromatoporoids, generally sparse, are locally abundant (eg. at the Sky Lake roadcut - Plate 12).

Chert nodules and beds are locally a constituent of this lithofacies. Some chert nodules in the Ebel Quarry contain coarse dark brown sphalerite. Other chert beds and nodules contain silicified corals and other fossil debris.

4.0 STRATIGRAPHIC RELATIONSHIPS

4.1 Internal Stratigraphy

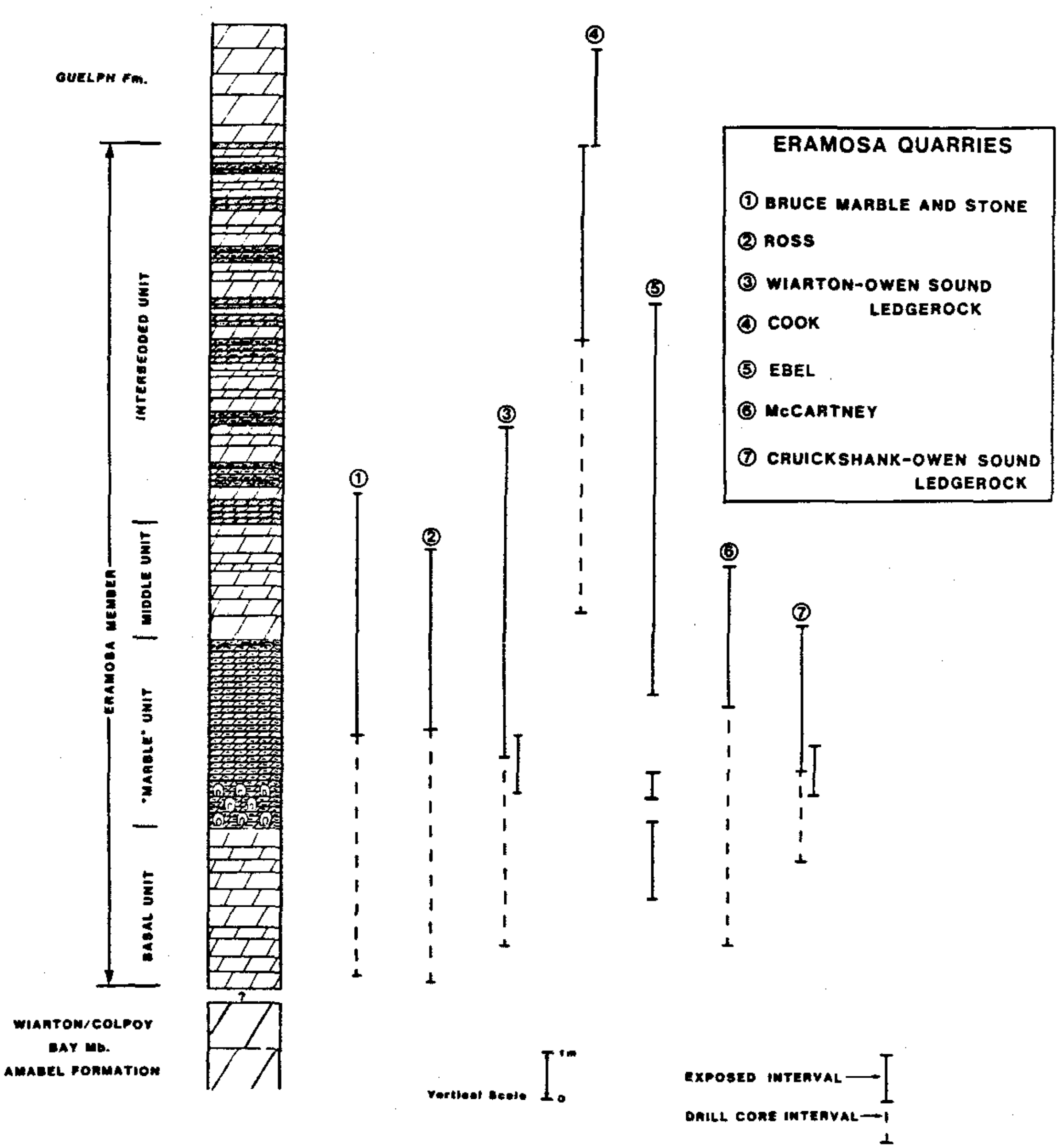
There is no single outcrop or quarry excavation on the Bruce Peninsula which exposes the entire Eramosa Member interval. Quarry excavations during the past twenty years have, however, exposed more Eramosa Member strata than was previously available during earlier geological mapping (eg. Liberty, 1966).

Various intervals of the Eramosa Member are exposed in the seven Eramosa quarries on the Bruce Peninsula (locations in Figure 1). Lithostratigraphic sections for the strata exposed in each of these quarries, and that intersected in the respective shallow drillholes, are presented in Appendix I.

The four quarries in the vicinity of Oliphant Road, west of Wiarton (see Figure 1), afford the most complete exposure of the Eramosa Member. A schematic composite section of the Member (see Figure 3) can be constructed by combining the lithostratigraphic sections and drillhole data from these quarries (Appendix I).

The Eramosa Member is subdivided into four informal stratigraphic units, based on the distribution of its lithofacies, as illustrated in Figure 3. These four informal units, previously only numbered in ascending order (Armstrong, 1986), are herein named as follows (in ascending order): (1) the **Basal Unit**; (2) the **"Marble"**

Figure 3: Schematic composite section of the Eramosa Member in the Oliphant Road area (location in Figure 1), Bruce Peninsula. Exposed and drillhole intersected intervals for all the Eramosa quarries discussed in the text (including those outside the Oliphant Rd. area) are plotted in their approximate stratigraphic position. Detailed lithologic descriptions of these quarries are presented in Appendix I and lithologic symbols used here are explained in the Legend in Appendix I. (N.B. Interbedded Unit is not present at the Bruce Marble and Stone Quarry (quarry #1); the Middle Unit is thicker at this quarry).



Unit; (3) the Middle Unit; and (4) the Interbedded Unit. Both the Basal and Middle Units consist predominantly of light brown lithofacies 2 dolostones which are similar in character to the bedded dolostones of the overlying Guelph Formation. The "Marble" Unit consists almost exclusively of the laminated lithofacies 1a dolostones, whereas the Interbedded Unit contains interbeds of all the Eramosa Member lithofacies except 1a.

The exposed and drillhole intersected intervals of the Eramosa Member from the Eramosa quarries on the Bruce Peninsula are plotted in their approximate stratigraphic position on the schematic composite section (solid and dashed lines, respectively, in Figure 3). The Middle Unit/ "Marble" Unit contact is used as a datum in Figure 3, because it is sharp, easily recognizable, and exposed in all but one of the Eramosa quarries (not exposed at the Cook Quarry). Maximum thicknesses of the units encountered in the four Oliphant Road quarries were used in constructing Figure 3. The Interbedded Unit is not present (eroded ?) at the Bruce Marble and Stone Quarry and the Middle Unit is thicker at this quarry than at the quarries in the Oliphant Road area.

The four units of the Eramosa Member are described in detail below, highlighting lithological variability among the various quarry exposures. This section then concludes with a discussion of the regional distribution and variability of the Eramosa Member units.

4.1.1 Basal Unit

The Basal Unit consists primarily of the thin- to medium-bedded, light brown dolostones of Eramosa lithofacies 2 with locally developed concentrations of dark brown anastomosing micro-stylolites. Due to its poor exposure, this unit was not previously recognized (eg. by Liberty and Bolton, 1971). The only positively identified outcrops of this unit are found immediately south of, and stratigraphically below, the main excavations of the Ebel Quarry and Owen Sound Ledgerock's Wiarton Quarries (see Figure 3 and sections in Appendix I). Vug-rich beds exposed in this unit on the Ebel Quarry property are similar to those strata previously assigned to the Guelph Formation at the Wiarton roadcut (Liberty, 1966; Liberty and Bolton, 1971).

The lower contact of the Basal Unit with the underlying Wiarton/Colpoy Bay Member (see Figure 2) is not exposed in any outcrop or quarry section. However, a light brown, fine-crystalline dolostone with relatively abundant small fossil debris and associated fossil-moldic porosity, outcropping immediately to the southeast of the Ebel Quarry property, may represent the transition from the underlying Wiarton/Colpoy Bay Member to the Basal Unit. The Wiarton/ Colpoy Bay Member differs from the Basal Unit in that it consists of thick- to massive-bedded, fine- to coarse-crystalline, grey-white, variably mottled blue-grey, dolostone which varies from sparsely to very fossiliferous (locally biohermal).

Although the Basal Unit was intersected in five drillholes of the shallow drilling program (see Appendix I and Figure 3), its lower contact was not encountered. The maximum thickness of this unit in the shallow drillholes is 3.76 metres at the Bruce Marble and Stone Quarry. The entire Basal Unit interval was intersected in a drill program conducted by Golder Associates on the Bruce Marble and Stone Quarry property in 1983 (R. King, pers. comm., 1986). Golder's drilling determined the Basal Unit to vary from 4.5 to 7.6 metres in thickness across this property (approximately 700 metres). East of this quarry, in outcrops along Highway 6, laminated stromatolitic dolostone lithologically similar to the "Marble" Unit, directly overlies apparent Wiarton/Colpoy Bay Member bioherms, suggesting that the Basal Unit is locally absent.

In 1982, the Ontario Geological Survey (OGS) drilled a regional stratigraphic drillhole, called OGS-82-4 (see Johnson et al., 1985), near Isaac Lake, northwest of the Oliphant Road area (location plotted on map in pocket). This drillhole was cored from the bedrock surface to the Pre-Cambrian basement. The uppermost approximately 3 metres of bedrock encountered in this drillhole consists of light brown dolostone (lithofacies 2) overlain by 5 cm of laminated dolostone (lithofacies 1a). Although very thin and occurring at bedrock surface the laminated dolostone appears to be "in place" and is interpreted to be the lowermost part of the "Marble" Unit. The remaining part of this 3 metre interval, thus, represents the entire thickness of the Basal Unit of the Eramosa Member in this area. This unit's contact with the underlying blue-grey-mottled dolostone of the Wiarton/Colpoy Bay Member appears to be brecciated in this drillhole.

4.1.2 "Marble" Unit

The "Marble" Unit consists almost entirely of the light to dark grey-brown, laminated dolostones of Eramosa Member lithofacies 1a. Portions of this unit are exposed in all currently active Eramosa quarries on the Bruce Peninsula (see Figure 3 and sections in Appendix I). The best, although never complete, exposures of this unit are in the quarry excavations and in outcrops south of Owen Sound Ledgerock's Wiarton Quarry (Plates 5 and 13). The thickness of the "Marble" Unit was determined, through the shallow drilling program, to vary from 3.0 to 3.85 metres among the Eramosa quarries (see Appendix I).

Although the basal contact of this unit appears sharp in outcrop (only exposed at Owen Sound Ledgerock's Wiarton Quarry and at the Ebel Quarry), in drillcore, minor thin (< 3 cm) interbeds of lithofacies 2 occur in the lower portion of this unit in some localities (see Appendix I). The base of the "Marble" Unit is placed at the lowest occurrence of laminated or stromatolitic dolostone.

Stromatolitic laminae or beds occur throughout the "Marble" Unit (Plates 3 and 4). These stromatolitic intervals are commonly light grey to pink in colour, may exhibit a faint colour lamination, and contain fine vuggy porosity (after original fenestral porosity?). At most of the quarries there is a thin (< 5 cm) stromatolitic bed within 10 cm of the top of this unit. In addition, the lowest 1 metre of the "Marble" Unit is commonly stromatolitic (Plate 5), with locally developed vuggy porosity, and infrequent sub-horizontal stylolites. At the Bruce Marble and Stone Quarry, the entire "Marble" Unit is generally more stromatolitic than at the other Eramosa quarries (see Appendix I).

The colour of the laminated, non-stromatolitic intervals (i.e. most) of the "Marble" Unit varies from light to dark grey-brown and is generally consistent within a quarry and among the Eramosa quarries (locally it may exhibit light shades of pink, yellow, and blue). However, the "Marble" Unit is significantly paler and pinker in colour at the Bruce Marble and Stone Quarry where, wetted cut surfaces exhibit distinct shades of blue-grey and pink. This colour variability appears to be a weathering phenomenon, although its mode of origin and extent is not known with certainty.

Although the "Marble" Unit is planar laminated in general, there are some zones in which bedding and lamination are "wavy". These "waves" typically have low amplitudes (typically < 10 cm) and long wavelengths (< 1 m) and their origin is uncertain. They are commonly bounded by stylolites which obscure their origin; they may be current-related (i.e. ripples), or soft sediment deformation features. Smaller scale waviness or crenulation of laminae and stylolites is generally related to the morphology of underlying stromatolites.

Frequency of horizontal partings or separations (informally termed "bedding thickness") in the "Marble" Unit varies within and among the quarry exposures. In addition to parting frequency measurements made from quarry exposures, measurements were made of apparent parting frequency in the drillcore from the shallow drilling program. These measurements are plotted (called apparent bedding thickness) beside their corresponding lithologic logs in Appendix I. The parting frequencies measured in the drillcore are termed "apparent" because drilling tends to impart more partings or separations than would naturally be there if the strata were exposed. However, these measurements do provide a relative measure of parting frequency which is useful for comparing units or lithofacies within and among drillholes.

As previously discussed, the frequency of horizontal partings or separations in this unit is generally a function of the well laminated nature and pattern of stylolitization of lithofacies 1a. Stromatolitic intervals are generally thicker bedded (see Appendix I) primarily because they are less well laminated and stylolites are less abundant.

As bedrock cover provides protection from weathering processes, the thickness of overlying bedrock is another factor controlling parting frequency. For example, where the "Marble" Unit is overlain by less than 2 metres of Paleozoic strata (eg. at Owen Sound Ledgerock's Cruickshank Quarry and at the McCartney Quarry), it separates into beds generally less than 10 centimetres thick. Where it is overlain by more than 2 metres of strata, the "Marble" occurs in beds up to 45 centimetres thick.

In some cases, such as at the Bruce Marble and Stone Quarry, parting separation appears to be related to anticlinal forms, locally termed "rolls". These anticlinal forms are domal to linear features with an approximate northwest orientation in plan view, and are apparently related to underlying Amabel Formation bioherms. Generally, on the top of anticlinal forms the "Marble" is flaggy (i.e. higher frequency of partings), whereas in depressions between them, this unit (and the overlying Middle Unit) is much more competent and partings are up to 1 metre apart.

4.1.3 Middle Unit

The Middle Unit consists of thin- to medium-bedded light brown dolostones of lithofacies 2 (Plate 9). This unit occurs, at least in part, in all of the active Eramosa quarries on the Bruce Peninsula and is exposed in its entirety (approximately 3 metres) at only the Ebel and Owen Sound Ledgerock's Wiarton Quarries, where it is overlain by additional Eramosa strata. In all other active quarry properties it is the uppermost Eramosa unit present.

The lower contact of this unit is sharp (Plate 14), typically with a thick (56 cm) vug-rich bed (or two thinner beds totalling 56 cm) of the Middle Unit overlying a thin bituminous parting at the top of the "Marble" Unit.

Bedding contacts are predominantly planar or slightly irregular and appear to be controlled by stylolites, forming either in thin (2 cm) zones of anastomosing micro-stylolites or single stylolites. Local irregular bedding contacts appear to have been solution enhanced.

As with the underlying "Marble" Unit, the parting or separation frequency of this unit may vary along strike within a quarry. This also may be related to anticlinal forms or "rolls" in the strata. At Owen Sound Ledgerock's Wiarton Quarry parting frequency is greater on the western flank of a north-south oriented linear anticline and beds tend to be thicker (i.e. lower frequency of partings) on the eastern flank (H. Stobbe, pers. comm., 1986). This variability in parting frequency may in part be related to glaciation processes.

4.1.4 Interbedded Unit

The Interbedded Unit is the uppermost unit of the Eramosa Member on the Bruce Peninsula. It consists of interbeds of dark brown to black lithofacies 1b dolostone and thin- to medium-bedded light to dark brown lithofacies 2 and 3 dolostones (Plate 15). Only three Eramosa quarries (the Cook, Ebel, and Owen Sound Ledgerock's Wiarton Quarries), all in the Oliphant Road area, expose strata of this unit. The underlying Middle Unit is the uppermost preserved strata at all the other Eramosa quarries on the Bruce Peninsula. The Interbedded Unit also outcrops in the Oliphant Road area, east of the McCartney Quarry, and the Eramosa Member strata exposed in the Sky Lake roadcut are also tentatively assigned to this unit.

The lower contact of the Interbedded Unit is taken at the lowest occurrence of thin-bedded, dark brown to black, bituminous, dolostone (lithofacies 3 or 1b). This contact is only exposed in the Ebel Quarry and in Owen Sound Ledgerock's Wiarton Quarry.

The upper contact of this unit (and of the Eramosa Member) with the Guelph Formation is taken at the base of a thick (1 to 1.5 metre) bed of light brown, non-bituminous, fine-crystalline, dolostone. This contact is exposed at the Sky Lake outcrop and is inferred between two quarry excavations on the Cook Quarry property (see Old and Main Quarry Sections for the Cook Quarry in Appendix I). From these limited exposures the maximum thickness of this unit is estimated to be approximately 8 metres.

The lithologic characteristics of the component lithofacies of the Interbedded Unit are gradational from lithofacies 2 through 3 to lithofacies 1b. Although interbeds of these lithofacies commonly have sharp contacts, the lithofacies appear to grade laterally across a quarry property. Although some individual beds can be traced across a quarry property, only packages of beds can be correlated between quarries or outcrops. A good example of this, is the difficulty encountered in the correlation of individual beds between the drillhole interval from the Cook Quarry and the stratigraphic section exposed in the Ebel Quarry (see Appendix I). The quarry floor (i.e. drillhole top) in the Cook Quarry is roughly the top of the Ebel Quarry section (within 1 metre), and they are within 200 metres of each other.

