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Precambrian Dolomite Resources in Southeastern Ontario

by

P.S. Lebaron and A. MacKinnon

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V.G. Milne

V.G. Milne, Director
Ontario Geological Survey

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ABSTRACT

Precambrian carbonate belts of the Grenville Province in southeastern Ontario contain bands of high-purity calcitic and dolomitic marbles which represent potential sources of industrial raw material. Traditionally in North America, high-calcium marbles have been preferred over dolomites as raw material for the mineral filler industry. However, the extensive use of dolomite fillers in Europe suggests that high-whiteness, high-purity dolomite can be substituted for calcium carbonate fillers in many industrial applications. Other important uses of high-purity dolomite are as refractory material and flux in the iron and steel industry, as a component in glass-making, and in the production of magnesium metal. Dolomitic marbles of lower purity may be suitable for agricultural uses, dimension stone and decorative aggregate, and various miscellaneous applications.

Geological mapping and chemical analyses of samples from 24 dolomitic marble occurrences in southeastern Ontario indicate that dolomites of moderate to very high purity and brightness are present within the study area.

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The study was initiated and the final manuscript reviewed by P.W. Kingston, Resident Geologist, Ministry of Northern Development and Mines, Tweed.

PRECAMBRIAN DOLOMITE RESOURCES IN SOUTHEASTERN ONTARIO

by: P.S. LeBaron[1] and A. MacKinnon[1]

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.

PART I

INTRODUCTION

The carbonate rocks of southeastern Ontario have been a major source of Ontario's industrial mineral production for over 100 years. Limestone and dolostone have been mined as source rocks for calcium and magnesium metal, mineral filler and whiting, flux, building stone, soil conditioner, refractory material, construction aggregate, cement, and lime used in building and chemical industries (Vos 1986). Some of these applications require a carbonate source of high purity and whiteness, which in southeastern Ontario is found only within the metamorphic equivalent of Paleozoic carbonate rocks, Precambrian marble.

The primary focus of this study is the potential of Precambrian marble in southeastern Ontario as a source of high-purity dolomite for use as high-grade industrial filler, as refractory material, and in the production of magnesium metal. Other potential applications such as building stone and low-grade

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

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filler are briefly discussed.

Part I of this report focusses on the chemistry, properties, and industrial applications of dolomite, market trends and outlook, and the geology and distribution of marble belts in southeastern Ontario.

Part II contains descriptions of Precambrian dolomite occurrences based on previous studies and on field examinations performed by the authors in 1986 and 1989.

Paleozoic carbonate rocks of southeastern Ontario are potential sources of dolomite but were not included in this study because they are of insufficient stratigraphic thickness and/or chemical purity to be considered as sources of high-purity doloma (MacKinnon 1986).

LOCATION OF THE STUDY AREA

The study area (Figure 1) extends from latitude 44° 15′ N to 45° 50′ N and longitude 76° W to 78° W. It is roughly triangular in shape, with apices near Pembroke, Brockville, and Minden. An extensive network of roads provides good access to all parts of the study area.

PREVIOUS GEOLOGICAL WORK

Marble occurrences in southeastern Ontario have been documented in reports by Miller (1904), Goudge (1938), Hewitt (1960, 1964a, 1964b), Hewitt and Vos (1972), Vos (1977), Vos and Storey (1979), Storey and Vos (1981), Papertzian and Kingston (1982), Grant and Kingston (1984), Guillet and Kriens (1984), and Derry Michener

FIGURE I: Location of the study area.

Booth and Wahl and Ontario Geological Survey (1989a, 1989b, 1989c).

Many of the marble belts, quarries, and prospects have also been described in various geological reports by the Ontario Geological Survey and the Geological Survey of Canada.

METHODOLOGY

Field Methods

This study began in 1986 as part of an investigation of refractory mineral potential in eastern Ontario. Initially, a literature search identified known dolomitic marble occurrences in the study area. The most comprehensive sources of data were: "Marbles of the Pembroke-Renfrew Area" (Vos and Storey 1979), "Industrial Minerals of the Pembroke-Renfrew Area, Part 1: Marble" (Storey and Vos 1981), "Chemistry of the Grenville Carbonate Rocks, Parts 1 and 2" (Papertzian and Kingston 1982), and "Geology and Geochemistry of Grenville Marble in Southeastern Ontario" (Grant and Kingston 1984).

Thirty-four areas were selected for reconnaissance based upon the criteria used by Storey and Vos (1981) to define high-purity dolomite, which are a combined $MgCO_3$ and $CaCO_3$ content of at least 97%, impurities totalling less than 3%, and a CaO:MgO ratio within the range of 1.40:1 to 1.67:1. The results of a preliminary examination of these areas are discussed by MacKinnon (1986). Areas which showed potential for significant widths (greater than 15 m) of high-purity dolomite, based on the 1986 field work, were examined in greater detail in 1989, as were several additional areas which had not been included in the 1986 study. Outcrop areas were mapped by pace and compass at scales ranging from 1:1000 to 1:3000, depending on the exposure and dimensions of the dolomite zones. Calcitic and dolomitic marbles were distinguished by testing with dilute hydrochloric acid. Representative samples were taken and analysed for whole rock chemistry, acid insoluble content, and brightness.

Analytical Methods

Chemical analyses and brightness tests were performed by Lakefield Research, Lakefield, Ontario. Samples were analysed by X-Ray Fluorescence for SiO_2, Al_2O_3, total iron as Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5, MnO, and Loss On Ignition. The instrument used is a Philips Sequential 1404 X-ray spectrometer calibrated for these analyses with a certified dolomite standard.

Acid insoluble residue content was determined by a separate procedure as follows: 1) 0.5 g of sample is dissolved in 10 to 15 cc 1:1 HCl; 2) boil to dryness; 3) take up residue with 25 cc hot water and 3 cc HCl; 4) filter and wash with hot water; 5) ignite, dessicate, and weigh insoluble residue.