The Interbedded Unit is characterized by a variety of sedimentary and biogenic structures, including convolute laminae, soft sediment slump structures, burrows, and fossil traces. This unit is the most fossiliferous interval in the Eramosa Member. It contains locally abundant small brachiopods, corals, stromatoporoids, and rare eurypterids, cephalopods, and graptolites. Locally, some of these fossils are silicified. At Sky Lake and in the outcrop east of McCartney Quarry, corals are so abundant that they constitute small biostromes up to 1 metre high and 3 metres in diameter. In addition, a small stromatolitic build-up outcropping at the north end of Owen Sound Ledgerock's Wiarton Quarry property may occur within the Interbedded Unit interval or be a topographic high within the upper part of the Marble Unit. Interbedded Unit strata are warped in the vicinity of this build-up at a similar scale as anticlinal forms at Bruce Marble and Stone Quarry.

Chert occurs in this unit as discrete, spherical or oblate nodules and as thin (< 10 cm) beds or patches. There is not any preferential silicification of any lithofacies within this unit. Occasionally, silicified fossils are at the core of the nodules and, locally, chert beds will contain abundant small fossil detritus.

Sulphide mineralization (pyrite and sphalerite) commonly occurs in association with chert in this unit. Sphalerite also occurs without chert in the stromatolitic build-up at Owen Sound Ledgerock's Wiarton Quarry and in the coralline biostrome east of McCartney Quarry. Locally, bitumen globules exude from fossil-moldic, vuggy, inter-crystalline, or fracture porosity.

4.2 Regional Distribution

Portions of the Eramosa Member stratigraphy occur in all of the Eramosa quarries on the Bruce Peninsula (see Figure 3 and Appendix I). The thicknesses of the Eramosa units in each quarry are summarized in Table 2. The two reasons for the absence of a particular unit in a given quarry are erosion or non-exposure (i.e. in the subsurface and not detected in this study). However, the stratigraphic sequence of the Eramosa Member on the Peninsula is consistent where present. The Eramosa Member is not present

Table 2: Thicknesses of Eramosa Member units.

ERAMOSA QUARRY	BASAL UNIT	MARBLE UNIT	MIDDLE UNIT	INTER-BEDDED UNIT
1: Bruce Marble and Stone	3.7 (d)	3.2	3.0	(a)
2: Ross	3.2 (d)	3.8	1.8 (c)	(a)
3: Wiarton - Owen Sound Ledgerock	3.3 (d)	2.9	2.1	2.3 (c)
4: Cook	(b)	(b)	1.4 (b)	7.4
5: Ebel	1.5 (e)	1.1 (d)	2.3	4.4 (c)
6: McCartney	2.7 (d)	3.7	1.5 (c)	(a)
7: Cruick-shank - Owen Sound Ledge-rock	1.0 (d)	3.5	0.2 (c)	(a)

Notes:

(a) = not present (eroded ?)

(b) = neither exposed nor encountered in drilling

(c) = unit exposed in quarry but may not be maximum thickness (subcropping or outcropping unit)

(d) = lower contact not encountered (not maximum thickness)

(e) = exposed in isolated outcrop

where Guelph Formation bioherms lie directly upon Amabel Formation bioherms (Liberty and Bolton, 1971).

Reconnaissance mapping of the Bruce Peninsula was undertaken to find new surface exposures of the Eramosa Member and to outline areas which are possibly underlain by Eramosa Member strata at depths which would probably permit its economic extraction. This would include situations where the Eramosa Member is overlain by a thin cover of younger rock or sediments.

Mapping focussed on the previously delineated Amabel/ Guelph formational contact as determined by Liberty (1966). Because of the lithological similarity between thin- to medium-bedded Guelph Formation dolostones and lithofacies 2 of the Eramosa Member's Middle and Basal Units, a wide area on either side of the indicated contact was investigated. Also, because of the apparent relationship between Guelph and Amabel Formation bioherms (Liberty and Bolton, 1971), areas in which Guelph bioherms outcrop are interpreted as not underlain by Eramosa Member strata.

In the following discussion of the reconnaissance mapping, the Bruce Peninsula is divided into four geographical zones, denoted A through D, which are plotted on the map in the back pocket. Results of the reconnaissance mapping are presented on the 1:100,000 scale resource distribution map (in back pocket). Lightly stippled areas on this map are possibly underlain by at least a portion of the Eramosa Member strata (i.e. at least the Basal Unit). Darkly stippled areas are definitely underlain by Eramosa Member strata probably up to and including the Middle Unit (the overlying strata being eroded). Some uncertainty is associated with the areal extent of both of these stippled areas and with the thickness of strata present in each. This is because of the lack of continuous exposure and absence of subsurface information (i.e. drillholes are required to confirm amount of strata and quality of stone). The economic significance of these outlined areas will be discussed in the Resource Potential section (section 5.3).

4.2.1 Zone A

Geographical Zone A covers the area on the Bruce Peninsula south and east of the town of Wiarton. Scattered outcrops of thin-bedded, fine- to very fine-crystalline dolostone occur in a broad region west and northwest of the Cruickshank Owen Sound Ledgerock's Quarry and suggest that this whole stippled area may be underlain by at least some Eramosa Member strata (indicated by light stipple on map). This interpretation is supported by the lack of fossiliferous Guelph Formation outcrops in the area. Goudge (1938) reported bituminous rocks near Park Head (south of Hepworth) and Liberty and Bolton (1971) report the same in the vicinity of Hepworth.

Eramosa Member strata end abruptly at their eastern erosional edge at the Cruickshank Quarry. Elsewhere in this stippled region the location of the erosional edge of this Member is less certain.

Another area possibly underlain by Eramosa Member strata occurs south of Wiarton in a belt between Mountain Lake and Boat Lake, north of Clavering. In this belt there is an area of high potential resource which includes the McCartney Quarry and an outcrop of the Interbedded Unit one kilometre to the east of this quarry. The northern boundary of this area is a covered erosional edge. Guelph Formation bioherms occur southeast of the McCartney Quarry, in the area of Mountain and Francis Lakes.

Outcrops of lithofacies 2 dolostone east of Boat Lake suggest possible underlying Eramosa Member strata in this area. Although not indicated by a stippled pattern, the broad area mapped as Guelph Formation (Liberty, 1966) west of Clavering and east to Francis Lake, may also be underlain by some Eramosa Member strata. The plain to the west and south of Wiarton is underlain by Wiarton/Colpoy Bay Member dolostones.

4.2.2 Zone B

Zone B, as indicated on the resource distribution map, covers the area north from Wiarton to Sky Lake and includes the high concentration of Eramosa quarries northwest of Wiarton in the Oliphant Road vicinity.

The quarries and outcrops in the Oliphant Road area indicate that it is probably underlain by most of the

Eramosa Member interval. This area is bounded to the south by an erosional edge, that is exposed in both the Ebel Quarry and in Owen Sound Ledgerock's Wiarton Quarry, and to the north by Guelph Formation bioherms north of the Cook Quarry. The Interbedded Unit outcrops between the Wiarton and Ross Quarries and the Basal Unit was intersected in Ontario Geological Survey drillhole OGS-82-4, north of the Ross Quarry. The western and northwestern boundaries of this area are uncertain, although fossiliferous Guelph Formation dolostones found near Berford Lake suggest that the Eramosa Member gives way to biohermal strata in this area.

A small outcrop of lithofacies 1a was found on the west side of a hill immediately north of the town of Wiarton. It overlies and may be in part equivalent to strata at the top of the Wiarton roadcut which were previously assigned to the Guelph Formation (Liberty, 1966). These strata may however represent the lower part of the "Marble" Unit and the Basal Unit of the Eramosa Member.

Strata exposed in the roadcut at the south end of Sky Lake have been assigned to the Eramosa Member (Liberty and Bolton, 1971) and are interpreted in this report to be equivalent to the Interbedded Unit of the Oliphant Road composite section. The Guelph/Amabel formational contact, as mapped by Liberty (1966), north and south of this outcrop at Sky Lake was not investigated in the present study.

4.2.3 Zone C

The third geographical zone, Zone C, includes the area from Sky Lake to Stokes Bay in the north, and covers the central portion of the Bruce Peninsula. Areas possibly underlain by Eramosa Member strata occur in a few small bays along the west shore of the Peninsula and in a broad area around the Bruce Marble and Stone Quarry (see resource map).

Liberty and Bolton (1971) reported Eramosa Member strata in the Red Bay, Pike Bay, and Stokes Bay areas. During the present study, outcrops of thin-bedded lithofacies 2 were found at Stokes Bay and Pike Bay, and lithofacies 1a was found below (< 1 m) the water level in Pike Bay. The Red Bay exposures were not examined in this study. Eramosa Member strata in the subsurface may connect these exposures on the west shore with those exposed at the Bruce Marble and Stone Quarry.

In the area around Bruce Marble and Stone Quarry the Eramosa Member overlies Amabel Formation bioherms. This relationship can be seen in outcrops at the erosional edge of the Eramosa Member along Highway 6 and is implied by the anticlinal rolls in the strata exposed in the Bruce Marble and Stone Quarry. Ridges to the west and south of the area are thick-bedded, locally fossiliferous (biohermal) dolostones of the Guelph Formation.

The flat area along Highway 6 south of Ferndale reported by Liberty and Bolton (1971) to be underlain by the Eramosa Member, is more likely underlain by the

Wiarton/Colpoy Bay Member of the Amabel Formation. The small outlier of Guelph Formation mapped at Ferndale by Liberty (1966) was not confirmed in the current study. The Guelph/Amabel Formational contact between Bruce Marble and Stone Quarry and Ferndale is poorly exposed.

The Guelph Formation outliers mapped by Liberty (1966) east of Highway 6, between Hope Bay and Lion's Head, are highly fossiliferous dolostones and may be biohermal.

4.2.4 Zone D

The last geographical zone, Zone D, encompasses all the area on the Bruce Peninsula north of Stokes Bay. A National Park covering much of the northern portion of this zone has recently been established.

Eramosa Member strata previously reported at Brinkman's Corners, near Cape Chin, and on the islands north of Tobermory (Liberty and Bolton, 1971; Williams, 1919) were not confirmed in the present study.

Lithofacies 1a dolostones were discovered in outcrops along the southern shore of Marley Lake, northwest of Dyer's Bay, and in a small outcrop southeast of Brinkman's Corners. Except for this latter occurrence of lithofacies 1a, the Guelph/Amabel formational contact from Lion's Head north to Dyer's Bay appears to be largely transitional from biohermal Amabel Formation dolostones to those of the Guelph Formation. Time constraints during this field investigation precluded detailed investigation of this geographical zone.

5.0 BUILDING STONE RESOURCES

5.1 Past and Current Products

The Amabel and Guelph Formations have been quarried for building stone since about the turn of the century on the Bruce Peninsula (Parks, 1912; Goudge, 1938; Hewitt, 1964; Hewitt and Vos, 1972). There are still a few buildings in Owen Sound dating from that time, which were built with coursing stone (traditional building stone blocks, 8 - 12 inches thick) locally quarried from the Wiarton/Colpoy Bay Member of the Amabel Formation (see Parks, 1912). A number of buildings in Wiarton were built with Eramosa Member coursing stone extracted from the Cook Quarry (J.S. Cook, pers. comm., 1986).

Currently, only the Eramosa and Wiarton/Colpoy Bay Members of the Amabel Formation are quarried for building stone on the Bruce Peninsula. Although not presently utilized, other dolostone units on the Peninsula, such as the Lions Head Member of the Amabel Formation and the Guelph Formation, are potential (yet untested) sources of building stone. Commercial interest in building stone on the Peninsula has recently increased with the awarding of a major contract to Arriscraft Corporation, which operates the Adair Marble Quarry near Hope Bay, to supply dimension stone from the Wiarton/Colpoy Bay Member for the new Canadian Chancery in Washington, D.C.

The Eramosa Member has been quarried for a wide variety of building stone products since at least the turn of the century. Parks (1912) reported that the Cook Quarry (the first Eramosa quarry) produced rubble, coursing stone (or ashlar), sills, caps, monument bases, and flagging (flagstone). Today, the six active Eramosa quarries still produce many of these products in addition to newer "value-added" building and ornamental stone products (eg. polished tiles, mantels, and table tops) and products utilized in the landscaping industry.

Demand for traditional building stone blocks (coursing stone or ashlar) is reduced, and some of the Eramosa quarries produce a thinner coursing stone (termed "ledgerock" by one operator). The larger blocks are now sometimes used in retainer-or dry-walls (mortar-less walls commonly used in landscaping). Random (irregular) and cut flagstone (or patio stone) are also major products from the Eramosa Member. Other landscaping products include "landscape" or "waterfall" stone, which are large (approximately 1 cubic metre) blocks with at least one solution enhanced vertical joint surface. Newer, polished products from the Eramosa Member include tiles for interior floors and walls, and mantels, counter tops, and ornamental pieces (eg. table tops). The products currently extracted from the Eramosa Member are discussed below in their litho-stratigraphic context and are summarized in Table 3.

Table 3: Products extracted from the Eramosa Member.

ERAMOSA MEMBER UNIT	QUARRY	PRODUCTS	COMMENTS
Interbedded Unit	Ebel and Wiarton - O.S.L.*	flagstone, patio stone, drywall, sills, etc., polished tiles and ornamental stone	local chert and sulphides
Middle Unit	primarily Ebel and Wiarton - O.S.L.*	drywall, rubble, coping stone, coursing stone, hearths, mantels, steps	
"Marble" Unit	all six quarries except Ebel	flagstone, coursing stone, drywall, rubble, coping stone, sills, mantels, "landscape" stone, polished products	use is a function of parting thickness, "fleuri" pattern
Basal Unit	Ebel	"landscape" stone	weathered blocks

Note: O.S.L.* = Owen Sound Ledgerock

The limited exposure of the Basal Unit of the Eramosa Member has constrained its exploitation. Weathered blocks of this unit have been quarried for "landscape" stone at the Ebel Quarry.

The Marble Unit is exposed in all six of the currently active Eramosa quarries on the Peninsula. Depending on the frequency of partings or separations, this unit is quarried for flagstone, coursing stone, drywall, rubble, coping stone, sills, or mantels. This unit is also the main source in the Eramosa Member for polished products, owing to its laminated nature. When cut and polished parallel to bedding, low amplitude wavy and micro-crenulated thin laminae and stylolites impart a distinctive pattern, termed "fleuri" by the local operators (Plate 16). Stone from this unit is also cut perpendicular to bedding, producing a "cross grain" or "walnut" pattern.

The thin- to thick-bedded, non-laminated dolostones of the Middle Unit are quarried for drywall, coursing stone, coping stone, hearths, mantels and steps. This lithofacies has also been polished, yielding an unpatterned buff-brown product.

The various lithofacies and variable bedding thicknesses of the Interbedded Unit yield a wide variety of products. Black and brown, random and cut, flagstone and patiostone are produced from the thin-bedded lithofacies 1b and 3. Thin coursing stone is produced from lithofacies 2 and 3 where they are thin-bedded, and drywall, medium coursing stone, sills, hearths, etc. where they are medium-bedded. Occasionally, lithofacies 1b (and sometimes lithofacies 3) is cut and polished for tiles and ornamental stone on a custom or special order basis. Because of the generally darker colouration of this lithofacies relative to lithofacies 1a, the "fleuri" pattern is less distinct. In addition, deleterious components such as chert and sulphide minerals are more abundant in this unit.

5.2 Geologic Factors Affecting Resource

The geologic factors affecting the potential of a building stone resource, range from the presence and abundance of desired strata, through factors which control the types of potential products, to factors which effect the quality of a specific product.

The most important and most obvious geological effect on a possible building stone resource is simply the presence of strata which could yield a desired product (eg. in this case the "Marble" Unit). This factor is particularly significant for the Eramosa Member, because its inter-biohermal depositional setting means that it was not deposited over the Bruce Peninsula in a continuous sheet-like deposit. In addition, post-depositional erosion (primarily glacial?) has probably removed much of the original strata, as evidenced by the now detached yet stratigraphically similar Eramosa quarry exposures.

The geologic factors controlling product type include, (a) bedding thickness and parting frequency, (b) joint orientation and spacing, (c) presence of lamination (i.e. product specific textures).

Parting frequency is, in part, a function of bedding thickness and the effect of these properties on the type of building stone product is evident in the review of current Eramosa products in the preceding section. In addition, polished products generally require mill blocks with specific dimensions, which include a minimum thickness. As previously discussed, parting frequency in the Eramosa Member is controlled by lamination, stylolite development, and to some extent by the amount of covering strata (which controls the degree of weathering).

Joints must be roughly vertical and square, and spaced wide enough apart to ensure adequate block size yet close enough together to facilitate ease of excavation. Closely spaced (< 0.5 metre), randomly oriented joints are generally only suitable for random flag or rubble, whereas steps, sills, or mill blocks for polished tile require the presence of consistent, widely spaced (0.5 to 1 metre), perpendicular joints. Generally, the Eramosa Member contains vertical joint sets oriented at 70-80° and 340-360°, with spacing from 1 to 4 metres. Minor fractured zones are not uncommon.

In addition to causing apparent bedding, lamination (or some similar such textural feature) is an aesthetic feature of finished surfaces. The market value of polished products from the Eramosa Member is related to the style of lamination. Wavy laminae and micro-crenulated stylolites create an appealing "fleuri" pattern when the stone is polished approximately parallel to the bedding plane.

The geologic factors which control product quality include the presence or absence of micro-fractures, vugs, deleterious minerals such as chert and pyrite, and the degree of homogeneity in physical properties (eg. hardness, grain or crystal size). Micro-fractures are not uncommon in the Eramosa quarry exposures, although their distribution is not well known and the factors controlling their occurrence are not understood.

Vugs occur scattered throughout (or sometimes concentrated in beds of) the Basal, Middle, and Interbedded Units, and also are associated with stromatolitic zones in the "Marble" Unit. They are commonly mineralized with medium- to coarse-crystalline calcite, dolomite, pyrite, sphalerite, or fluorite.

Silica is much harder than dolomite and thus presents problems in extraction, cutting, and finishing the stone. Minor silica occurs throughout the Eramosa Member as micro-crystalline, inter-crystalline quartz or chert. Silica content of samples from the Member (see Appendix II) generally range from 0.40 to 2.00 wt.%, with higher values (up to 4.00 wt.%) for samples from lithofacies 1b and 3 (and a few from lithofacies 2). The higher values are consistent with the observed occurrence of chert in the Interbedded

Unit. Chert in this unit occurs as isolated nodules or silicified fossils, to beds and abundant lenses. The "Marble" Unit (lithofacies 1a) generally has the lowest SiO_2 content and there is little variation among samples from different quarries (see Appendix II).

Sulphide minerals, such as pyrite and sphalerite, are susceptible to oxidation and weathering in finished surfaces (especially in exterior cladding). These minerals are only significant as infillings in vugs, and locally in nodules in the Interbedded Unit. Lithofacies 1b samples have generally higher sulphur, iron and sulphophile trace element (eg. Pb, Zn, Cu) contents (see Appendix II), reflecting the presence of some disseminated sulphide mineralization.

Homogeneity of properties is an important factor in specific building stone products, such as those which are polished. Patches or zones of silica or sulphide mineralization have different properties (such as hardness, and resistance to chemical weathering) than the host dolostone. These heterogeneities can cause technical problems during cutting and polishing of the stone and result in an uneven finish. In general, silica (i.e. chert) and sulphide minerals occur only locally in the Eramosa Member, concentrated in nodules, beds, or in vugs, and are not a pervasive problem.

In a laminated rock, laminae with sufficiently different grain or crystal size may behave differently during polishing. Petrographic examination revealed that the crystal size is relatively consistent within Eramosa Member lithofacies ranging from very fine- to fine-crystalline. Crystals comprising laminae in the "Marble" Unit range from 0.05 mm to 0.50 mm in size.

5.3 Resource Potential

Resource estimates can be determined using the stippled areas on the 1:100,000 scale resource distribution map (in back pocket) which indicate areas which are possibly (light stipple) and probably (dark stipple) directly underlain by Eramosa Member strata. This resource assessment focusses on the "Marble" Unit and a conservative estimate of 3 m is used for this unit's thickness in the following resource volume (or reserve) calculations.

As previously explained (in section 4.2), the density of stippling on the resource map indicates the degree of certainty attached to the presence of underlying Eramosa Member strata. Due to the high uncertainty associated with the presence and quality (i.e. parting frequency) of the "Marble" Unit in the lightly stippled areas, these areas are not included in the following reserve estimates.

The darkly stippled areas on the resource map are probably underlain by at least the lower three units of the Eramosa Member (see Figure 3 in section 4.1). These areas can be considered "possible resource" areas, because there is a higher certainty of presence of the "Marble" Unit and the unit is likely covered by at least 3 m of rock strata in these areas.

The thickness of rock strata covering the "Marble" Unit has two effects on the evaluation of its resource potential. Firstly, a minimum of thickness of rock cover of approximately 3 m appears necessary to ensure lower frequency of partings (i.e. better quality) in this unit. Secondly, if the rock cover is too thick, the economics of stripping the cover to expose the "Marble" become excessive. An advantage the Eramosa Member has in this regards, is that its upper two units (the Middle and Upper Units) yield a variety of building and landscaping stone products (see section 5.1 and Table 3) such that one is not necessarily stripping "waste" to get at the "Marble". An arbitrary maximum of 10 m of rock cover was used in the determination of the resource (i.e. stippled) areas. Thus, Eramosa Member strata which are overlain by Guelph Formation strata are not included as a potential resource in this report. Quaternary cover (mostly unconsolidated glacial sediments) on the Bruce Peninsula is generally less than 1 m thick, so that stripping to expose bedrock is not considered a prohibitive factor.

In addition to assuming a constant thickness for the "Marble" Unit, the internal characteristics of this unit (eg. frequency of partings) are also assumed to be relatively constant. These generalizations are necessary because the available data do not permit accurate characterization of the internal variability of the Eramosa Member across the study area. These assumptions and generalizations can be refined and improved through detailed geological mapping on a regional scale and drilling to test potential resource areas. Finally, in the following resource volume (or reserve) calculations, no allowance or consideration was made for the new National Park plans, Niagara Escarpment Commission zoning restrictions, road allowances, pipelines, or other forms of resource sterilization.

Taking into account the above considerations and assumptions, reserve calculations for the "Marble" Unit of the Eramosa Member can be made. The possible reserves (from the darkly stippled areas), for this unit on the Bruce Peninsula are estimated to be 20 x 10^6 m^3. By comparison, probable reserves of the "Marble" Unit can be calculated using estimates of this unit present within the licenced areas of all of the existing Eramosa quarry properties. The probable reserves for the "Marble" Unit are in the order of 3 x 10^6 m^3, or only 15 % of the possible reserve value. Much work remains to better quantify both of these possible and probable reserve estimates.

6.0 SUMMARY AND CONCLUSIONS

From mapping and drilling data collected in and around seven active and abandoned building stone quarries on the Bruce Peninsula, a lithostratigraphic framework was constructed for the Eramosa Member (of the Amabel Formation). Three lithofacies were identified and their stratigraphic distribution defines four units within the Eramosa Member.

The Eramosa Member on the Bruce Peninsula was assigned to the Amabel Formation by Liberty and Bolton (1971) and Bolton (1957) and was treated as such in this report even though the Eramosa Member exhibits more lithologic affinities to the overlying Guelph Formation than to the underlying Amabel Formation. Future detailed regional mapping may result in the formal re-assignment of this member to the Guelph Formation.

The units of the Eramosa Member from which the variety of building and landscaping stone products are extracted were identified. Value-added products, such as polished tile, represent potential growth areas in the building stone industry on the Bruce Peninsula, and as such, units and lithofacies of the Eramosa Member which are the source of these products were the focus of this investigation. These products have been produced on a custom basis from the Interbedded Unit and from the "Marble" Unit. The "Marble"

Unit is the more widespread and consistent of these two units on the Peninsula.

A number of geological factors govern the type and quality of products yielded by the Eramosa Member. The suitability of the "Marble" Unit for the fabrication of value-added products, such as polished tile, is primarily a function of the presence and pattern of lamination (and related stylolites) in this unit. The laminated (and stylolitized) nature of this unit imparts a natural weakness called parting (or separation) yet gives the finished polished product a characteristic "fleuri" pattern.

Reconnaissance mapping delineated areas which are possibly underlain and those which are probably underlain by Eramosa Member strata (illustrated on resource map in pocket). Possible reserves of the "Marble" Unit on the Bruce Peninsula were calculated using an assumed thickness of 3 m for this unit for the areas probably underlain by Eramosa Member strata. A number of significant generalizations and assumptions were also taken into consideration in this calculation. The possible reserves for the "Marble" Unit are estimated to be in the order of 20 x 10^6 m^3, as compared to probable reserves, which are estimated from all currently licenced Eramosa quarries to be approximately 3 x 10^6 m^3. Additional detailed geological research (eg. mapping and drilling) is required to better quantify these estimates.

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APPENDIX I: QUARRY DESCRIPTIONS AND SECTIONS

Introduction and Legend

Eramosa Quarries:

1. Bruce Marble and Stone
2. Ross
3. Wiarton - Owen Sound Ledgerock
4. Cook
5. Ebel
6. McCartney
7. Cruickshank - Owen Sound Ledgerock

INTRODUCTION

The location and description of exposed strata in each Eramosa quarry studied is presented in this appendix. Also presented for each quarry, are schematic sections of exposed strata and drillhole intersected strata. Bar graphs show "apparent bedding thickness" (explained in section 4.1.2) for intervals of drillcore.

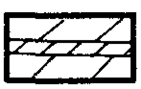
The lithologic symbols used in the schematic sections are described in the legend below. Datum (0 m elevation) for each section is the main quarry floor and positive and negative elevations indicate position relative to this datum.

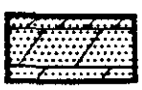
LEGEND


Lithofacies 1a - laminated thin-bedded dolostone


Lithofacies 1a - Stromatolitic


Lithofacies 1b - bituminous, laminated, thin-bedded dolostone


Lithofacies 2 - thin- to thick-bedded dolostone


Lithofacies 3 - bituminous, thin- to medium-bedded dolostone

1. BRUCE MARBLE AND STONE QUARRY

The Bruce Marble and Stone Quarry is located in lot 3, concession I (EBR), of Albemarle Township, one concession road west of Highway 6, 6.2 km north of the village of Mar. This quarry was previously known as the Perfect Stone Quarry (1960 - 1971), Rouse Quarry (1972 - 1980), and Clearstone Quarry (1982 -1984).

Quarrying in at least five small excavations on this property has exposed about 5 m of section consisting of (in ascending order) parts of the "Marble" and Middle Units of the Eramosa Member. The uppermost unit, the Middle Unit, is similar in character to strata of the Guelph Formation exposed in the vicinity, however mapping in and around quarries in the Oliphant Road area (northwest of Wiarton) indicates that this unit is a "Guelph-like" interval within the Eramosa Member. The Middle Unit is thicker at the Bruce Marble and Stone Quarry than it is at the Eramosa quarries in the Oliphant Road area. The characteristics of the "Marble" Unit in this quarry are similar to those of this unit exposed in the other Eramosa quarries on the Bruce except that it is somewhat lighter in colour, less bituminous, more stromatolitic, and more vug-rich in its stromatolitic zones.

Abundant domal to linear (with roughly northwest orientation) anticlinal features on the property may be related to underlying Amabel Formation bioherms. Generally, parting separations on the tops of the domes are more abundant and closely spaced, whereas partings in interdomal areas occur less frequently. Two joint sets are present in the quarry trending 70-80° and 335-345° at average spacings of 1 to 3 metres. Glacial overburden is generally less than 1 m thick on the property.

DESCRIPTION OF EXPOSED STRATA

Unit Thickness

Middle Unit, Eramosa Member........................3.0m

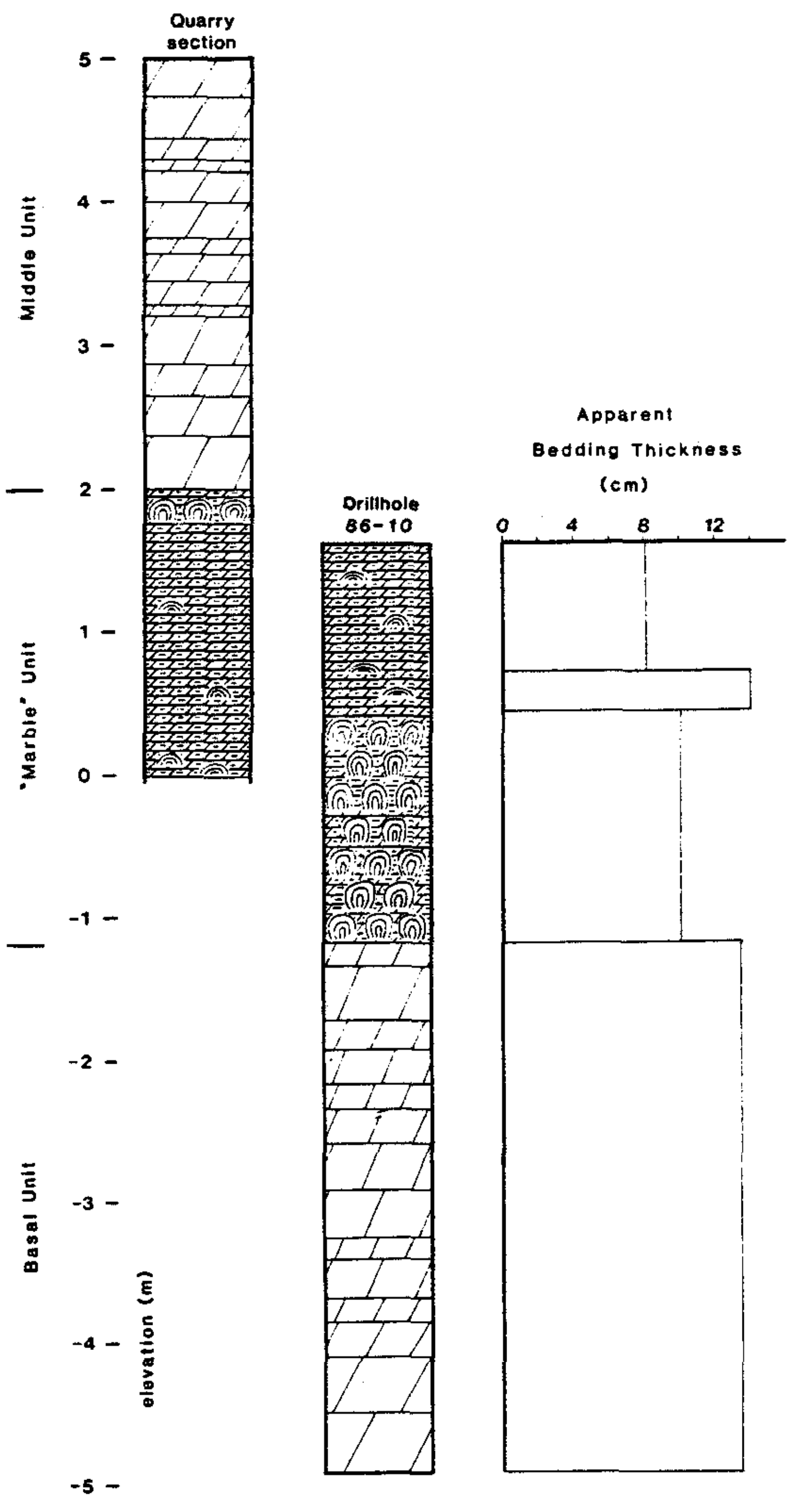
Lithofacies 2: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; thin to thick bedded with irregular to planar contacts which appear to be related to thin bands of dark brown microstylolites; rare silicified corals and crinoidal fragments; calcite mineralization occurs in local vugs; lower contact of unit is sharp, at top of a thin shaly bituminous bed.

"Marble" Unit, Eramosa Member......................2.0m

Lithofacies 1a: light grey to light grey-brown, weathers light grey to light buff-brown; very fine to fine crystalline; laminated to thin bedded with planar to wavy and locally crenulated contacts; locally stromatolitic; locally vug-rich in stromatolitic zones; calcite, pyrite and fluorite mineralization in vugs; thin bituminous partings (planar microstylolites); lower contact of unit is not exposed.

Total Exposed Thickness.................5.0m

BRUCE MARBLE AND STONE QUARRY



2. ROSS QUARRY

The Ross Quarry is located in lots 10 and 11, concession XXV, of Amabel Township, 5.7 km northwest of Wiarton, on a side road north of Oliphant Road. The quarry consists of two small excavations, a western opening which is currently active, and an eastern opening which is currently used for processing and storage of building stone inventory.

The quarry excavations expose up to 4 metres of section consisting of (in ascending order) the "Marble" and Middle Units of the Eramosa Member. The "Marble" Unit, a laminated light grey-brown dolostone, is the main source for building stone products in this quarry. The overlying Middle Unit is a thicker bedded, non-laminated, locally vuggy, light brown dolostone. The thickness of this unit varies somewhat over the quarry property due to its erosion.

The strata in this quarry exhibit low amplitude warping and rolls. There are two main joint sets in the quarry, trending approximately 360° and 74-80°, with spacings of 2 to 4 m. Glacial overburden is generally less than 1 m thick.

DESCRIPTION OF EXPOSED STRATA

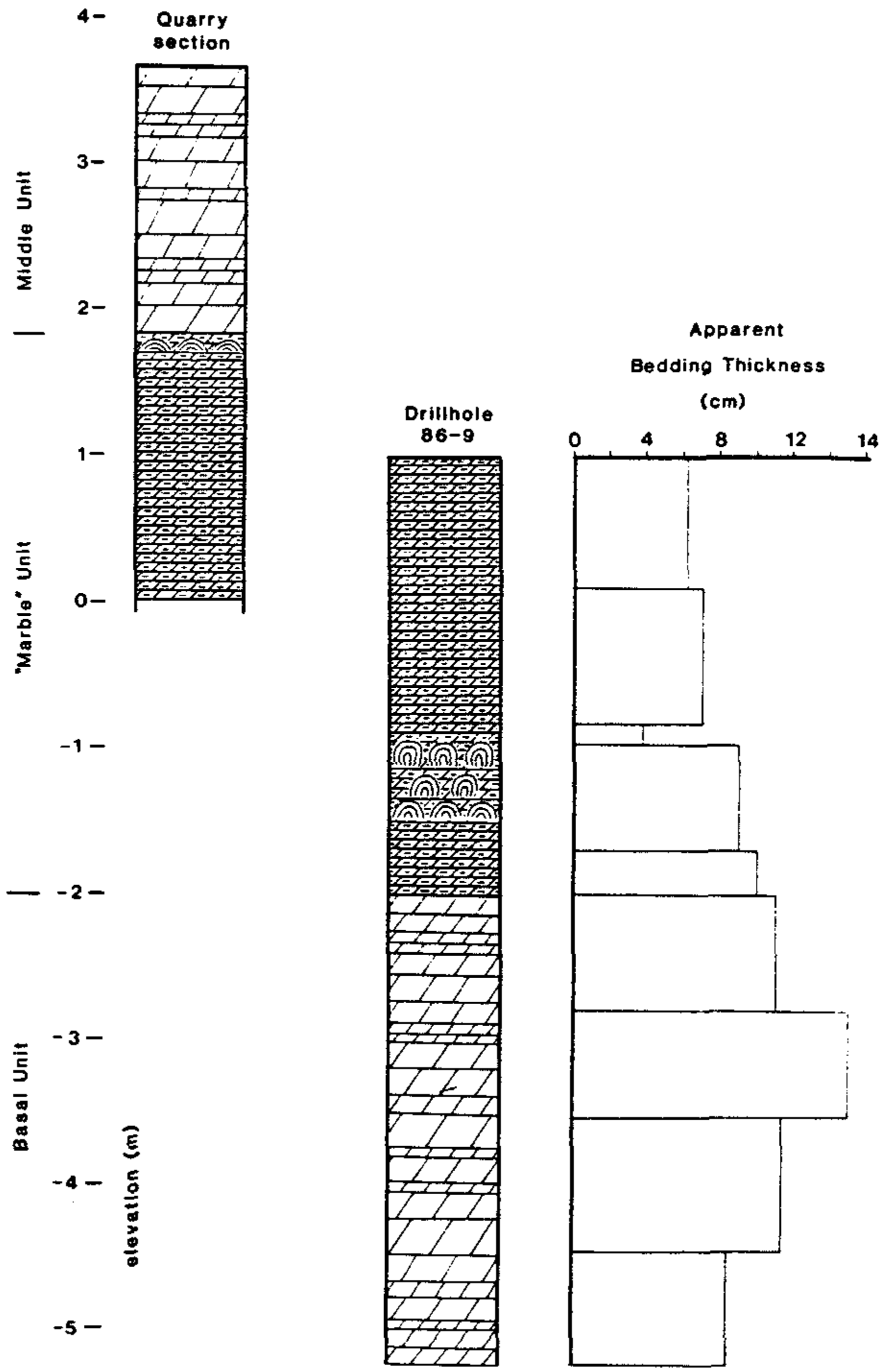
Unit Thickness

Middle Unit, Eramosa Member........................2.0m
Lithofacies 2: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded, with planar to irregular contacts; rare corals and crinoidal fragments; calcite mineralization occurs in local vugs; lower contact of unit is sharp.