Brightness tests were done with a Photovolt 577 spectrophotometer, using $MgCO_3$ as a standard. Reflectance of the standard is set at 100 and the measured value from the sample is expressed as a percentage of this. Sample pulps from the whole rock analyses, ground to -200 mesh in a chrome steel mill, were used in the brightness tests. A more accurate determination of brightness requires careful grinding to a uniform particle size in an agate mill. Non-uniform particle size reduces brightness (Bert Carr, Manager of Analytical Services, Lakefield Research, Lakefield, personal communication 1989) and an agate mill introduces fewer coloured impurities than a chrome steel mill.

CLASSIFICATION OF CARBONATES

The marble classification scheme used in this report is that used by Storey and Vos (1981), shown in Table 1. It is based primarily on natural breaks in the CaO:MgO distribution within Pembroke-Renfrew area marbles. Pure dolomite has a CaO:MgO ratio of 1.40 and the strongest natural break in the data set occurs at about CaO:MgO of 1.6. Therefore, the range of CaO:MgO values for dolomite marble was set at 1.40 to 1.67, corresponding to a range in calcite content of 0 to 10%.

TABLE 1: Marble Classification Based on CaO:MgO Ratio (from Storey and Vos 1981)

Marble Type		CaO:MgO	MgO%
Dolomite Marble		1.40- 1.67	19.7-21.8
Magnesian Marble	Calcitic dolomite	1.67- 3.95	10.9-19.7
	Dolomitic calcite	3.95-24.40	2.2-10.9
Calcite Marble		>24.40	0.0- 2.2

A more complete description of the scheme and a comparison with previous classifications are presented by Storey and Vos (1981).

This study is limited to dolomite marbles and, more specifically, to high-purity dolomite marbles, which are defined as marbles having CaO:MgO ratios within the range of 1.40 to 1.67 and containing less than 3% impurities. Samples for which acid insoluble data were not available were categorized as high-purity if the total of SiO_2, Fe_2O_3, and Al_2O_3 is less than 3%. In the field, dolomitic marble containing up to 5% impurities, visually estimated, was considered as possible high-purity dolomite.

DOLOMITE PRODUCTION, USES AND SPECIFICATIONS

Applications

The uses for dolomite can be broken down into the following categories: 1) aggregates and construction materials; 2) agricultural; 3) chemical and metallurgical; 4) mineral fillers; 5) dimension stone; and 6) miscellaneous uses. These are listed in approximate order of magnitude by consumption (O'Driscoll 1988). Exact figures are not available because official statistics on limestone and marble production in both Canada and the United States do not differentiate between limestone and dolomite. Also, the contribution of Precambrian carbonate rocks to the total production figures is difficult to assess because the source rocks are generally classified simply as limestone.

Historically and currently, Precambrian dolomite in Canada is used primarily for the production of magnesium metal and low-grade filler and, to a lesser extent, for dimension stone, marble chips, and agricultural uses. High-calcium marble, however, is widely used in Canada and the United States as a filler in the paper, paint, and plastics industries. Important properties of filler-grade carbonate include whiteness, fineness, freedom from grit, low oil absorption and equidimensional particle shape. These properties can be provided by both calcite and dolomite, therefore, high-purity white dolomite could substitute for calcium carbonate in most filler uses, as it commonly does in Europe (Guillet and Kriens 1984).

Precambrian dolomite also has potential application in the chemical and metallurgical category as refractory material and metallurgical flux, applications which currently use Paleozoic dolostone as source material.

These two categories -- fillers and chemical/metallurgical applications -- offer the greatest potential as markets for Precambrian dolomite resources and are discussed in more detail below. The remaining four categories, listed above, are also briefly discussed.

Dolomite Fillers

Uses and Specifications

There is little or no North American production of high-purity filler from white dolomitic marble. In Europe, however, dolomitic fillers are used extensively for paints, plastics, and other applications requiring high whiteness, low oil absorption, and low abrasiveness. The availability and traditional use of high-purity calcitic marble combined with a lack of detailed performance characteristics for dolomite appear to be the main reasons for the limited use of dolomitic fillers in North America (Guillet and Kriens 1984).

The most significant properties of carbonate fillers are particle size (fineness), whiteness (brightness), and mineralogical and chemical purity.

Particle size distribution depends upon the grinding and classification method used. Changes in particle size distribution affect the packing density of the particles, which can affect product performance such as oil absorption.

Whiteness and brightness are closely related factors which are important in applications such as paint, plastics, and papers. Other applications such as asphalt roofing, caulking compounds and some plastics can accept off-white carbonate fillers if other specifications such as particle size, bulk density and oil absorption are met. These low-grade fillers are commonly produced as by-products of limestone and dolostone quarried for the production of lime used by the steel industry. Brightness is affected by particle size, uniformity of particle size, and by impurities introduced during sample preparation, therefore, in order to compare products, it is necessary that the method for brightness determinations be standardized.

Carbonate fillers must have high chemical and mineralogical purity. They should be free of deleterious components such as arsenic, lead, and water-soluble salts, and have low content of abrasive minerals (quartz, tremolite, etc.) and dark minerals (graphite, hematite, etc.).

High-grade dolomite fillers, depending on the application, can improve colour and weatherability, increase mechanical stability and reduce shrinkage, internal stress, fissure development, and oil and water absorption. They can also provide low-cost substitutes for titanium dioxide as a whitener (O'Driscoll 1988a).

Table 2 summarizes the specifications for various applications of carbonate fillers.

TABLE 2 Primary Uses for Carbonate Fillers (from Guillet and Kriens 1984)

Application	Function	General Specifications
Paint	Extender of prime pigments in interior and exterior paint formulations.	High whiteness; controlled particle size, 44 microns to 8 microns top size.
Plastics	As a resin extender in a wide range of polymer systems.	High whiteness; controlled particle size, 30 to 5 microns top size; fillers treated with coatings and coupling agents are used.
Paper	As a filler or for paper coating. Partial displacement of kaolin.	High whiteness; controlled particle size, low abrasion, very fine products with top sizes ranging from 10 to 4 microns.
Putty, Caulking, Sealing		White, medium to fine, 90-99% passing 325 mesh (44 microns).
Vinyl Floor Covering	As a filler in vinyl tile	Coarse granular (-40 mesh) to fine (-325 mesh); good white colour; controlled particle size and bulk density.
Carpet Backing		White to gray colour; 90%-99% passing 325 mesh.
Asphaltic Products	Filler in roofing materials and asphalt sealers.	Off-colour buff to gray; coarse ranging from 80% passing 325 to 80% passing 200 mesh.
Rubber	Filler pigment in footwear, automotive goods, non-reinforced rubber, wire and cable coatings.	White to off-colour; Fine to medium fine products.
Construction	Filler in jointing compounds for gypsum board.	Lower grade white products; 90-95% passing 325 mesh.
Other	Synthetic Marble	White, coarse products; 80-85% finer than 200 mesh, and granular grades.
	Coal Dusting	White to buff, coarse filler used in coal mining.

There have been reports that indicate that magnesium carbonate fillers may cause yellowing of paper. It is not known if this is related to the use of dolomitic marble or precipitated $MgCO_3$ (Guillet and Kriens 1984).

The use of dolomite in paint may lead to the formation of magnesium sulphate as the dolomite reacts with sulphur dioxide and water (sulphurous acid). Magnesium sulphate is water soluble and may cause white streaks on the painted surface. However, the extensive use of dolomite fillers in paint in Europe suggests that this potential problem does not arise or can be easily overcome.

Based on the specifications listed in Table 2, there is no apparent reason for the exclusion of dolomite fillers from the corresponding applications, with the possible exception of the paper industry. More research on the use of high-purity, white, dolomitic marble for fillers is warranted.

Production

There are currently only two producers of carbonate fillers from Precambrian marbles in Ontario; Steep Rock Resources Inc. and Easton Minerals Ltd.

Steep Rock Resources Inc., recently acquired by Pleuss-Staufer AG (August 1988), produces a wide range of high-quality calcium carbonate fillers at Perth, from a white marble deposit at Tatlock (Darling Township), about 40 km north of the plant. Prices range from $20 per tonne for low grade, off-white filler to $145 per tonne for high-brightness, micronized filler.

Pleuss-Staufer, through Steep Rock Resources, also holds the mining rights on two marble deposits north of Tweed. One deposit, in Elzevir Township, contains substantial widths of both high-purity, white calcite and dolomite. The other deposit, in Hungerford Township, contains an estimated 4 million tonnes of high-MgO dolomite. Quarrying of the Elzevir Township calcite zone is currently being considered, but Pleuss-Staufer has no immediate interest in quarrying the dolomitic material (Dale MacGregor, General Manager, Steep Rock Resources Inc., Perth, personal communication 1989). These two deposits are described in more detail in Part II of this report (ELZ-01 and HUN-01).

Easton Minerals Ltd., a subsidiary of Barmin Inc., produces low-grade dolomite filler and marble chips from tremolitic, dolomite marble mined by Canada Talc Limited, also owned by Barmin Inc. The dolomite is produced as a by-product of underground talc mining operations at Madoc (Huntingdon Township) and is trucked to the Easton Minerals mill at Northbrook, about 50 km northeast of Madoc, for processing. The filler product is high in brightness, but of low mineralogical purity, containing talc and tremolite. It is marketed as a low-grade, general purpose filler and as line marking for outdoor athletic facilities (LeBaron and van Haaften 1989).

Easton Minerals is currently developing a new quarry in calcitic and dolomitic marble in Griffith Township, about 65 km north of the Northbrook plant. This rock will be used to produce marble chips and low to medium grade filler, priced at about $30 to $60, per tonne, which contains both calcite and dolomite in a ratio of 1:1, and about 1.7% acid insolubles (Bob Kirkwood, Manager, Easton Minerals Ltd., Madoc, personal communication 1989). This deposit is further described in Part II (GRI-01).

Two additional dolomitic marble deposits in Griffith and Mayo townships have undergone bulk sample testing and quarry development is expected to begin in late 1989 to early 1990.

Two Island Marble Corporation is developing a marble dimension stone quarry in Griffith Township (GRI-02), about 2 km northeast of the Easton Minerals quarry. The marble is very similar to that of the Easton Minerals deposit, and contains a 40 to 50 m wide zone of very white, high-purity dolomite. The company plans to market quarry waste as marble chips and filler material.

Mangrove Bay Resources expects to begin production in 1989 from a dolomitic marble quarry in Mayo Township (MAY-01). The marble is of high brightness but contains 6% acid insolubles and will be used to produce aggregate and low-grade filler.

These recent developments suggest that the market for both low and high-grade dolomite fillers is increasing.

Chemical and Metallurgical Applications

Chemical and metallurgical applications of carbonate rocks require that the raw materials be calcined, or burned, in order to release carbon dioxide gas and produce a material composed primarily of CaO and MgO in quantities proportional to the original carbonate contents of the source rock. The product of calcination of limestone is referred to as lime (or quicklime), and that of calcined dolomite is known as dolime. Dolime may contain 18.0 to 45.0% MgO and 30.0 to 57.5% CaO depending on the composition of the raw material, and may also be referred to as low or high-magnesium lime. The dissociation temperatures of pure $CaCO_3$ and pure $MgCO_3$ are, respectively, about 900^oC and 450^oC. The proportions of calcium and magnesium carbonates in a dolostone will affect the dissociation temperature (Derry Michener Booth and Wahl and Ontario Geological Survey 1989a).

Another important form of burned dolomite is produced by sintering dolomite at higher temperatures (1650^o to 1800^oC) to a much denser, more inert product known as dead-burned dolomite, refractory lime, or doloma. Doloma derived from high-purity, low-iron dolomite is used for refractory brickmaking.

Both dolime and doloma are used in a number of chemical and metallurgical applications which are outlined below.

i) Magnesium Metal

Magnesium metal is produced by variations of two basic processes:

1) electrolysis of molten $MgCl_2$ using sea water and brines as source material, and

2) thermal reduction of MgO using magnesium-bearing minerals as source material.

These processes involve the production of magnesia, MgO, or magnesium hydroxide, $Mg(OH)_2$, prior to reduction to Mg Metal. In many cases, these components are produced through the use of dolomite.