"Marble" Unit, Eramosa Member......................2.0m
Lithofacies 1a: light grey-brown to brown, weathers light grey to light grey-brown; very fine to fine crystalline; laminated to thin bedded with planar to slightly wavy contacts; minor stromatolitic laminae throughout and especially in top 1 to 3 cm; lower contact of unit is not exposed.

Total Exposed Thickness..................4.0m

ROSS QUARRY


Quarry
section
Drillhole
86-9
Apparent
Bedding Thickness
(cm)
0
4
8
12
14
4
3
2
1
0
-1
-2
-3
-4
-5
Middle Unit
"Marble" Unit
Basal Unit
elevation (m)

3. WIARTON QUARRY - OWEN SOUND LEDGEROCK

This quarry is located in lots 10 and 11, concession XXIII, of Amabel Township, on the south side of Oliphant Road, 4.1 km west of Wiarton. The quarry is situated on the south flank of a hill (bedrock high). Excavation in the quarry has exposed up to 6.3 m of the Eramosa Member, with an additional 2.0 m of this member exposed in outcrop at the south end of the property.

Three units of the Eramosa Member occur in the main excavation of this quarry (the "Marble", Middle, and Interbedded Units), with a lower fourth unit (the Basal Unit) exposed in outcrop below and south of the quarry. The uppermost unit, the Interbedded Unit, contains locally abundant chert nodules or beds, and is generally more bituminous than the other units. This unit also exhibits extreme warping which may be related to a stromatolitic bioherm which outcrops immediately north of the quarry. Other low amplitude rolls occur locally in the quarry. There are two main joint sets in the quarry, trending at 75-85° and 335-345°, with 1 to 3 m spacing. Glacial overburden is generally less than 0.5 m thick.

The stratigraphy exposed in this quarry can be correlated with that exposed in the Ebel Quarry, 1.3 km to the east. Owen Sound Ledgerock Ltd. also owns a currently inactive quarry on the north side of Oliphant Road which exposes stratigraphy above this quarry (possibly up into the Guelph Formation).

DESCRIPTION OF EXPOSED STRATA

Unit Thickness

Interbedded Unit, Eramosa Member..................2.4m

Interbedded Lithofacies 1b, 3, and 2: (a) light to dark brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded; with variable bitumen content; and (b) dark brown to black, weathers dark grey-brown; fine to medium crystalline; laminated to thin bedded; bituminous.

For both (a) and (b): bed thicknesses vary laterally and bedding is significantly warped at the north end of the property; pyrite occurs disseminated and with calcite infilling vugs and burrows; sphalerite mineralization is associated with stromatolitic mound at north end of property; locally abundant small brachiopods; rare graptolites, cephalopods, corals, eurypterids, and stromatolites; some bedding planes with burrows and trails; chert nodules and beds; the lower contact of unit is taken at the lowest dark brown to black laminated bed.

Middle Unit, Eramosa Member.......................2.4m

Lithofacies 2: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; thin to thick bedded with planar to slightly irregular contacts; calcite occurs locally as vug infilling; small (< 5 cm) vugs occur scattered throughout and locally in bands; rare corals and crinoidal fragments; lower contact of unit is sharp.

"Marble" Unit, Eramosa Member.....................3.0m

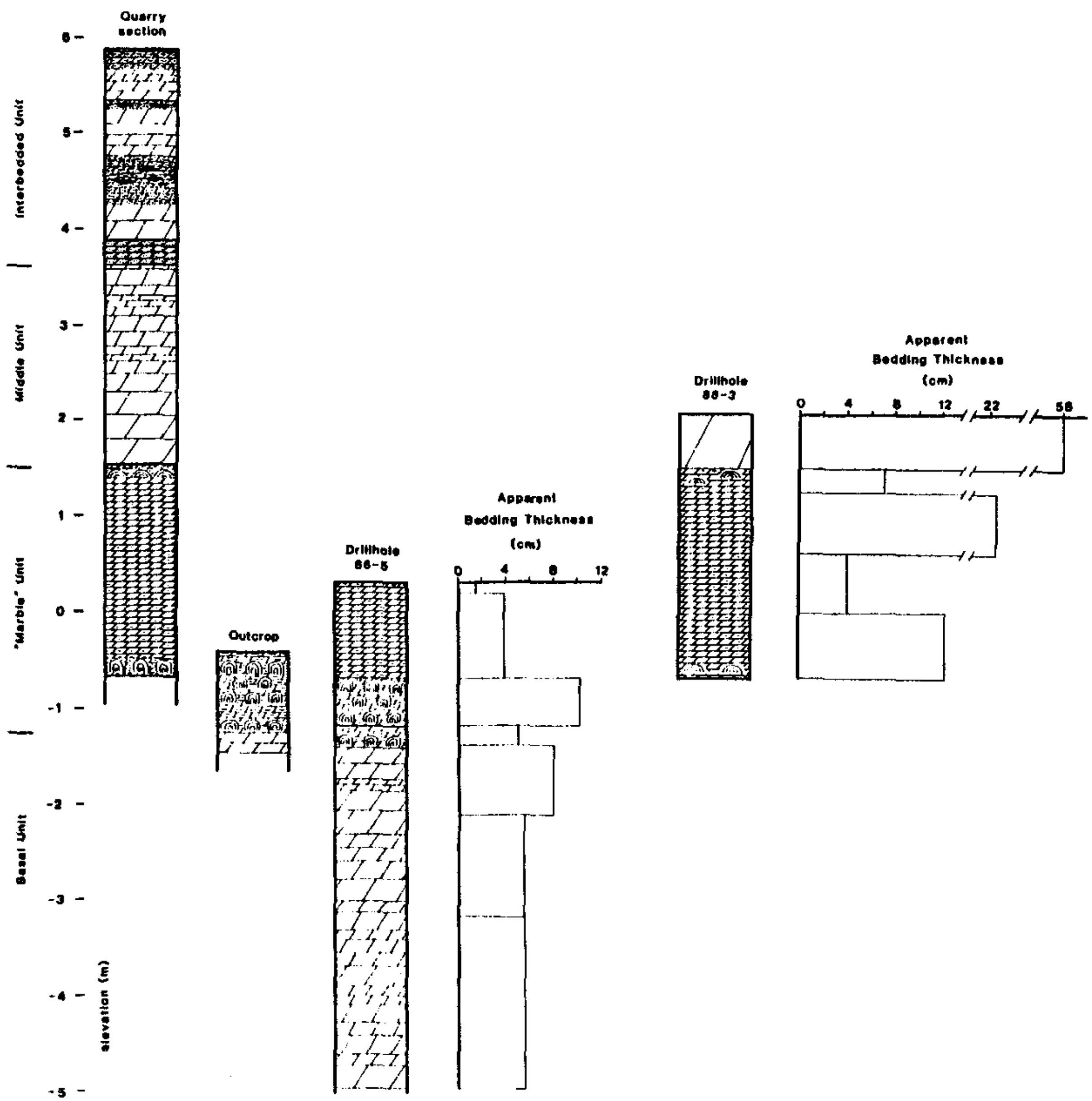
Lithofacies 1a: light grey to grey-brown, weathers light grey-brown; very fine to fine crystalline; laminated to thin bedded with planar to wavy contacts and locally significant bituminous partings (especially in the uppermost beds); occasional stromatolitic laminae, especially abundant in the lower 1 m, and upper 1 to 3 cm; local soft sediment deformation features; lower contact of unit is sharp and is exposed in outcrop south of main excavation.

Basal Unit, Eramosa Member........................0.5m

Lithofacies 2: light grey-brown to light brown, weathers grey to buff-brown; fine to medium crystalline; thin to medium bedded, with bedding related to thin bands of wispy dark brown stylolites; lower contact of unit is not exposed.

Total Exposed Thickness.................8.3m

WIARTON QUARRY - OWEN SOUND LEDGEROCK



4. COOK QUARRY

The Cook Quarry is currently inactive and is located in lots 7 and 8, concession XXIV, of Amabel Township, on the north side of Oliphant Road, 3.2 km west of the town of Wiarton. Another abandoned quarry, the Bruce Peninsula Stone Quarry, is located adjacent to the Cook Quarry in lot 9. As this small quarry exposes identical stratigraphy to the Cook Quarry it was not included in this report.

The Cook Quarry exposes 2.6 m of the Interbedded Unit of the Eramosa Member and approximately 2.0 m of the overlying Guelph Formation. The Eramosa Member at this quarry consists of interbedded dark brown, laminated, bituminous dolostones and thin- to medium-bedded, light to dark brown dolostones. The thick-bedded, massive-textured, light brown Guelph Formation dolostones are exposed in old workings northwest of the main excavation. Ridges, up to 10 m high, consisting of biohermal rocks of the Guelph Formation outcrop north of the quarry excavations.

The strata exposed in this quarry overlie that of the Ebel and Owen Sound Ledgerock Wiarton Quarries and are equivalent to those exposed in the adjacent, abandoned Bruce Peninsula Stone Quarry. The glacial overburden thickness on the Cook Quarry property is generally less than 0.5 m.

DESCRIPTION OF EXPOSED STRATA

Unit Thickness

Guelph Formation.................................2.0m

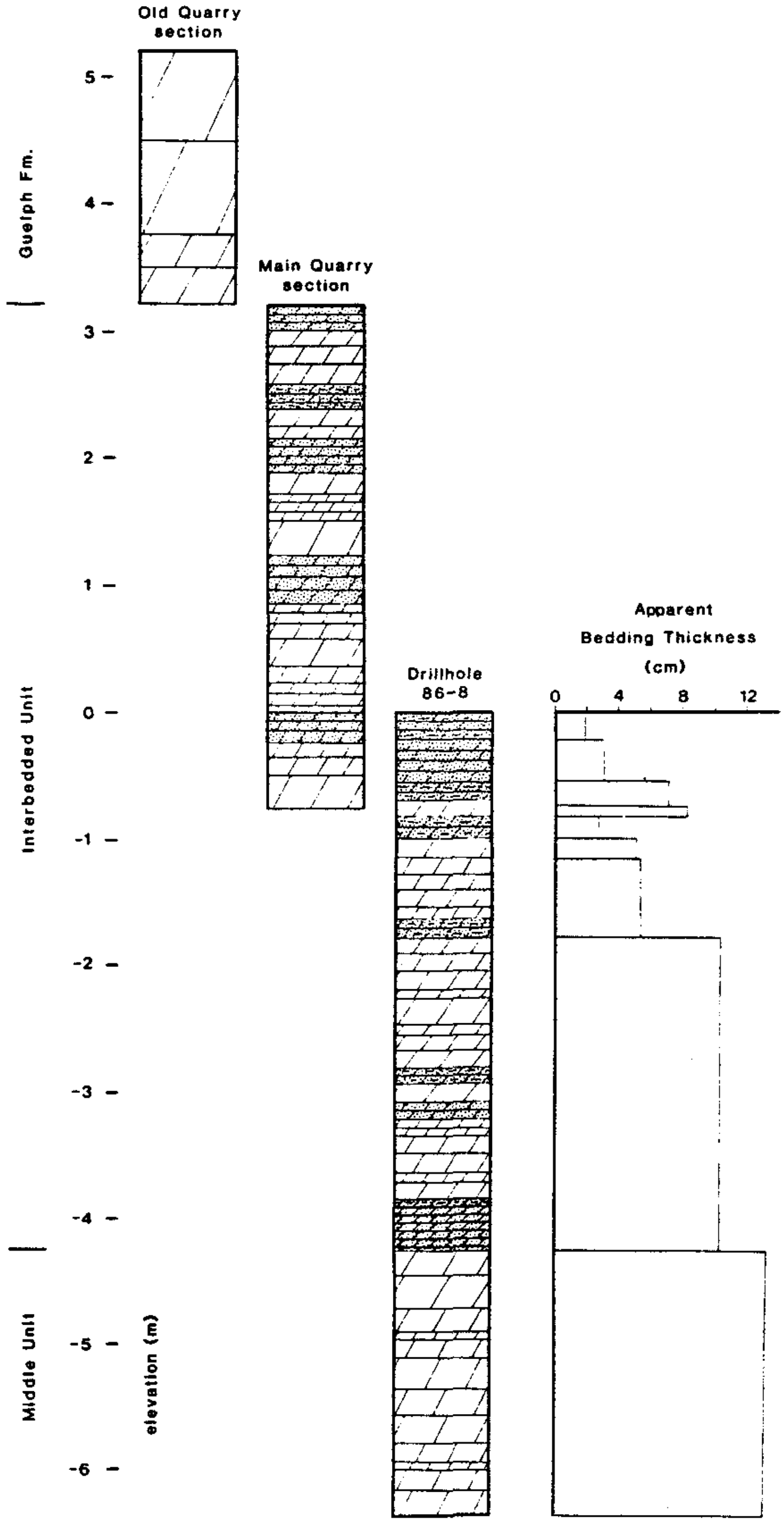
Dolostone: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; medium to massive bedded; local corals and large brachiopods; underlying or interbedded with biohermal build-ups on north side of property; bioherms contain variably abundant large brachiopods, corals, stromatolites, and other fossils; lower contact of formation is not well exposed.

Interbedded Unit , Eramosa Member..................2.6m

Interbedded Lithofacies 1b, 3, and 2: (a) light to dark brown, weathering light grey-brown; fine to medium crystalline; thin to medium bedded; with variable bitumen content; locally abundant small brachiopods; and (b) dark brown to black, weathering dark grey-brown; fine to medium crystalline; laminated to thin bedded; bituminous; lower contact of unit is not exposed.

Total Exposed Thickness..................4.6m

COOK QUARRY


Old Quarry section
Main Quarry section
Drillhole 86-8
Apparent Bedding Thickness (cm)
0
4
8
12
Guelph Fm.
Interbedded Unit
Middle Unit
elevation (m)
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6

5. EBEL QUARRY

The Ebel Quarry is located in lots 6, 7, and 8, concession XXIII, of Amabel Township, on the south side of Oliphant Road, 2.8 km west of the town of Wiarton. Like Owen Sound Ledgerock's Wiarton Quarry to the west, this quarry is situated on the south flank of a hill (bedrock high) and exposes a similar stratigraphic interval.

Excavations in this quarry have exposed up to 7 m of the Eramosa Member, with a further approximately 5 m of this member exposed in outcrop below and south of the quarry.

Two units (the Interbedded and Middle Units) of the Eramosa Member are exposed in the main excavation of this quarry, with two additional units (the "Marble" and Basal Units) exposed in outcrop to the south. Overlying strata, including the Eramosa/Guelph Formation contact, are exposed on the north side of the road in the abandoned Bruce Peninsula Stone (not described in this report) and Cook Quarries. Although the uppermost unit in the Ebel Quarry, the Interbedded Unit, is correlative with the Interbedded Unit of Owen Sound Ledgerock's Wiarton Quarry, the former is more extensive, contains less chert, and does not exhibit the severe warping of the latter exposure. Glacial overburden in the Ebel Quarry is generally less than 0.5 m thick.

DESCRIPTION OF EXPOSED STRATA

Unit Thickness

Interbedded Unit, Eramosa Member.................. 4.0m

Interbedded Lithofacies 1b, 3, and 2: (a) light to dark brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded; with variable bitumen content; and (b) dark brown to black, weathers dark grey-brown; fine to medium crystalline; laminated to thin bedded; bituminous.

For both (a) and (b): local chert as nodules (some with sphalerite), in beds, or replacing fossils; vugs filled with calcite and pyrite; locally abundant small brachiopods; rare stromatoporoids, graptolites, eurypterids, cephalopods; few bedding planes with burrows and trails; lower contact of unit is taken at lowest dark brown to black laminated bed.

Middle Unit, Eramosa Member........................3.0m

Lithofacies 2: light grey-brown to light brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded, with planar to slightly irregular contacts which are generally related to thin bands of dark brown stylolites; calcite occurs as vug filling; small (< 5 cm) vugs occur scattered throughout and locally in bands; rare crinoidal fragments, stromatoporoids, and corals; lower contact of unit is sharp.

"Marble" Unit, Eramosa Member......................3.5m

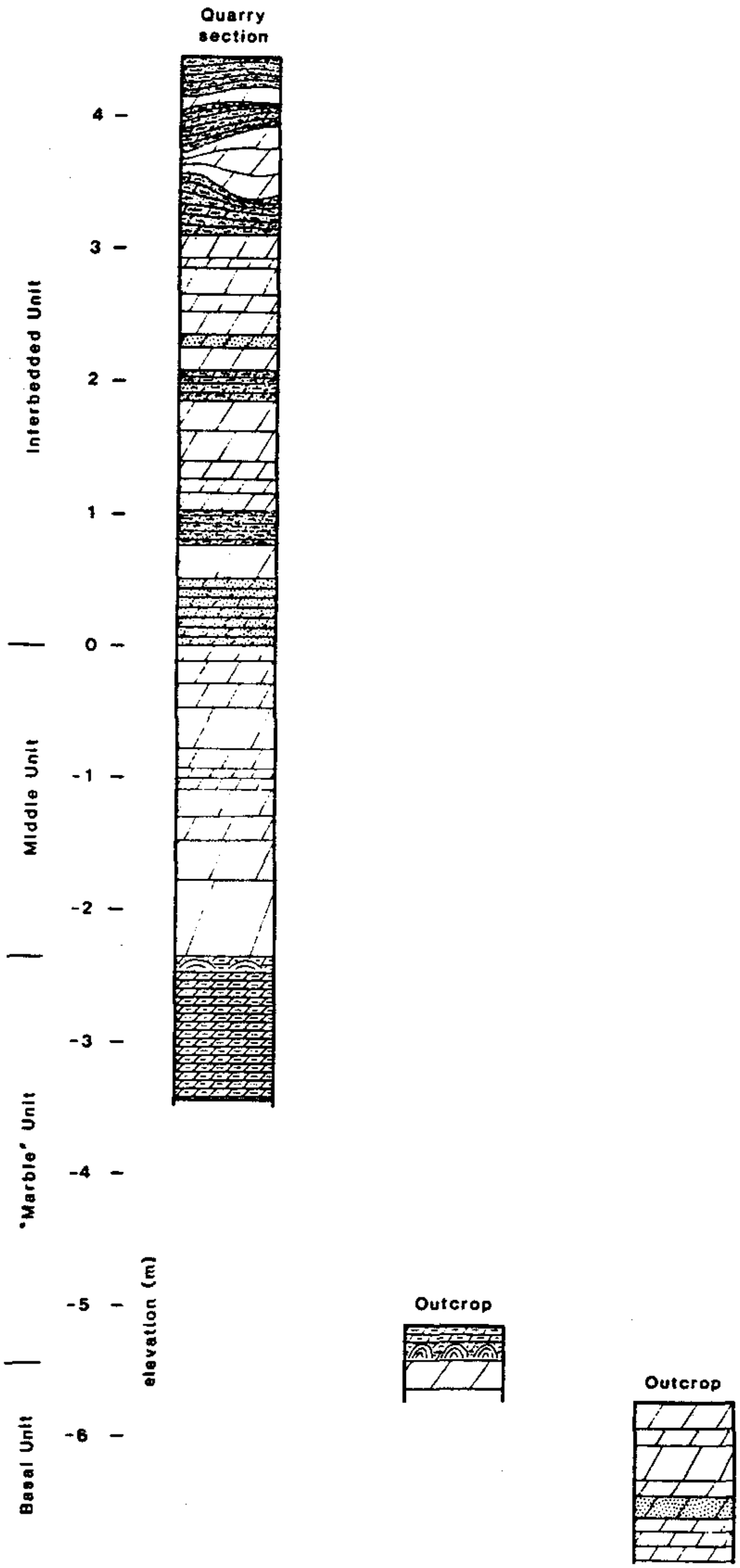
Lithofacies 1a: light grey to grey-brown, weathers light grey-brown; very fine to fine crystalline; laminated to thin bedded with planar to wavy contacts and locally significant bituminous partings; local soft sediment deformation structures; local stromatolitic beds (especially in the lowermost beds); lower contact of unit is sharp.

Basal Unit, Eramosa Member.........................1.5m

Lithofacies 2: light grey-brown to light brown, weathers grey to buff-brown; fine to medium crystalline; thin to medium bedded, with planar to slightly irregular contacts which are related to thin bands of wispy brown stylolites; small (< 5 cm) vugs are locally abundant and infilled with calcite and pyrite.

Total Exposed Thickness.................12.0m

EBEL QUARRY


Quarry section
Outcrop
Outcrop
4
3
2
1
0
-1
-2
-3
-4
-5
-6
elevation (m)
Interbedded Unit
Middle Unit
"Marble" Unit
Basal Unit

6. McCARTNEY QUARRY

The McCartney Quarry is located in lots 7, 8, and 9, concession XVIII, of Keppel Township, on the north side of a concession road 3.1 km east of Highway 6, 8 km south of the town of Wiarton.

This quarry exposes up to 3.4 m (lowermost 1 m only exposed in small exploratory excavation) of the Eramosa Member, consisting of parts of the Middle and "Marble" Units, in three excavations. The Middle Unit is only present in the southern half of the McCartney property.

The strata in this quarry exhibits broad low amplitude warping. Two joint sets are present in the quarry, trending 350-360° and 65-85° with 1 to 2 m spacing. Glacial overburden is generally less than 1 m thick.

DESCRIPTION OF EXPOSED STRATA

Unit Thickness

Middle Unit, Eramosa Member........................1.2m

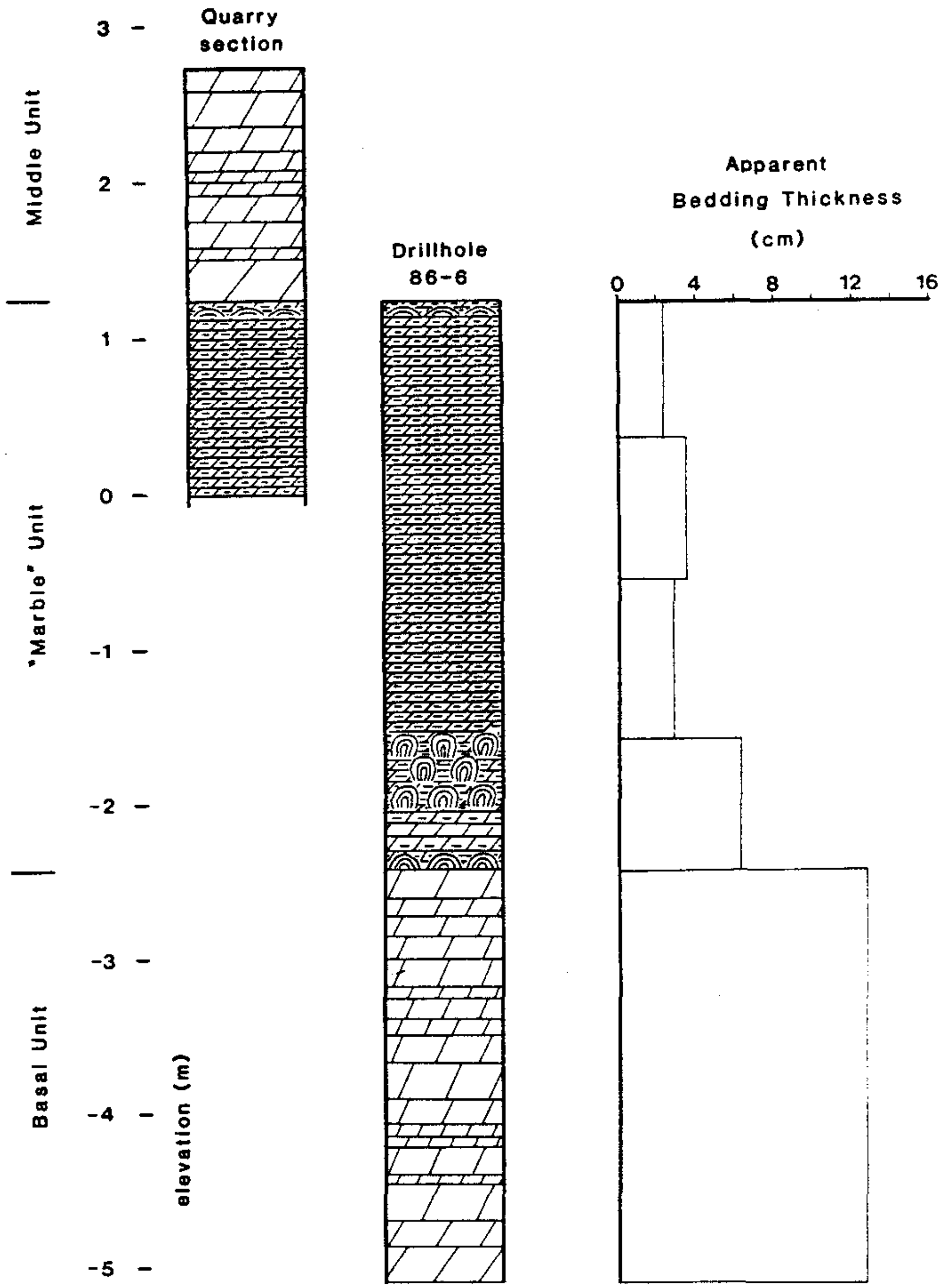
Lithofacies 2: light brown, weathers buff-brown; fine to medium crystalline; thin to medium bedded, with planar to irregular contacts; calcite infilling locally abundant small (< 5 cm) vugs; lower contact of unit is sharp.

"Marble" Unit, Eramosa Member.....................2.2m

Lithofacies 1a: light grey to grey-brown; very fine to fine crystalline; laminated to thin bedded, with locally wavy contacts; thin bituminous partings (especially in the upper 30 cm); thin stromatolitic laminae in uppermost few centimetres.

Total Exposed Thickness.................3.4m

McCARTNEY QUARRY



7. CRUICKSHANK QUARRY - OWEN SOUND LEDGEROCK LTD.

Owen Sound Ledgerock's Cruickshank Quarry is located in lot 17, concession IV, of Keppel Township, approximately 0.5 km southwest of Cruickshank, 8.6 km northwest of Owen Sound.

This quarry has exposed up to 2.2 m of stratigraphy, consisting of parts of the Middle and "Marble" Units of the Eramosa Member. Quarrying here has centered on the "Marble" Unit (1.9 m thick). The Middle Unit is thin (< 0.3 m) at this quarry and is only present in patches in the southwest corner of the property. Stromatolitic beds present in the "Marble" Unit below the quarry floor are exposed in outcrop north of the quarry and in a small exploratory excavation (1 m deep) in the main quarry. Two subparallel linear anticlinal rolls, oriented 325° and 335°, run through the center of the quarry. Major joints occur at 335-345° and 74-80°, with 1 to 2 m spacing.

DESCRIPTION OF EXPOSED STRATA

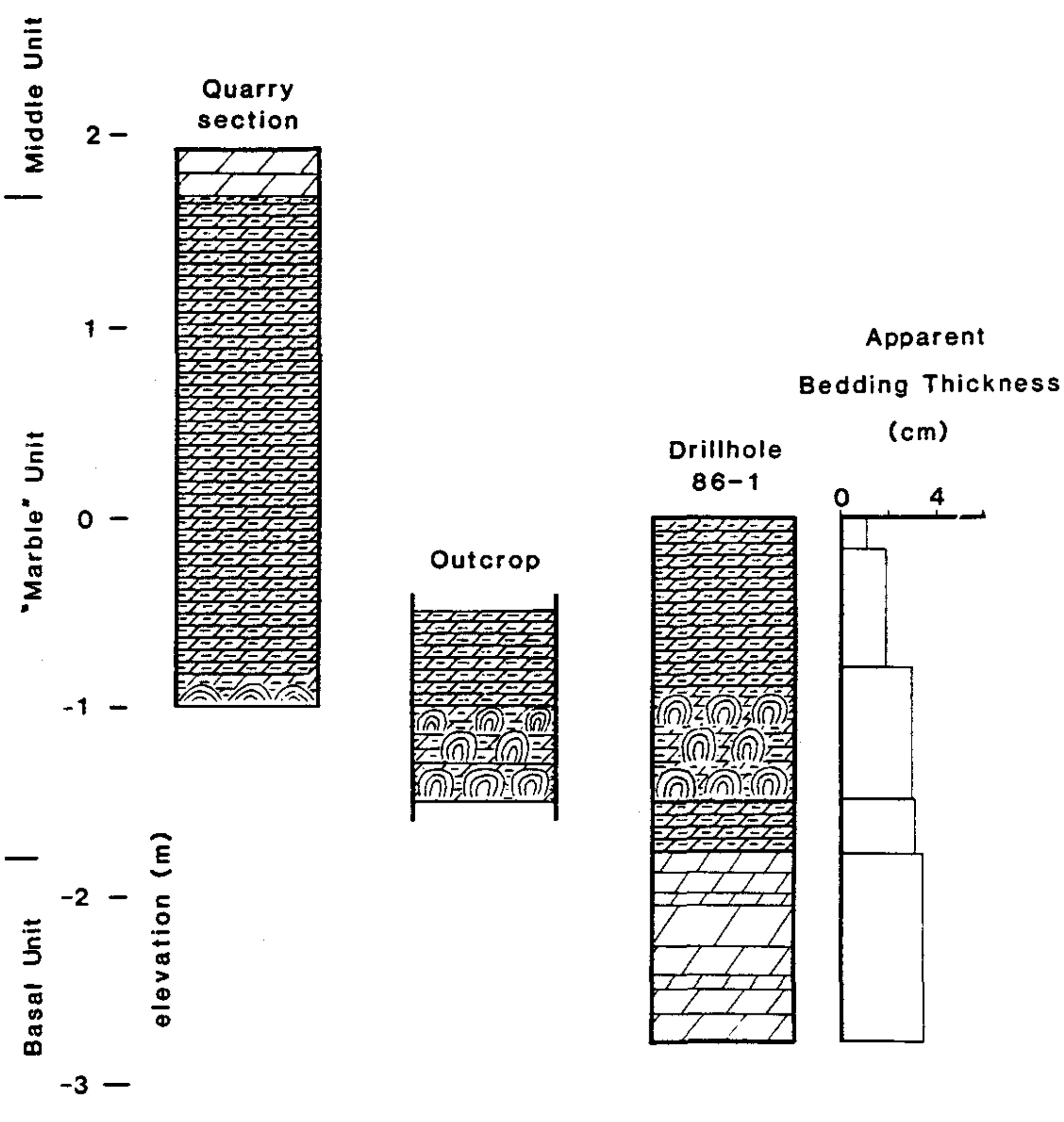
Unit Thickness

Middle Unit, Eramosa Member........................0.3m
Lithofacies 2: light brown, weathers buff-brown; fine to medium crystalline; thin bedded; rare corals and crinoidal fragments; some small brachiopods; calcite infilling vugs; lower contact of unit is relatively sharp, but not well exposed.

"Marble" Unit, Eramosa Member......................1.9m
Lithofacies 1a: light grey to grey-brown, weathers light grey-brown; very fine to fine crystalline; laminated to thin bedded, with local wavy contacts; thin bituminous parting planes; local soft sediment deformation features.

Total Exposed Thickness.................2.2m

CRUICKSHANK QUARRY - OWEN SOUND LEDGEROCK



APPENDIX II: GEOCHEMICAL DATA

INTRODUCTION

The following tables list all of the data from the major, minor, and trace element analyses conducted for representative samples of the Eramosa Member (38 samples) and one sample of the Wiarton/Colpoy Bay Member of the Amabel Formation (Middle Silurian). These geochemical analyses were all conducted by the Ontario Geological Survey Geoscience Laboratories (77 Grenville St., Toronto). The major elements were analysed by X-ray fluorescence (O.G.S. "M3" package). All of the trace elements, except chlorine and fluorine, were analysed by atomic adsorption. Chlorine and fluorine were determined colourimetrically. Acid insoluble residues were determined gravimetrically after acid (hot HCl) digestion and sample combustion at 900-1000°C (O.G.S. procedure "C9").

The symbols used in the following tables to represent the various Eramosa quarries, lithofacies, and units are listed in the following legend. These data are discussed in the text in section 5.2.

LEGEND FOR SYMBOLS USED IN GEOCHEMISTRY TABLES:

Quarry (Eramosa Quarries)

B	Bruce Marble and Stone
R	Ross
W	Wiarton - Owen Sound Ledgerock
C	Cook
E	Ebel
M	McCartney
O	Cruickshank - Owen Sound Ledgerock
I	drillhole OGS-82-4 at Isaac Lake

Litho (Lithofacies)

A	1a
B	1b
2	2
3	3
W	Wiarton/ Colpoy Bay dolostone

Unit (Units)

1	Basal
2	"Marble"
3	Middle
4	Interbedded
0	Wiarton/ Colpoy Bay Member

Table 4: Major Element Data - Grouped by Lithofacies.