Calcined dolomite is used in some variations of the electrolytic process to precipitate $Mg(OH)_2$ from sea water, which contains about 1300 ppm Mg. The $Mg(OH)_2$ is then converted to $MgCl_2$, either by reacting it with HCl (Dow process) or by calcining to MgO and mixing the oxide with $MgCl_2$ brines (IG Farben and Norsk processes). The $MgCl_2$ is then dried and heated to form molten, anhydrous $MgCl_2$ feed for electrolytic cells (O'Driscoll 1988a).

Either lime or dolime can be used to precipitate $Mg(OH)_2$ from sea water, as the process involves the reaction of Mg salts in sea water with CaO to give insoluble $Mg(OH)_2$ and soluble calcium salts. However, the yield is much greater from dolime because it contributes about half of the magnesium in the final product (Coope 1981a).

In the thermal reduction processes, calcined dolomite is combined with ferrosilicon (FeSi) and retorted in a vacuum furnace, forming Mg vapour and a residue composed of calcium silicate and iron oxide. The Mg vapour is condensed externally and recovered (O'Driscoll 1988a). A variation of this process, using a small diameter vacuum furnace and fluorspar flux (the Pidgeon process), is used by Timminco Limited of Haley, Ontario to produce Mg metal which is 99.98% pure. Magnesium derived from the electrolytic processes is 99.8% pure (Trusler, 1977).

The demand for magnesium metal is growing, primarily due to increasing use of die-cast magnesium parts in the automotive sector. Magnesium consumption by the automotive industry in the western world is expected to increase from about 30,000 t in 1988 to 55,000 t in 1991 (Couturier 1989). The largest application for magnesium is as an alloy with aluminum. Aluminum/magnesium alloys have greater hardness, tensile strength and corrosion resistance than unalloyed aluminum. Beverage cans, which contain about 1.9% Mg, represent one of the most important applications of these alloys, but with increased recycling of can scrap in recent years, consumption of Mg for alloying has remained close to the 1985 level of 121,000 t (Couturier 1989). Magnesium is also used in electronic equipment, as a deoxidizing and desulphurizing agent in the iron industry, and as a reducing agent in the production of titanium, zirconium, and other reactive metals. World consumption of magnesium over the next decade is expected to grow at an average annual rate of 3.5% (Couturier 1989).

Timminco Limited is Canada's only producer of Mg metal, but two large-capacity plants, Norsk Hydro AS in Quebec and MAGCAN in Alberta, should be in operation by early 1990.

Timminco uses the Pidgeon process, described above, to extract magnesium from a very high-purity dolomite marble which is quarried at the plant site near Haley, Ontario (Ross Township). In 1988, Timminco produced about 6,000 t of magnesium from about 45,000 t of dolomite (Larry Ball, Quality Control Metallurgist, Timminco Limited, Haley, personel communication 1989).

Production capacity was reduced from 9,000 to 6,000 tpa in 1988 with the introduction of modifications to the plant which have improved the efficiency of the operation. In addition to magnesium, Timminco recovers calcium metal from lime produced from southern Ontario limestone and strontium metal from imported celestite. The Timminco dolomite deposit is described in Part II of this report (ROSS-01).

Norsk Hydro AS expects to begin production of magnesium from its plant at Becancour, Quebec in September 1989. The plant has an initial production capacity of 40,000 tpa which will later be expanded to 60,000 tpa. High-purity magnesite ($MgCO_3$) imported from China will be leached with hydrochloric acid to produce $MgCl_2$ feed for electrolytic cells (Gilles Couturier, Mineral Economist, Energy Mines and Resources Canada, Ottawa, personal communication 1989).

MAGCAN, a joint venture formed by Magnesium International Corporation Ltd. and Alberta Natural Gas Company Ltd., is constructing a plant near High River, Alberta, which may be producing Mg metal by January 1990. MAGCAN will use a new process that converts magnesite to molten, anhydrous $MgCl_2$ in a single step, followed by reduction to Mg metal by electrolysis. Magnesite ore will be obtained from the Baymag Mines Co. Limited magnesite deposit in British Columbia, about 300 km from High River. Production will begin at a rate of 10,000 tpa and can be expanded to 62,500 tpa, subject to demand (Couturier 1989).

A third new Mg metal project, a joint venture by Noranda Minerals Inc. and Lavalin Inc., is at the feasibility stage. The project involves the extraction of Mg from asbestos tailings in the Thetford Mines area of Quebec (Couturier 1989).

(ii) Refractory Material for the Iron and Steel Industry

Both dolime and doloma are used by the iron and steel industry. Dolime is used as a flux in steelmaking, to remove impurities such as silica, alumina, sulphur, and phosphorus. Historically, only high-Ca lime (90-93% CaO) was used, but it has been recognized that substitution of dolime for a portion of the lime flux gives greater protection of the furnace lining. Dolime now accounts for 20 to 30% of the flux in most basic oxygen furnaces (BOFs), and up to 50% in some cases (Derry Michener Booth and Wahl and Ontario Geological Survey 1989a). Dolomite for fluxing should contain less than 3% impurities and, particularly, a low content of sulphur and phosphorus (Hewitt 1960).

Doloma is used in the manufacturing of refractory brick and monolithic refractories for the steel industry. In the past, these materials were used primarily in the hearth of open-hearth furnaces, in which the hearth was constructed of dolomite bricks covered with a lining of monolithic doloma. However, with the replacement of open-hearth furnaces by BOFs and electric arc furnaces (EAFs), the main applications for doloma bricks are in BOFs, ladle linings, cement kilns, argon-oxygen decarburisation vessels, and in some cases, EAFs (O'Driscoll 1988a).

Dolomite for refractory brickmaking must contain less than 2 weight percent impurities, and must produce a calcined material which has a density greater than 3.0g/cc. Dolomite which will calcine in a single firing to a density greater than 3.0g/cc represents a considerable energy saving over raw material that must be double-burned (Springer 1983). Clancy and Benson (1982), in a study of 14 samples of refractory dolomite, found that the only samples which calcined to the required density in one firing were recrystallized dolomites consisting of large, twinned crystals. These authors suggest that dolomite with a specific gravity greater than 2.80 will meet the density requirement upon calcining. Hewitt (1964a) reports specific gravities, all of which are greater than 2.80, for a number of dolomitic marble occurrences in southeastern Ontario (Table 3). Based on the criteria of purity and density, it appears that Precambrian dolomites of southeastern Ontario have potential as raw material for the refractories industry.