Sample	Quarry	Litho	Unit	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	TOTAL
DA-86-79V	W	A	2	0.39	0.10	0.14	20.7	30.4	0.01	0.04	0.01	0.01	0.01	46.4	ND	47.0	98.8
DA-86-74D	W	A	2	0.94	0.29	0.14	21.2	30.1	0.01	0.16	0.02	0.02	0.01	46.4	ND	46.5	99.4
DA-86-73C	W	A	2	0.69	0.18	0.11	20.5	30.1	0.02	0.07	0.02	0.01	0.01	45.7	ND	47.1	98.8
JM-86-55F	R	A	2	0.58	0.22	0.19	21.2	29.9	0.01	0.10	0.01	0.02	0.01	46.2	0.01	46.8	99.0
ROSS-1	R	A	2	0.51	0.15	0.17	20.9	30.1	0.01	0.09	0.01	0.01	0.01	44.9	0.01	46.4	98.4
JM-86-5	O	A	2	1.17	0.28	0.21	20.6	30.3	0.01	0.40	0.02	0.01	0.02	47.0	0.03	46.4	99.4
JM-86-8	O	A	2	0.91	0.26	0.32	21.4	29.8	0.01	0.24	0.02	0.01	0.02	46.6	0.03	46.3	99.3
JM-86-21	M	A	2	0.93	0.33	0.18	20.5	30.1	0.01	0.21	0.02	0.03	0.01	47.0	0.02	47.0	99.3
DA-86-39N	M	A	2	0.74	0.25	0.15	20.1	29.8	0.01	0.11	0.02	0.02	0.01	46.8	ND	47.1	98.3
DA-86-38	M	A	2	1.06	0.36	0.24	21.0	30.3	0.01	0.26	0.02	0.03	0.01	45.0	0.01	46.6	99.9
DA-86-62B	E	A	2	0.81	0.22	0.22	20.7	29.9	0.01	0.13	0.02	0.02	0.01	47.2	ND	46.9	98.9
DA-86-64B	E	A	2	1.16	0.27	0.31	21.0	30.5	ND	0.22	0.02	0.02	0.01	46.0	ND	46.3	99.8
DA-86-90	B	A	2	1.26	0.32	0.20	20.9	30.3	0.01	1.01	0.02	0.02	0.01	45.3	ND	46.1	100.1
DA-86-89B	B	A	2	1.27	0.34	0.16	20.3	30.2	0.01	1.46	0.03	0.02	0.01	45.3	0.01	46.2	100.0
DA-86-88A	B	A	2	0.92	0.30	0.27	21.4	30.4	0.01	0.24	0.02	0.03	0.01	46.5	0.01	46.5	100.1
JM-86-52A	W	B	4	2.01	0.49	0.29	20.1	28.9	0.01	ND	0.03	0.04	0.01	49.6	0.13	46.6	98.5
GK-4	W	B	4	3.24	0.81	1.33	20.5	27.8	0.01	ND	0.05	0.05	0.01	51.6	1.14	44.9	98.7
DA-86-106F	S	B	4	2.04	0.40	0.20	20.2	29.8	0.01	1.12	0.03	0.01	0.01	47.1	0.06	46.0	99.8
JM-86-31A	E	B	4	2.23	0.64	0.43	19.8	28.7	0.01	ND	0.04	0.04	0.01	51.3	0.10	47.0	98.9
DA-86-80A	E	B	4	2.31	0.58	0.28	19.7	29.4	0.01	ND	0.04	0.03	0.01	49.1	0.07	46.4	98.8
JM-86-31B	E	B	4	0.62	0.15	0.08	20.0	30.2	0.02	0.06	0.01	0.01	0.01	46.9	0.01	47.7	98.9
JM-86-92	C	B	4	2.12	0.59	0.30	19.8	29.3	0.02	ND	0.04	0.03	0.01	53.1	0.13	47.0	99.2
JM-86-45A	W	2	4	4.00	0.11	0.13	20.8	29.5	0.01	0.01	0.01	0.00	0.01	44.5	0.03	43.9	98.5
DA-86-78C	W	2	3	2.54	0.60	0.21	20.2	30.0	ND	ND	0.03	0.02	0.01	46.1	ND	45.6	99.2
DA-86-102	R	2	3	0.91	0.32	0.18	21.4	30.2	ND	0.25	0.02	0.02	0.01	46.6	ND	46.3	99.6
DS-86-1-1	O	2	1	1.08	0.28	0.21	21.0	29.9	ND	0.31	0.02	0.02	0.02	46.7	0.03	46.3	99.1
DA-86-40	M	2	3	1.08	0.30	0.16	20.7	30.4	ND	0.18	0.02	0.01	0.01	46.9	ND	46.3	99.2
CMS-D4-1	I	2	1	2.17	0.53	0.35	20.4	30.1	0.01	ND	0.04	0.03	0.02	46.1	0.11	45.3	99.0
JM-86-35D	E	2	4	1.43	0.37	0.19	20.2	29.8	0.01	0.36	0.02	0.02	0.01	46.5	0.04	46.2	98.6
DA-86-58	E	2	1	1.30	0.29	0.12	20.2	30.6	0.01	0.21	0.02	0.01	0.01	47.0	ND	46.2	99.0
DA-86-54A	E	2	1	1.24	0.35	0.14	20.7	30.0	0.01	0.21	0.02	0.03	0.01	46.9	ND	46.4	99.1
JM-86-90	C	2	4	1.66	0.42	0.18	20.8	30.2	0.01	ND	0.03	0.03	0.01	46.7	ND	46.2	99.5
JM-86-74	B	2	3	1.22	0.29	0.13	20.6	29.9	0.01	0.38	0.02	0.01	0.01	46.7	ND	46.1	98.7
JM-86-75	B	2	3	1.20	0.33	0.14	20.9	30.0	0.01	0.44	0.02	0.02	0.01	47.6	ND	46.3	99.4
DA-86-100	E	3	4	3.33	0.74	0.42	19.6	28.4	0.01	ND	0.04	0.04	0.01	48.9	0.09	45.7	98.3
JM-86-35A	E	3	4	2.12	0.39	0.16	20.5	30.1	0.01	0.28	0.03	0.01	0.01	46.2	0.03	45.8	99.4
DA-86-70C	E	3	4	3.28	0.71	0.35	20.2	29.4	0.01	ND	0.04	0.03	0.01	46.0	0.01	44.6	98.6
DA-86-67A	E	3	4	2.94	0.56	0.25	20.5	28.8	0.01	ND	0.03	0.01	0.01	48.0	0.09	45.5	98.6
ADAIR-2	A	W	0	0.51	0.28	0.13	21.1	30.3	0.02	0.06	0.01	0.01	0.01	46.8	0.01	46.9	99.3
DUPLICATES:																	
DA-86-38				1.03	0.38	0.26	20.8	30.1	0.02	0.28	0.02	0.03	0.01	44.8	0.01	46.5	99.4
DA-86-102				0.88	0.31	0.18	21.2	30.1	ND	0.27	0.02	0.02	0.01	46.9	0.01	46.1	99.1
JM-86-31A				2.17	0.63	0.43	19.7	28.6	0.01	ND	0.04	0.04	0.01	51.9	0.09	47.0	98.6
GK-4				3.24	0.82	1.32	20.2	27.7	0.01	ND	0.05	0.06	0.01	51.9	1.16	45.0	98.4

NOTE: - all values reported in weight percent.
- "ND" = not detected.

Table 5: Trace and Minor Element Data - Grouped by Lithofacies.

Sample	Ba	Cu	Li	Ni	Pb	Zn	Sr	Cl	F	Mn	Insol.	CaO/MgO
DA-86-79V	80	8	3	-5	-10	-10	61	1000	430	75	3.28	1.47
DA-86-74D	70	9	4	-5	-10	-10	57	688	270	83	5.20	1.42
DA-86-73C	70	8	3	-5	-10	45	54	670	1920	68	5.76	1.47
JM-86-55F	61	7	3	-5	-10	-10	50	513	300	73	2.94	1.41
ROSS-1	76	7	3	-5	-10	49	50	445	220	85	2.54	1.44
JM-86-5	51	7	3	-5	-10	-10	68	495	380	111	4.96	1.47
JM-86-8	74	10	4	-5	-10	-10	66	520	330	133	5.00	1.39
JM-86-21	69	8	4	-5	-10	-10	69	968	350	98	3.44	1.47
DA-86-39N	83	8	4	-5	-10	-10	67	813	380	101	6.16	1.48
DA-86-38	78	20	4	-5	-10	-10	73	790	440	93	3.14	1.44
DA-86-62B	81	9	5	-5	-10	-10	69	1013	480	65	3.42	1.44
DA-86-64B	79	8	4	-5	-10	12	55	650	460	81	3.50	1.45
DA-86-90	65	9	5	-5	-10	-10	52	625	230	91	2.62	1.45
DA-86-89B	60	8	5	-5	11	-10	54	563	390	92	3.90	1.49
DA-86-88A	78	16	5	-5	23	-10	60	625	270	95	3.40	1.42
JM-86-52A	56	9	5	12	10	-10	62	625	1140	53	3.76	1.44
BK-4	61	10	7	12	33	-10	60	513	530	59	9.40	1.36
DA-86-106F	61	7	5	-5	10	-10	62	500	470	53	5.90	1.48
JM-86-31A	64	11	7	12	17	-10	76	513	530	96	6.10	1.45
DA-86-80A	93	12	8	9	15	-10	68	663	460	86	6.38	1.49
JM-86-31B	58	7	3	-5	-10	-10	55	375	260	77	3.00	1.51
JM-86-92	56	9	6	6	-10	-10	87	750	610	59	6.70	1.48
JM-86-45A	48	7	5	-5	-10	-10	52	375	200	64	9.38	1.42
DA-86-78C	98	9	6	-5	-10	-10	62	763	470	67	3.24	1.49
DA-86-102	56	8	3	-5	-10	14	44	340	270	75	2.10	1.41
OS-86-1-1	61	7	3	-5	-10	-10	55	375	220	143	5.06	1.42
DA-86-40	90	9	4	-5	-10	-10	60	550	340	96	2.20	1.47
CMS-D4-1	93	10	5	-5	-10	13	60	500	370	111	2.12	1.48
JM-86-35D	48	8	5	-5	-10	-10	73	725	510	69	3.90	1.48
DA-86-58	89	7	3	-5	-10	-10	49	263	300	101	2.80	1.51
DA-86-54A	95	8	4	-5	-10	-10	63	388	310	97	5.82	1.45
JM-86-90	61	8	5	-5	-10	-10	60	413	400	78	4.00	1.45
JM-86-74	61	6	3	-5	-10	-10	50	263	230	78	3.80	1.45
JM-86-75	58	7	3	-5	-10	-10	53	350	260	81	5.48	1.44
DA-86-100	65	10	8	11	23	-10	58	413	460	71	3.68	1.45
JM-86-35A	53	8	5	-5	-10	-10	67	663	420	63	6.94	1.47
DA-86-70C	90	8	7	-5	18	22	55	425	500	68	1.66	1.46
DA-86-67A	84	9	6	9	10	-10	59	375	430	68	5.82	1.40
ADAIR-2	78	9	-3	-5	-10	-10	65	1100	230	90	4.90	1.44
DUPLICATES:												
DA-86-38	84	21	5	-5	-10	-10	72	800	410	91	3.54	1.45
DA-86-102	62	7	3	-5	-10	14	47	338	260	74	2.16	1.42
JM-86-31A	67	10	8	12	19	-10	75	500	320	94	6.16	1.45
GK-4	67	9	7	15	30	-10	59	513	530	58	9.50	1.37

NOTE: - all values reported in "ppm" (except "Insol." and "CaO/MgO").
- "Insol." = acid insoluble residue in wt. %.
- "-10" indicates value below detection limit of 10 ppm.

Table 6: Geochemistry Data Statistics.

	SiO2	Al2O3	Fe2O3	MgO	CaO	Na2O	K2O	TiO2	P2O5	MnO	CO2	S	LOI	Total	Insol.	CaO/MgO
ALL ERAMOSA SAMPLES (n=38)																
MEAN	1.56	0.37	0.24	20.56	29.83	0.01	0.23	0.02	0.02	0.01	47.06	0.06	46.25	99.11	4.43	1.45
STD	0.903	0.177	0.200	0.476	0.613	0.005	0.322	0.010	0.011	0.003	1.814	0.185	0.727	0.501	1.863	0.033
MIN	0.39	0.10	0.08	19.60	27.80	0.00	0.00	0.01	0.00	0.01	44.50	0.00	43.90	98.30	1.66	1.36
MAX	4.00	0.81	1.33	21.40	30.60	0.02	1.46	0.05	0.05	0.02	53.10	1.14	47.70	100.10	9.40	1.51
LITHOFACIES 1A (n=15)																
MEAN	0.89	0.26	0.20	20.83	30.15	0.01	0.32	0.02	0.02	0.01	46.15	0.01	46.61	99.30	3.95	1.45
STD	0.271	0.073	0.062	0.388	0.223	0.004	0.394	0.005	0.007	0.004	0.755	0.011	0.342	0.595	1.158	0.028
MIN	0.39	0.10	0.11	20.10	29.80	0.00	0.04	0.01	0.01	0.01	44.90	0.00	46.10	98.30	2.54	1.39
MAX	1.27	0.36	0.32	21.40	30.50	0.02	1.46	0.03	0.03	0.02	47.20	0.03	47.10	100.10	6.16	1.49
LITHOFACIES 1B (n=7)																
MEAN	2.08	0.52	0.42	20.01	29.16	0.01	0.17	0.03	0.03	0.01	49.81	0.23	46.51	98.97	5.89	1.46
STD	0.770	0.208	0.417	0.279	0.785	0.005	0.420	0.013	0.015	ERR	2.331	0.402	0.891	0.423	2.088	0.051
MIN	0.62	0.15	0.08	19.70	27.80	0.01	0.00	0.01	0.01	0.01	46.90	0.01	44.90	98.50	3.00	1.36
MAX	3.24	0.81	1.33	20.50	30.20	0.02	1.12	0.05	0.05	0.01	53.10	1.14	47.70	99.80	9.40	1.51
LITHOFACIES 2 (n=12)																
MEAN	1.65	0.35	0.18	20.66	30.05	0.01	0.20	0.02	0.02	0.01	46.53	0.02	45.93	99.08	4.16	1.46
STD	0.880	0.126	0.062	0.365	0.284	0.005	0.161	0.008	0.009	0.004	0.752	0.033	0.716	0.344	2.083	0.039
MIN	0.91	0.11	0.12	20.20	29.50	0.00	0.00	0.01	0.00	0.01	44.50	0.00	43.90	98.50	2.10	1.41
MAX	4.00	0.60	0.35	21.40	30.60	0.01	0.44	0.04	0.03	0.02	47.60	0.11	46.40	99.60	9.38	1.51
LITHOFACIES 3 (n=4)																
MEAN	2.92	0.60	0.30	20.20	29.18	0.01	0.07	0.04	0.02	0.01	47.28	0.06	45.40	98.73	4.53	1.44
STD	0.559	0.161	0.114	0.424	0.741	0.000	0.140	0.006	0.015	0.000	1.408	0.041	0.548	0.472	2.340	0.028
MIN	2.12	0.39	0.16	19.60	28.40	0.01	0.00	0.03	0.01	0.01	46.00	0.01	44.60	98.30	1.66	1.40
MAX	3.33	0.74	0.42	20.50	30.10	0.01	0.28	0.04	0.04	0.01	48.90	0.09	45.80	99.40	6.94	1.47

NOTES: "STD" = standard deviation
"MIN" = minimum
"MAX" = maximum
"ERR" = zero variance
- not detected (ND) values in previous tables, counted as zeros in statistical calculations.

PHOTOGRAPHIC PLATES

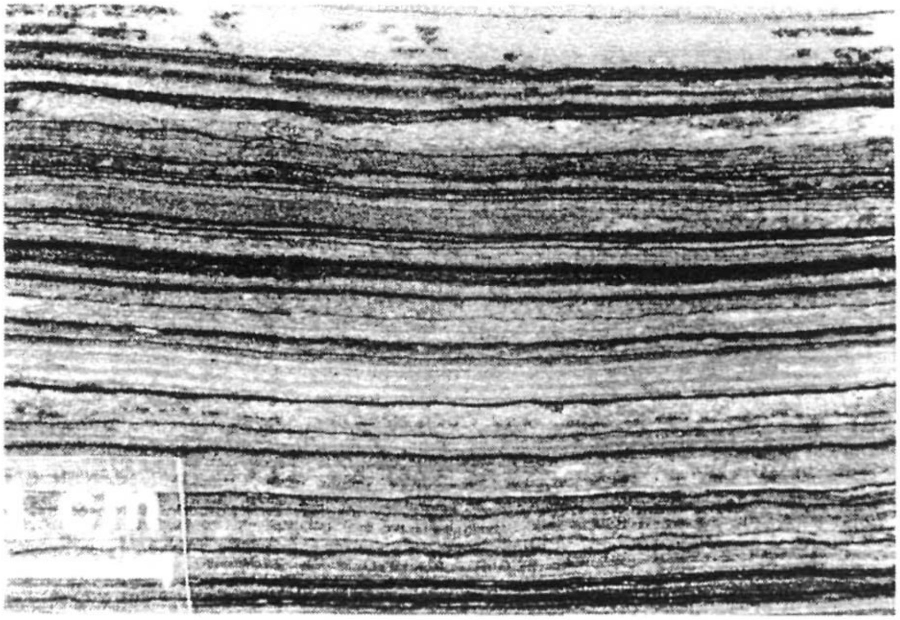


Plate 1: Polished slab of lithofacies 1a, "Marble" Unit, Eramosa Member, from McCartney Quarry. Paper-thin black lines are planar microstylolites.

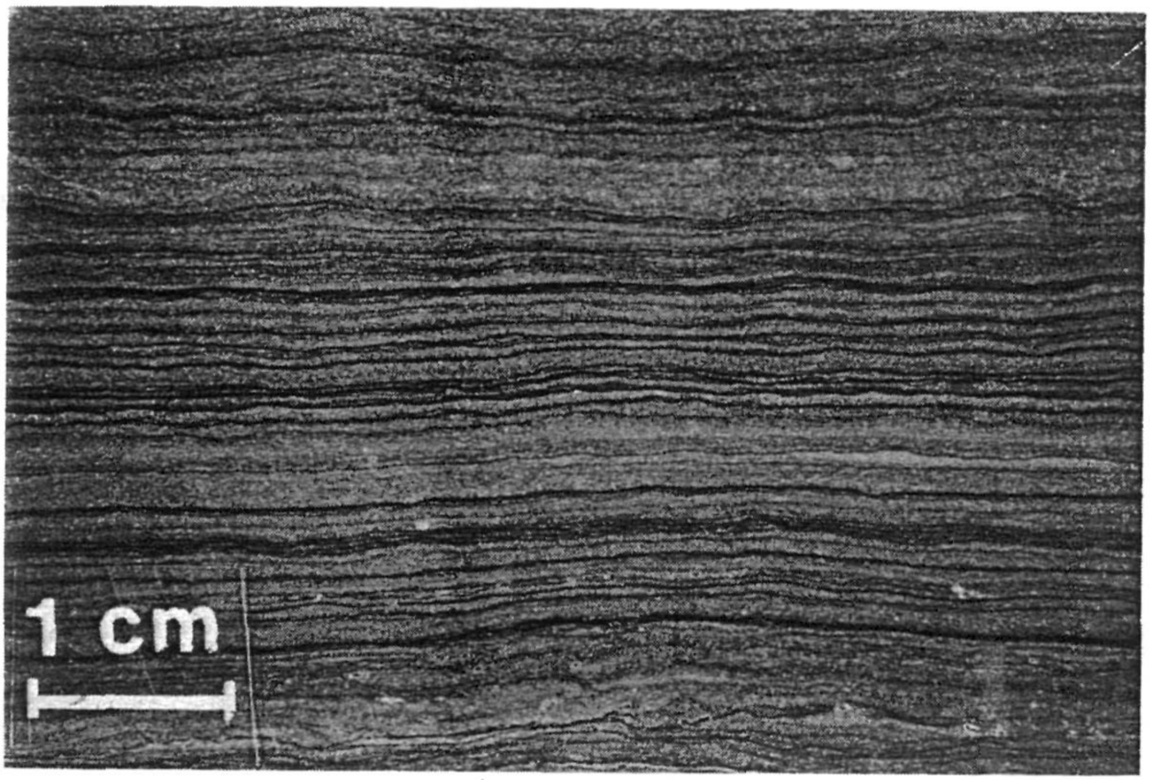


Plate 2: Polished slab of lithofacies 1a, from "Marble" Unit of Eramosa Member, from Pike's Bay.

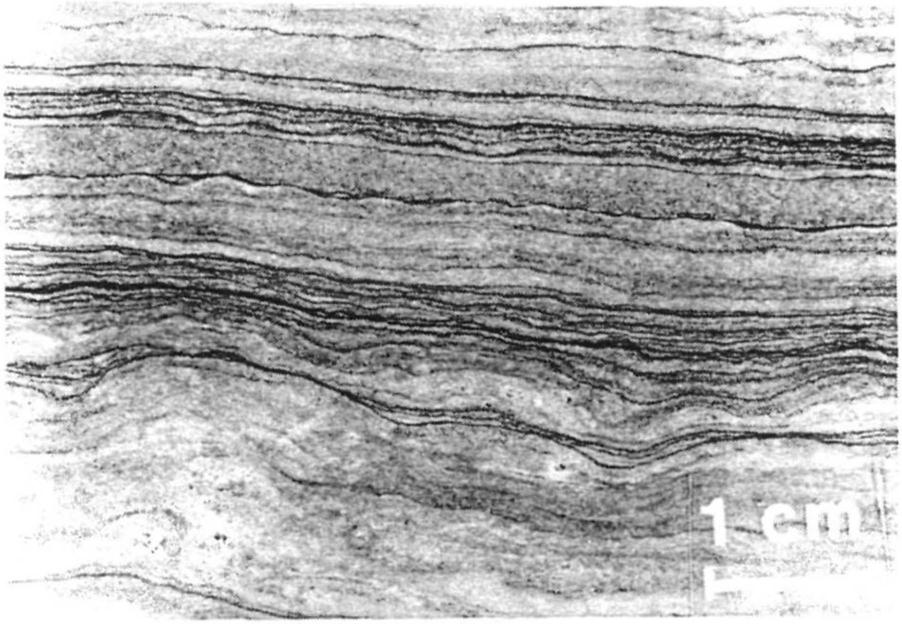


Plate 3: Polished slab of lithofacies 1a, "Marble" Unit, Eramosa Member, from Bruce Marble and Stone Quarry. Note stromatolitic laminae in lower half, with small vuggy porosity and contorted microstylolites.

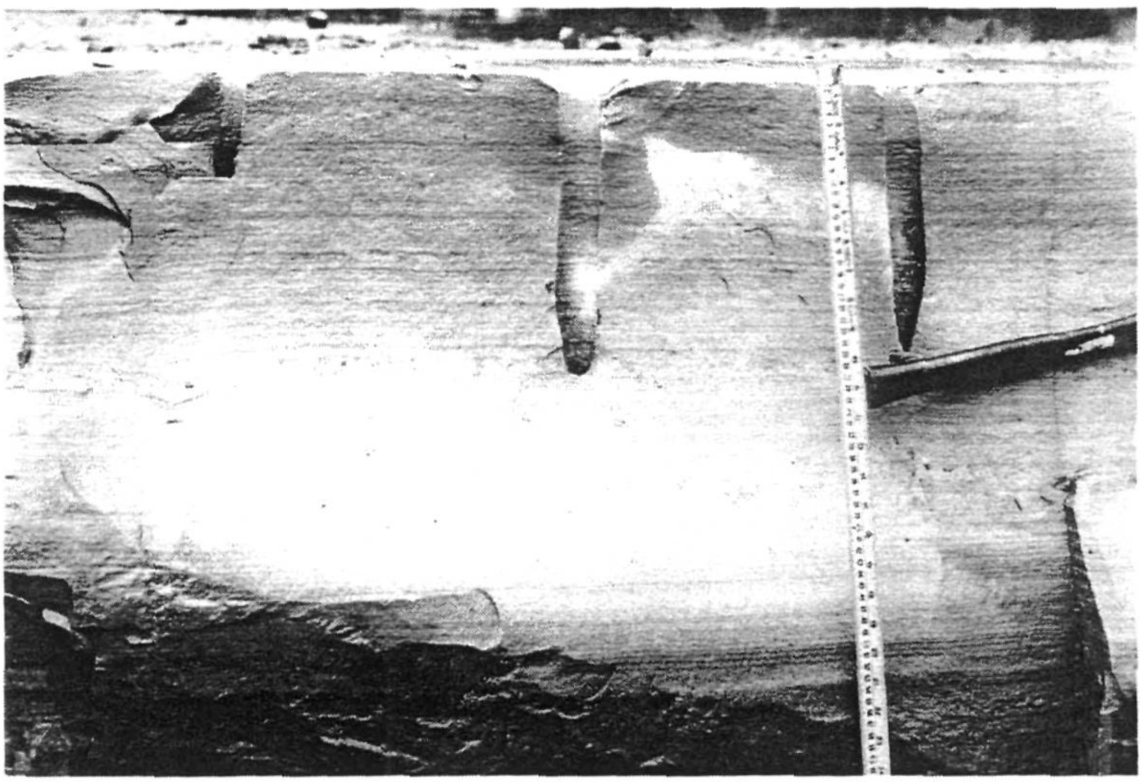


Plate 4: Quarry exposure of lithofacies 1a, "Marble" Unit, Eramosa Member, at Bruce Marble and Stone Quarry. Note lack of horizontal partings and few thin stromatolitic beds.

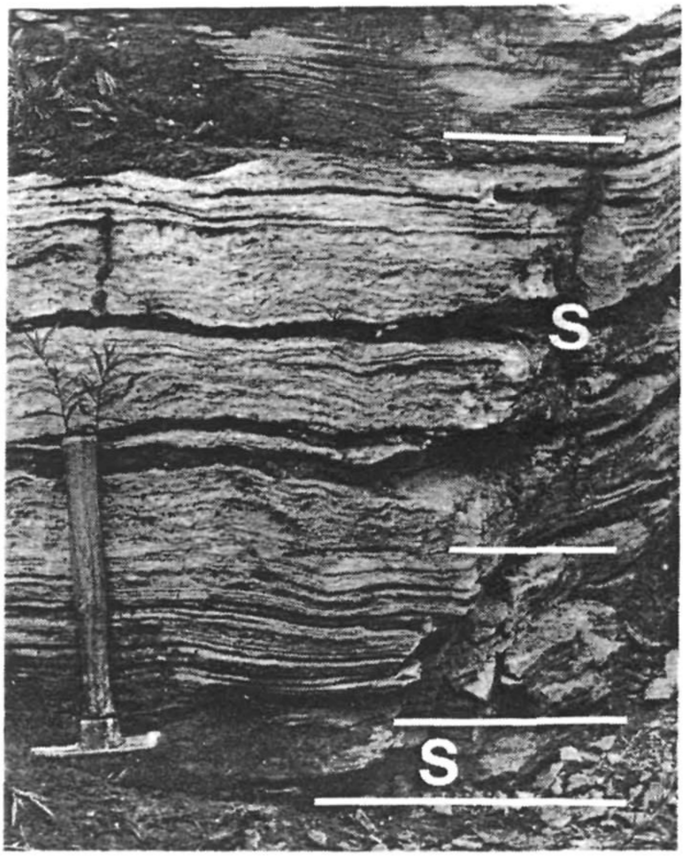


Plate 5: Outcrop of lowest part of "Marble" Unit, south of O.S.L.'s Wiarton Quarry. Middle and lowest beds in photo are stromatolitic (indicated with "S"). Note contorted laminae in stromatolitic beds.

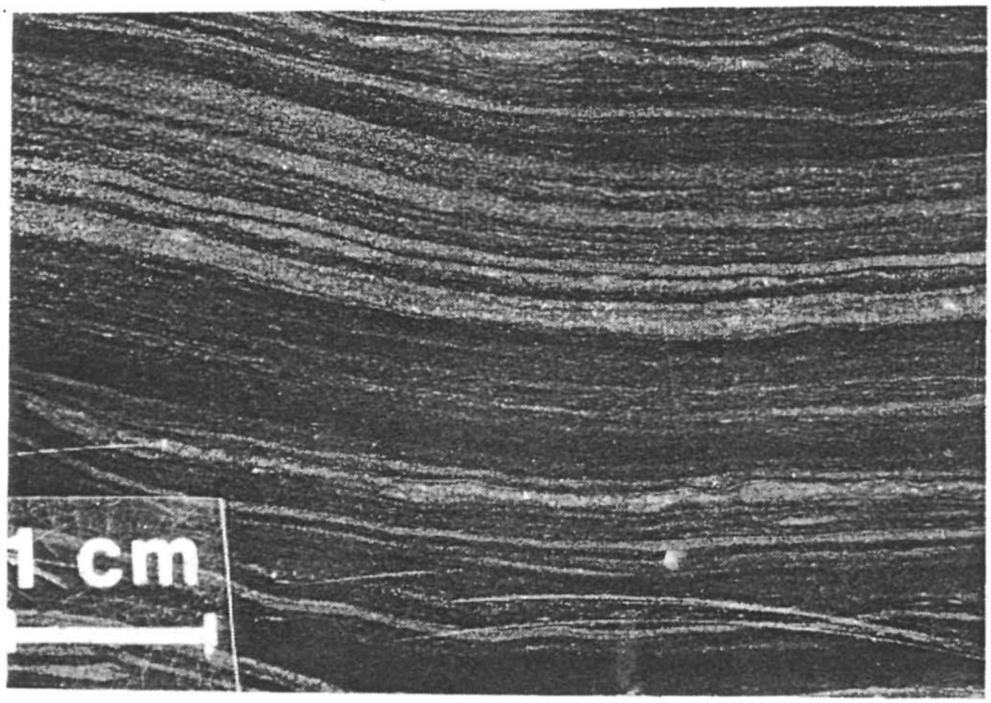


Plate 6: Polished slab of lithofacies 1b, Interbedded Unit, Eramosa Member, Ebel Quarry. Dark colour due to high organic content and abundant microstylolites.

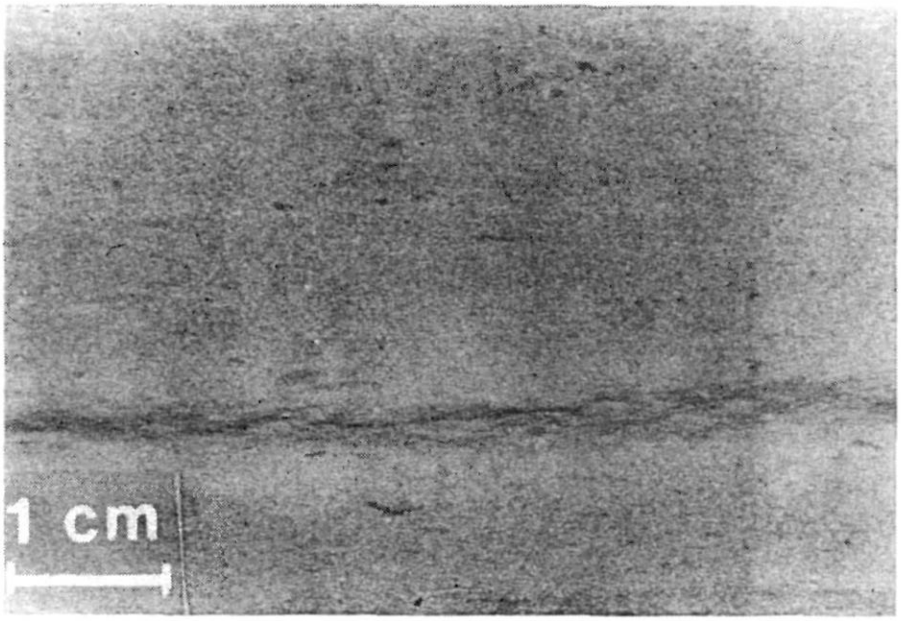


Plate 7: Polished slab of lithofacies 2, Middle Unit, Eramosa Member, from O.S.L.'s Cruickshank Quarry. Note non-laminated nature. Bedding is imparted by thin bands of microstylolites such as in lower half of photo.

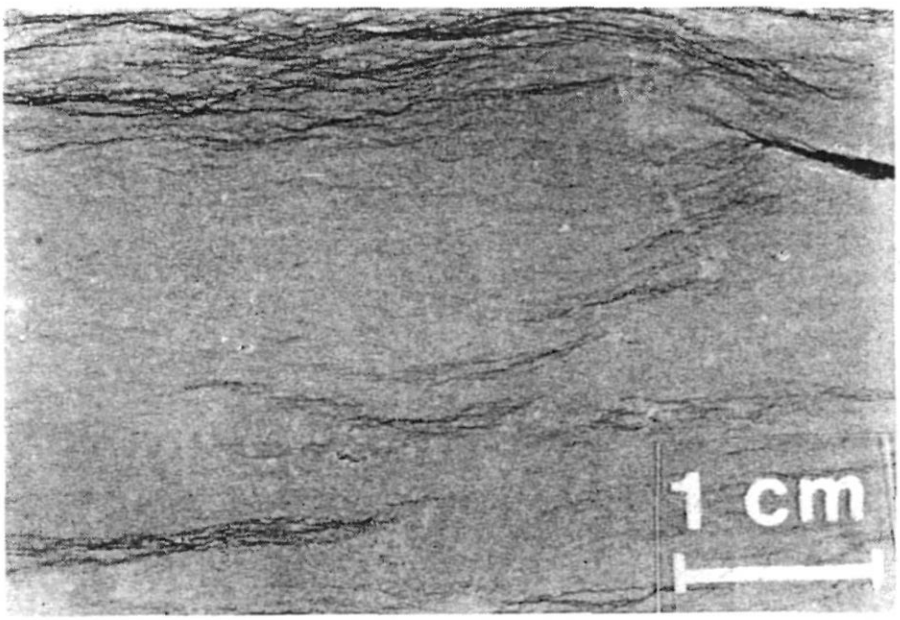


Plate 8: Polished slab of lithofacies 2, Middle Unit, Eramosa Member, Bruce Marble and Stone Quarry. Note small concentrations or "horsetails" of microstylolites.

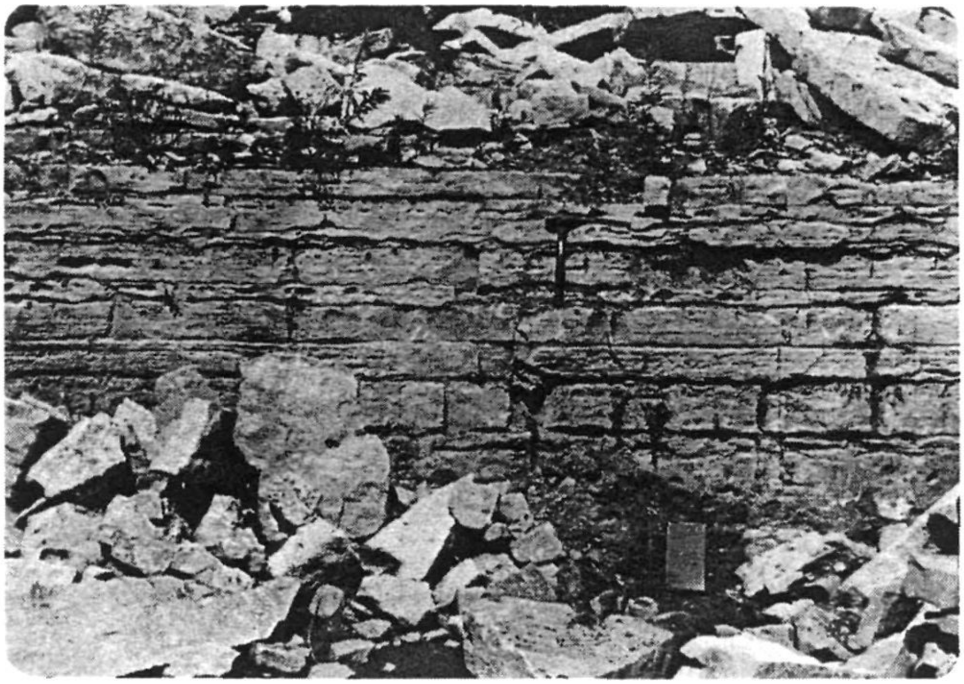


Plate 9: Quarry exposure of lithofacies 2, Middle Unit, Eramosa Member, at O.S.L.'s Wiarton Quarry. Note planar to slightly irregular bedding contacts (hammer in centre of photo for scale).

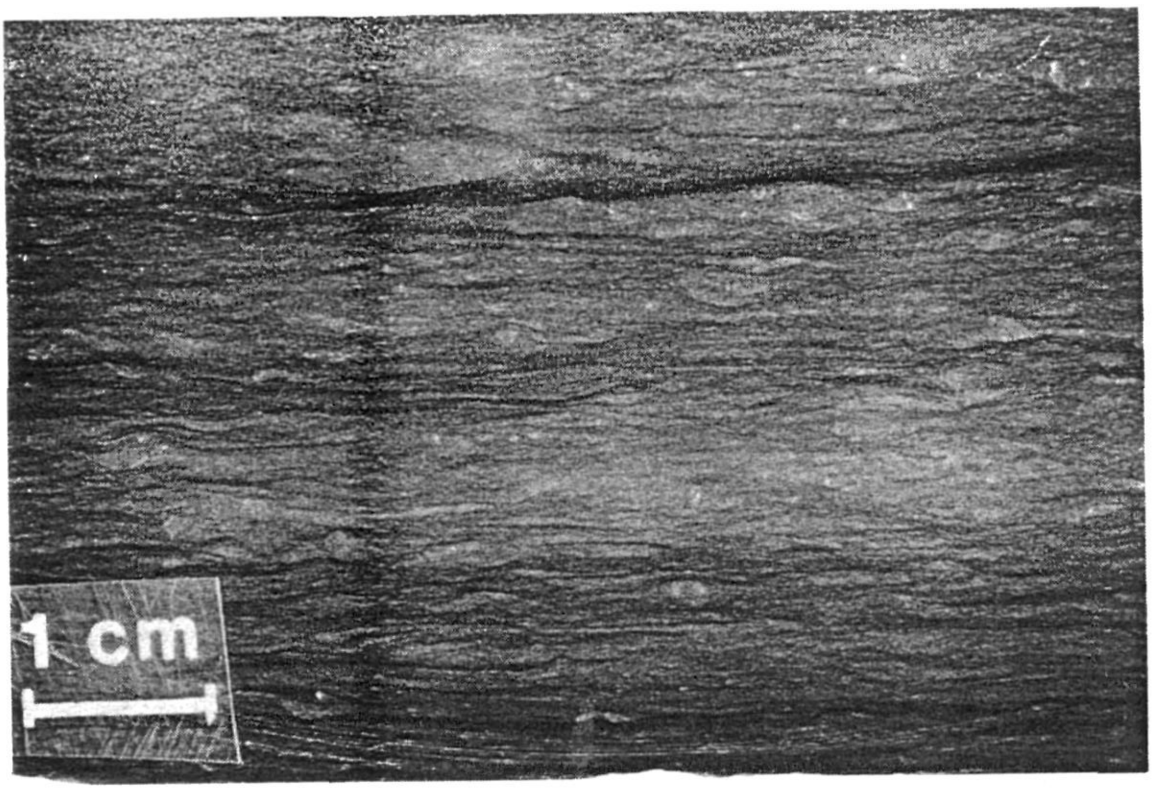


Plate 10: Polished slab of lithofacies 3, Interbedded Unit, Eramosa Member, Ebel Quarry. Note abundant microstylolitic networks and bioturbated appearance.