The only current producer of refractory grade doloma in southern Ontario is the Steetley Industries Limited Dundas plant and quarry, located in West Flamborough, Hamilton-Wentworth Regional Municipality. The upper lift of the quarry is the source of high-purity dolostone of Middle-Silurian age used to produce dolime and doloma. It is 14 to 15 m high and consists of 6 to 7 m of medium-bedded dolostone of the Guelph Formation underlain by 6 to 8 m of thick-bedded dolostone of the upper part of the Eramosa Member, Lockport Formation (Scott and Yundt 1983). The upper lift is reported to contain less than 0.5% SiO_2 and less than 0.5% combined Al_2O_3 and Fe_2O_3 (Hewitt 1960). Products manufactured from this stone include dolime, used as a flux in steelmaking; dead-burned dolomite, which is coated with iron oxide and used to fettle open hearth and electric arc furnaces; and double-burned dolomite for the production of refractory bricks (Scott and Yundt 1983). The quarry also produces stone for construction aggregate, armour stone and riprap, fertiliser grit, fine sand for the glass industry, and low-grade fillers for roofing shingles and sound deadeners.

Several other quarries in central and southwestern Ontario produce lime and/or dolime from Paleozoic carbonates for use in the iron and steel industries. In southeastern Ontario, only Timminco Limited produces dolime, as part of the process of extracting magnesium metal from Precambrian dolomite.

(iii) Glass

Limestone and dolostone, after silica sand and soda ash, are the third largest constituents of glass. They act as a flux for the melting of silica sand, forming chemically fused calcium and/or magnesium silicates. High-calcium limestone is used in the manufacture of window glass, and dolostone (with limestone) is used in the manufacture of glass containers and glass fibre. Magnesium oxide in glass increases resistance to acid and thermal shock (Derry Michener Booth and Wahl and Ontario Geological Survey 1989a).

Dolime is used, to a small extent, in the manufacture of fibreglass and container glass, but the carbonates are more

TABLE 3: Specific Gravity of Southeastern Ontario Precambrian Dolomitic Marbles (from Hewitt 1964)

Township	Property	Specific Gravity
Guilford	Eagle Lake Quarry	2.84
Dungannon	McMillan Quarry	2.86
Dungannon	Stewart Quarry	2.87
Faraday	Barker Quarry	2.93
Madoc	Stoklosar Quarry	2.86
Madoc	Hastings Marble Products	2.85
Madoc	Madoc Marble Quarries	2.84
Huntingdon	Canada Talc	2.88
Elzevir	Madoc Marble Quarries	2.86
Olden	Rideau Aggregates Ltd.	2.86
Oso	Sharbot Lake Quarry	2.84
Ross	Dominion Magnesium Ltd.	2.87
Ross	McGinn Quarry	2.86

commonly added to the glass batch as crushed, dried limestone and dolostone which becomes calcined within the glass furnace. The crushed stone is less expensive and less hazardous to handle than calcined stone (O'Driscoll 1988b).

Dolostone for the glass industry must contain at least 96% CaO + MgO, less than 0.1% Fe_2O_3, and less than 4% combined SiO_2 + Al_2O_3 (Hewitt 1960). Several Paleozoic limestone/dolostone quarries in central and southwestern Ontario produce glass grade material. Those producing dolomite for the glass industry include Steetley Industries Limited (Dundas quarry) and E.C. King Contracting (Owen Sound Dolomite quarry).

Aggregates and Construction Materials

The aggregates and construction market is the single largest consumer of dolomite. Crushed dolostone and limestone are used primarily as road building material and as aggregate in portland cement concrete for roads, buildings, and other structural applications. Virtually all of the stone used for these applications is obtained from Paleozoic dolostone/limestone quarries. High purity is not a requirement, but the content of chert, shale, and clay fragments in coarse aggregates should not exceed 5% (O'Driscoll 1988a). Because of the industry's requirements for large volumes of low-cost aggregate, Precambrian dolomites are not considered to be a viable source of raw material for these applications.

Agriculture

The main use of limestone and dolostone in agriculture is in neutralizing soil acidity. Other benefits of this application are enrichment of calcium and magnesium soil content and improvement of the soil structure. Additional agricultural applications include use of dolomite as "barnstone", to neutralize and absorb organic waste and to give a clean appearance; as filler material in fertilizers; and as poultry grit and mineral food (O'Driscoll 1988a).

Dolomite for this market is produced primarily as a by-product of aggregate production in Paleozoic limestone/dolostone quarries. However, two marble quarries in southeastern Ontario produce crushed stone for agricultural uses. Steep Rock Calcite, a subsidiary of Pleuss-Stauffer AG of Switzerland, produces poultry grit and agricultural limestone from a high-purity calcitic marble deposit near Tatlock, Darling Township, as a by-product of high-grade $CaCO_3$ filler production. Bolenders Limited produces poultry grit, in addition to marble chips and stucco dash, from a white, siliceous, dolomitic marble at the Eagle Lake quarry, Guilford Township (Kriens and Guillet 1984).

Dimension Stone

Both Paleozoic and Precambrian dolostones were extensively quarried for use as building stone in the early development of the construction industry in southeastern Ontario. Parks (1912) mentions 137 quarries producing building stone from Paleozoic rock and 19 from Grenville marble. However, with the development of the portland cement industry and the increasing use of cement and concrete building materials, many building stone quarries were abandoned or switched to the production of crushed stone.

By 1933 there were only 14 active building stone quarries in Paleozoic rock (Goudge 1933). There are presently only four producers of Paleozoic limestone and dolostone for architectural use and one dimension stone quarry in Precambrian dolostone, which is in the early stage of development. Several quarries throughout southern Ontario produce other building and landscaping products such as flagstone, masonry stone, and crushed marble.

Three of the four Paleozoic dimension stone quarries are located near Wiarton and Owen Sound on the Bruce Peninsula, where blue-grey and brown dolostones of the Amabel Formation are extracted by Arriscraft Corporation, Ebel Quarries Ltd., and Owen Sound Ledgerock Limited. The fourth quarry, operated by Cornwall Gravel Company Limited near Cornwall, produces black limestone of the Bobcaygeon Formation which is used to manufacture polished marble tiles (Derry Michener Booth and Wahl and Ontario Geological Survey 1989b, 1989c).

A dimension stone quarry in Precambrian dolostone is under development by Two Island Marble Corporation in Griffith Township, about 45 km southwest of Renfrew. The rocks in the quarry area include high-purity, white, dolomitic marble and interlayered calcitic/dolomitic marble containing pale blue and green bands. The quarry is described in more detail in Part II of this report (GRI-02).

High-purity dolomitic marbles have good potential as dimension stone with respect to uniformity of colour and texture. However, areas of marble with joint patterns which allow the extraction of large quarry blocks are rare. In general, marbles of the Grenville Province in southeastern Ontario hold little potential for the development of large dimension stone quarries, but deposits of marketable stone in quantities sufficient to fill the needs of domestic markets are present (LeBaron et al 1989).

Miscellaneous Applications

Minor quantities of dolostone, primarily from Paleozoic sources, are used in mineral wool manufacture, flue gas desulphurization, coal mine dusting, sewage treatment and water purification.

HIGH-PURITY DOLOMITE IN SOUTHEASTERN ONTARIO

Regional Geology

The study area is underlain by Precambrian rocks of the Central Metasedimentary Belt of the Grenville Province. This belt is dominated by rocks of the Grenville Supergroup, a suite of metamorphic carbonates, calc-silicates, quartzites, paragneisses, amphibolites, and metavolcanic rocks (Figure 2). Deposition of the oldest rocks, metavolcanics of the Tudor Formation, began about 1,300 Ma ago, followed by clastic and carbonate sedimentation and locally repeated volcanic/sedimentary cycles (Bartlett 1985). A varied suite of plutonic rocks was emplaced between about 1,250 and 1,100 Ma ago and younger metasediments (Flinton Group) were deposited about 1050 Ma ago (Carter 1984).

The Grenville Orogeny, which culminated about 1,000 Ma ago, superimposed a northeast structural trend over most of the Central Metasedimentary Belt and produced regional metamorphic grades ranging from greenschist facies near Madoc to granulite facies north of Kingston.

The Central Metasedimentary Belt is bounded by older rocks of the Ontario Gneiss Segment of the Central Gneiss Belt to the north and west and by overlying Paleozoic sedimentary rocks of the St. Lawrence Platform to the south and east.

Geology of the Marble Belts

As shown in Figure 2, carbonate metasedimentary rocks are widely distributed throughout the Central Metasedimentary Belt in

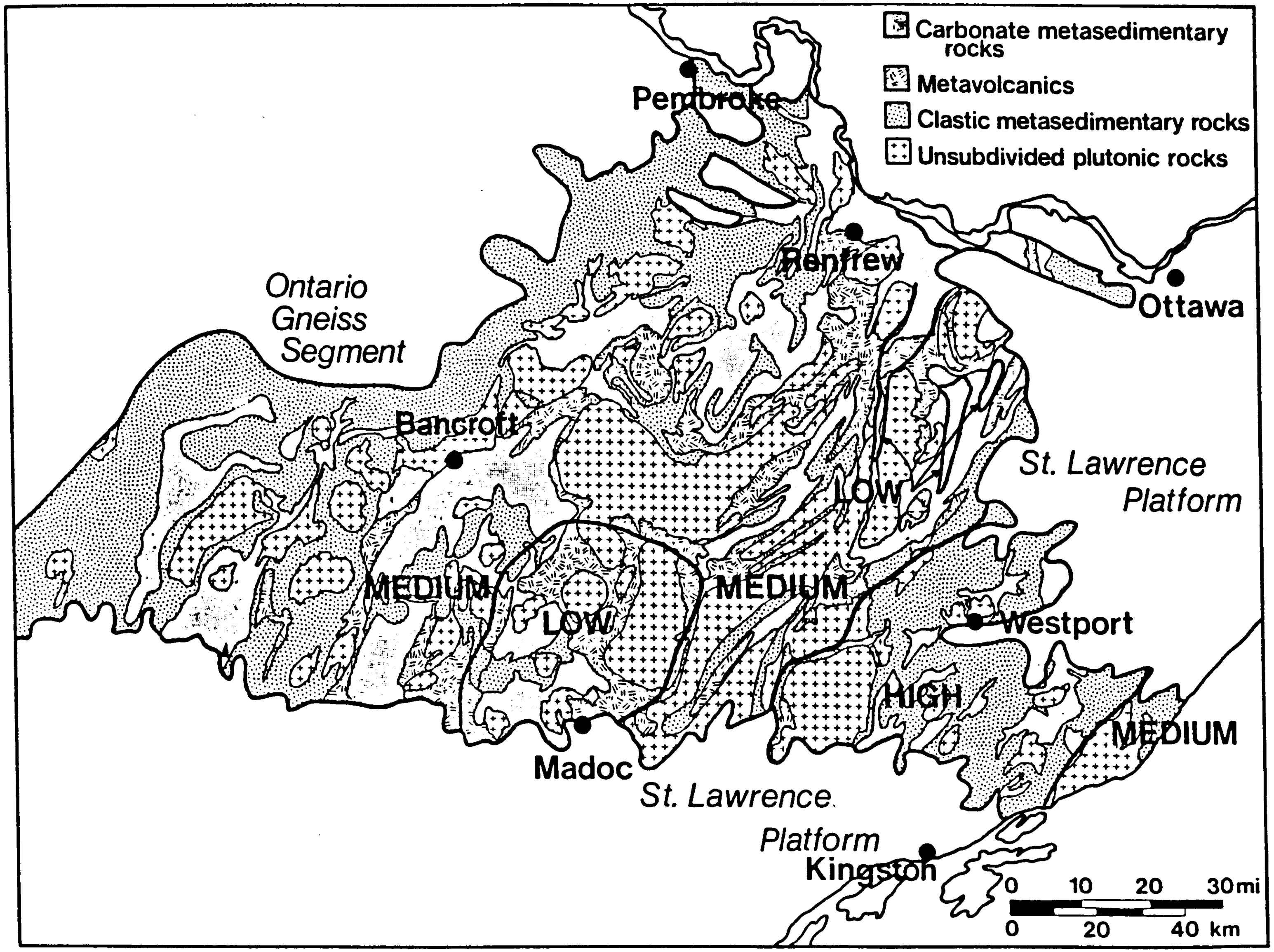

FIGURE 2: Generalized geology and metamorphic isograds within the Central Metasedimentary Belt of southeastern Ontario (after Carter 1984).