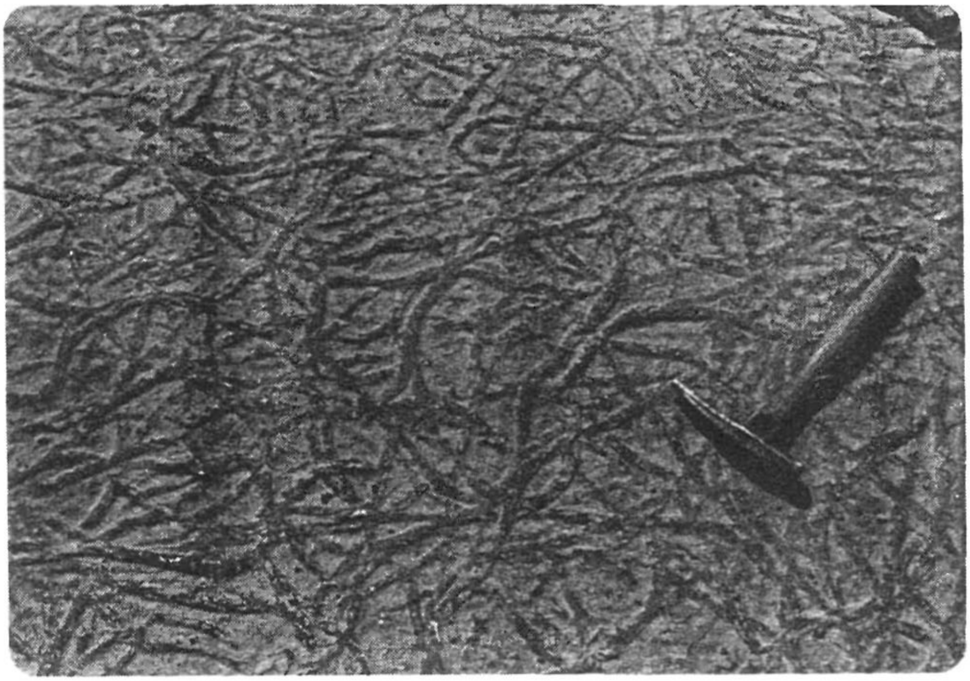


Plate 11: Casts of burrows on bedding plane in Interbedded Unit, Eramosa Member, Ebel Quarry.

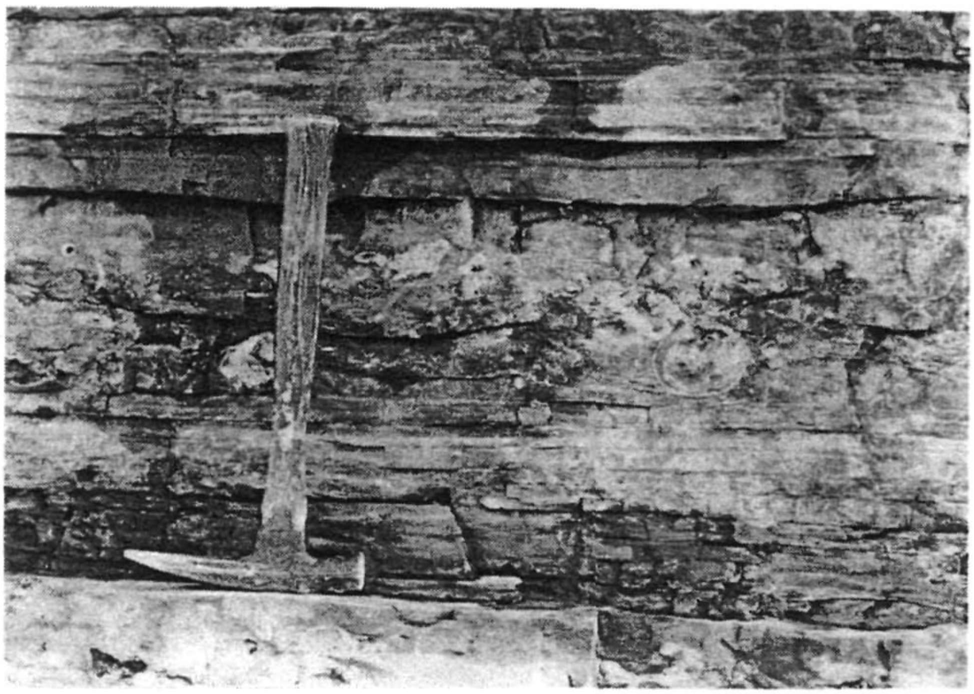


Plate 12: Outcrop of Interbedded Unit, Eramosa Member, at Sky Lake roadcut. Note round stromatoporoid in centre right and other fossil (mostly coral) material in middle and lowest beds in photo.

Plate 13: Quarry exposure of "Marble" Unit, Eramosa Member, at O.S.L.'s Wiarton Quarry. Note wavy bedding (hammer on ledge in centre for scale).

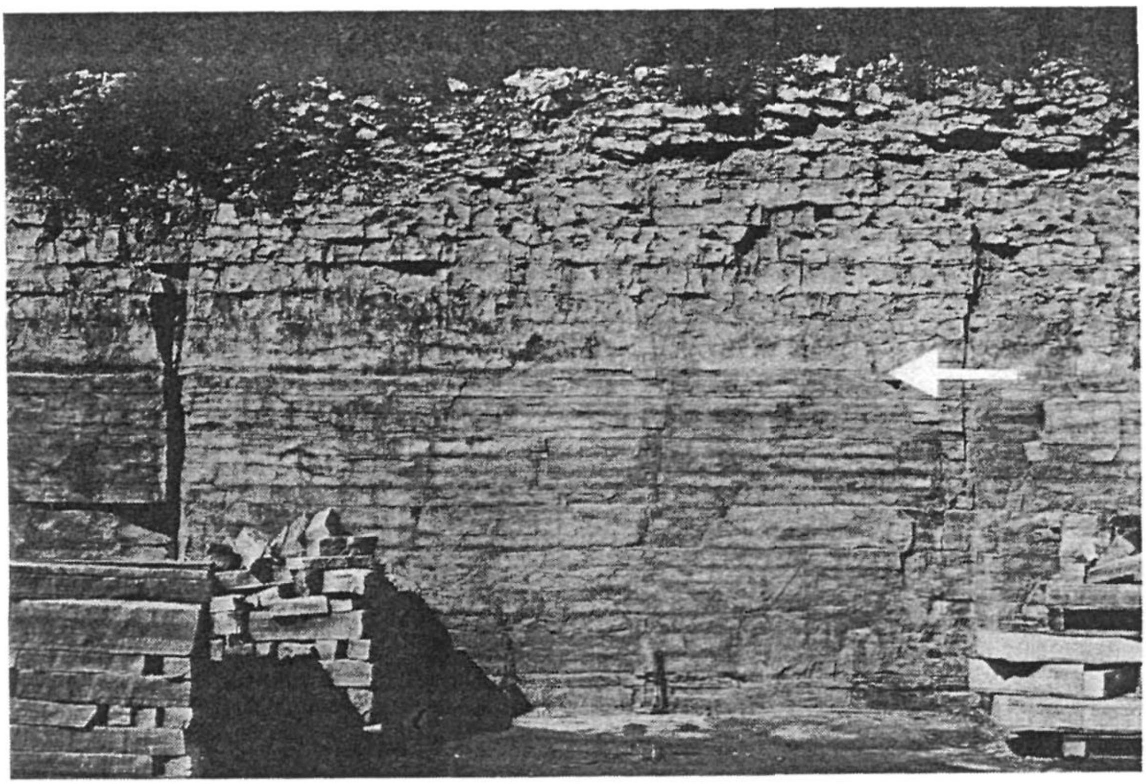


Plate 14: Quarry exposure of contact (indicated by arrow) between "Marble" Unit (lithofacies 1a) and Middle Unit (lithofacies 2), both of Eramosa Member, in Ross Quarry. Note vugs in Middle Unit. Split-faced blocks in foreground are from "Marble" Unit.

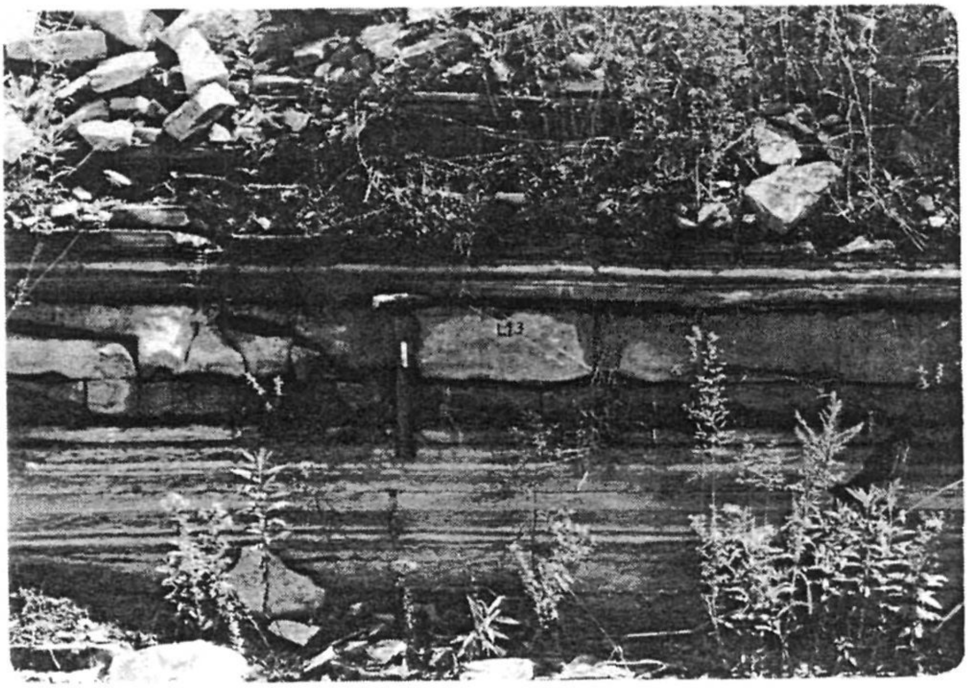


Plate 15: Quarry exposure of Interbedded Unit in Ebel Quarry (hammer in centre for scale). Lithofacies 1b beds above hammer, lithofacies 2 bed beside hammer, and lithofacies 3 beds below hammer.

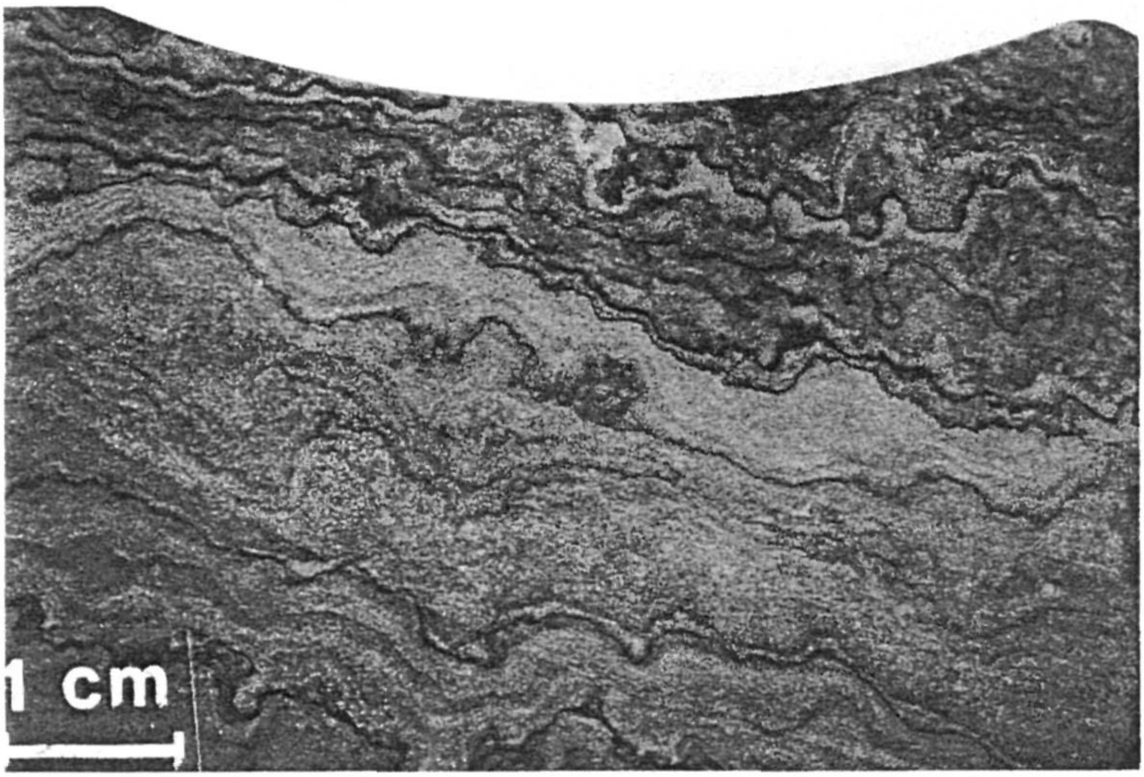


Plate 16: Polished slab, cut parallel to bedding, of lithofacies 1a, Marble Unit, Eramosa Member, from Bruce Marble and Stone Quarry. Note distinctive "fleuri" pattern.

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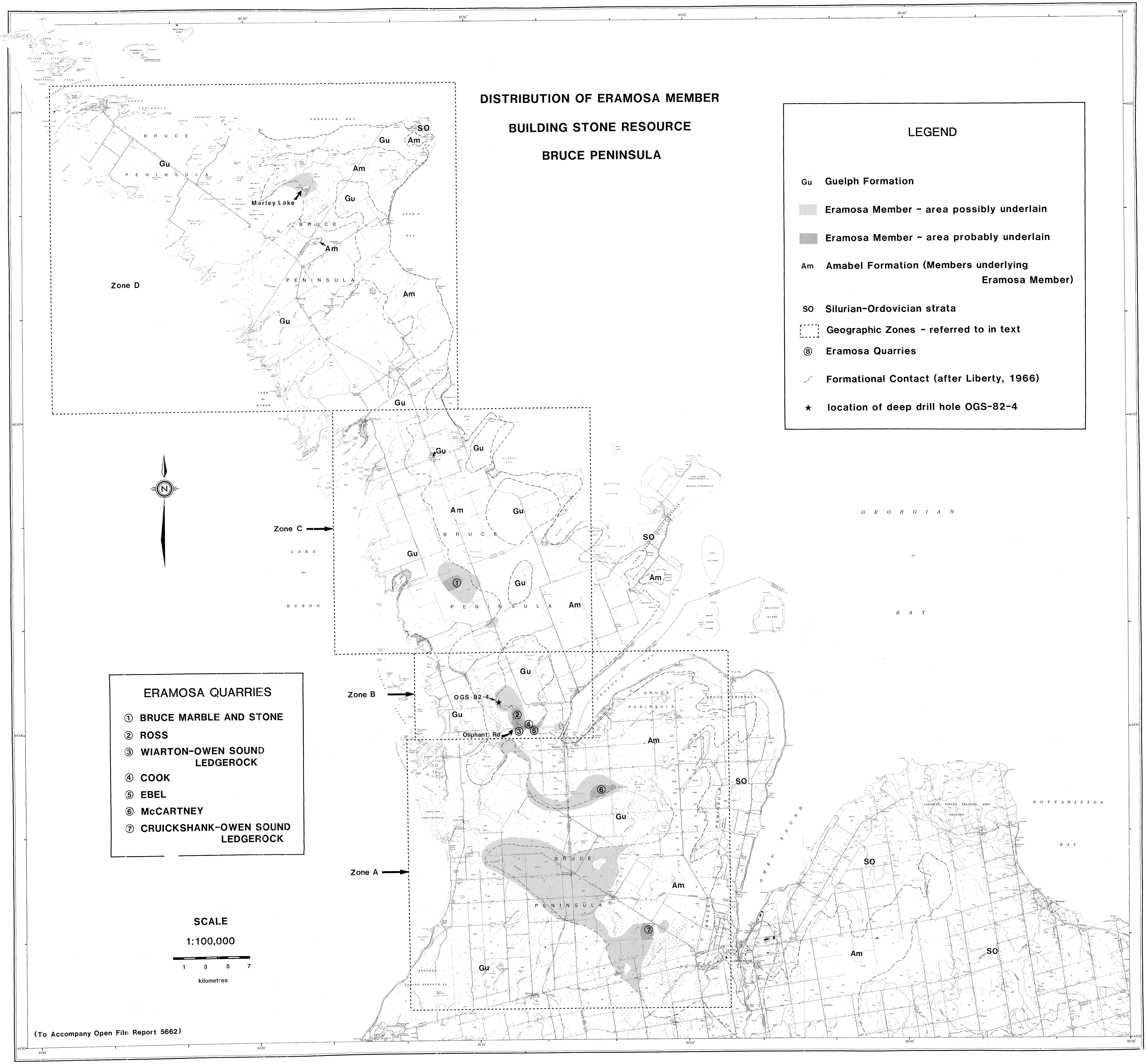
DISTRIBUTION OF ERAMOSA MEMBER
BUILDING STONE RESOURCE
BRUCE PENINSULA
LEGEND
Gu Guelph Formation
Eramosa Member - area possibly underlain
Eramosa Member - area probably underlain
Am Amabel Formation (Members underlying Eramosa Member)
SO Silurian-Ordovician strata
Geographic Zones - referred to in text
⑧ Eramosa Quarries
Formational Contact (after Liberty, 1966)
★ location of deep drill hole OGS-82-4
ERAMOSA QUARRIES
① BRUCE MARBLE AND STONE
② ROSS
③ WIARTON-OWEN SOUND LEDGEROCK
④ COOK
⑤ EBEL
⑥ McCARTNEY
⑦ CRUICKSHANK-OWEN SOUND LEDGEROCK
SCALE
1:100,000
1 3 5 7
kilometres
Zone D
Zone C
Zone B
Zone A
Marley Lake
OGS-82-4
Oliphant Rd
GEORGIAN BAY
LAKE HURON
BRUCE PENINSULA
OWEN SOUND
NOTTAWASAGA BAY
(To Accompany Open File Report 5662)