southeastern Ontario, forming marble belts up to several kilometers in width and tens of kilometers in length. The general trend of the belts is northeasterly, although within the belts, strike and dip may deviate considerably from the northeasterly trend due to local structural conditions. The marbles are also variable in colour, texture, and composition, both between belts and within a single belt. These variations are the result of differences in composition of the original carbonate sediment and differences in the grade and type of metamorphism.

Grain size of the marbles increases with metamorphic grade, from the fine-grained, sugary-textured marbles of greenschist facies in Hastings County to the very coarse-grained marbles of upper amphibolite facies such as those in Ross Township, Renfrew County.

Layering is a common feature of the Grenville marbles, both large scale (meters to tens of meters), which generally reflects major compositional differences (i.e. calcitic or dolomitic) and small scale (millimeters to centimeters), which is caused by concentrations of impurities such as phlogopite and graphite. The layering is generally parallel to contacts with non-carbonate units, suggesting that it is a reflection of bedding in the original sediment.

Colour is related to impurities in the marble. Most carbonate sediments contain at least a small amount of detrital quartz and feldspar which reacts with the carbonates during metamorphism to form silicates such as talc, serpentine, phlogopite, tremolite, diopside, forsterite, and enstatite. These minerals are often concentrated in layers, giving the rock a banded appearance in buff, brown and green colours. Graphite is also a common impurity, giving marbles a grey or blue colour. Sulphides such as pyrite, sphalerite and bornite are also locally present in trace amounts.

In addition to disseminated mineralogical impurities, bands of marble often contain larger-scale, lithological impurities such as narrow units of quartzite and amphibolite which are commonly boundinaged into widely spaced, rounded masses. In some cases, although the host marble is of high purity, the marble zone as a whole must be considered as low-purity for quarrying purposes, due to a high content of siliceous or amphibolitic boudins. If the non-carbonate layers have remained intact, however, selective quarrying and separation of the impurities from the marble may be possible.

Calcitic marble is best distinguished from dolomitic marble in the field by its reaction to dilute hydrochloric acid. Where the two rock types occur in close proximity, they can sometimes be visually differentiated on the basis of grain size or colour, but these comparisons cannot be applied consistently. For example, in Belmont Township (property BEL-02), dolomite layers are fine grained and sugary-textured and calcitic marble is medium grained. However, in Brougham Township (BRO-01), the dolomitic layers are coarser-grained than the calcitic layers and can be easily distinguished, particularly on the weathered outcrop surface.

The majority of the Grenville marbles are calcitic with at least 5% siliceous impurities. High-purity marbles are rare and are often poorly exposed because they are more easily weathered and eroded than siliceous marbles. The high-purity carbonates are generally white with an obvious lack of impurities. However, some white marbles may contain white or colourless siliceous minerals which are difficult to detect in hand specimen but which may give a high SiO_2 content upon chemical analysis (ELZ-01). Conversely, some buff, brown, or grey marbles may appear impure but contain only trace amounts of coloured impurities such as graphite or iron oxide (CLA-01).

Characteristics and Potential Applications of the High-Purity Dolomite Occurrences

A total of 23 high-purity dolomitic marble occurrences are described in detail in Part II of this report. Locations of the occurrences are shown in Figure 3 and partial chemical analyses are listed in Table 4. Three of the occurrences are not high-purity dolomites according to the criterion of less than 3% impurities. However, prospects BAT-01 and ELZ-01, with 3.35 and 3.77% SiO_2, respectively, were included because they contain substantial widths of high-brightness dolomite which may be suitable as low to moderate grade filler. Similarly, prospect MAY-01, with 6.73% SiO_2, was included because it is a high-brightness dolomite which is currently under development as a low

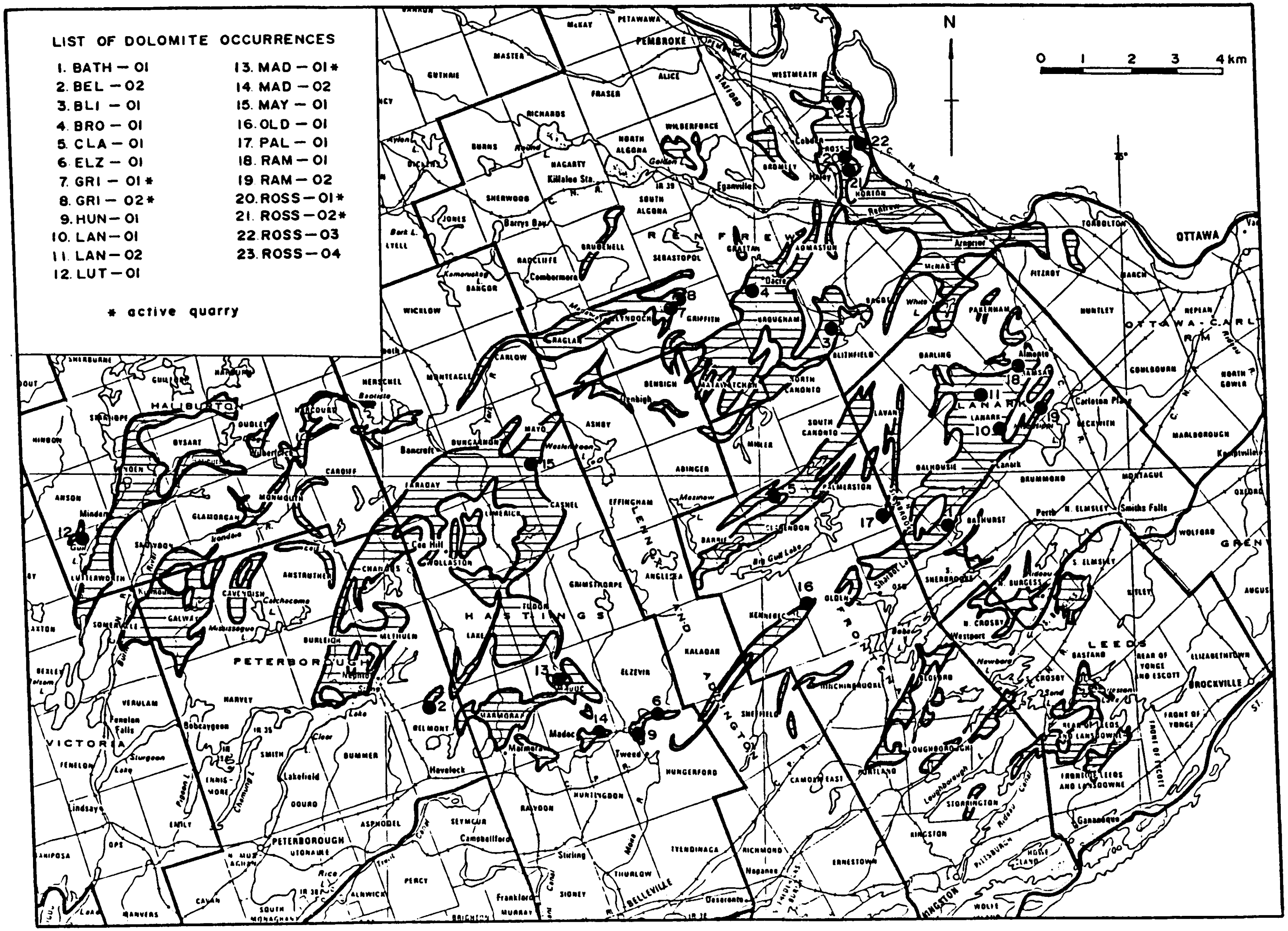

FIGURE 3: Distribution of marble belts in southeastern Ontario, also showing locations of high-purity dolomite occurrences.

TABLE 4: Chemical Analyses of Southeastern Ontario Precambrian Dolomitic Marbles

Property	MgO	CaO	Fe_2O_3	Al_2O_3	SiO_2	L.O.I.	Brightness
BAT-01	21.1	29.5	0.40	0.58	3.35	44.0	89
BEL-02	21.1	30.7	0.39	0.14	0.48	46.7	90.1
BLI-01[1.]	20.7	30.2	0.2	0.1	1.17	47.3	93.2
BRO-01[1.]	21.1	30.7	0.2	0.1	0.50	47.0	88.4
CLA-01	21.1	30.6	0.28	0.13	0.65	46.5	79.5
ELZ-01	21.6	29.5	0.29	0.42	3.77	43.7	90.2
GRI-01*	21.2	30.9	0.14	0.03	1.56	45.6	90.3
GRI-02*	21.1	31.0	0.11	<.01	0.44	46.6	93.6
HUN-01	21.3	30.6	0.42	0.19	0.84	46.2	90.0
LAN-01	20.9	30.8	0.23	0.14	0.59	46.5	87.4
LAN-02	21.1	30.1	0.28	0.11	0.37	46.6	87.5
LUT-01[2.]	19.7	28.3	0.19	0.2	1.0	46.9	ND
MAD-01*	21.6	30.3	0.18	0.19	0.90	46.3	87.4
MAD-02[3.]	20.5	29.6	0.08	0.08	1.28	39.2	ND
MAY-01	19.7	28.3	0.58	0.34	6.73	43.2	90.3
OLD-01[3.]	20.93	29.33	0.21	0.23	1.39	44.9	ND
PAL-01[3.]	20.6	29.6	0.26	0.09	0.80	45.8	ND
RAM-01	20.6	30.1	0.25	0.19	0.85	46.3	86.3
RAM-02	21.5	30.3	0.27	0.24	1.02	46.0	88.0
ROSS-01*	21.2	30.8	0.05	<0.01	0.31	47.1	91.5
ROSS-02*	21.4	30.8	0.08	<0.01	0.39	46.9	90.7
ROSS-03	21.3	30.8	0.10	0.04	0.73	46.4	90.6
ROSS-04	21.3	30.7	0.19	0.01	0.70	46.4	88.1

*Active Quarry
ND Not Determined
Analyses by the authors, except: 1: Storey and Vos (1981), 2: Easton (1986), and 3: Papertzian and Kingston (1982).

grade filler. The list of occurrences also includes 5 active quarries, which are:

1) GRI-01 Easton Minerals Ltd. (marble chips, low to medium grade filler)
2) GRI-02 Two Island Marble Corp. (dimension stone)
3) MAD-01 Stoklosar Marble Quarries Ltd. (marble chips)
4) ROSS-01 Timminco Limited (magnesium metal)
5) ROSS-02 H & H Aggregates (marble chips, concrete bricks)

The occurrences can be subdivided into several categories based on combinations of brightness and purity, each with a different range of potential applications, as shown in Table 5. This classification is somewhat subjective, and is intended as a method of rating the occurrences with respect to relative purity and brightness, rather than as an absolute determination of potential applications. Also, it is based on one representative analysis from each prospect which may not accurately reflect the chemistry and brightness of the dolomite zone as a whole. However, based upon the classification of occurrences in Table 5 combined with additional analyses and detailed geological descriptions in Part II of this report, the following conclusions can be drawn:

1) The greatest potential for high-purity, high-brightness dolomite is in Ross Township, within a marble belt that extends southward into Horton and McNab townships. The Ross Township occurrences exhibit large widths of pure, white, coarse grained dolomitic marble.

2) The Lanark-Ramsay marble belt, which extends southwestward into Dalhousie and Bathurst townships, contains several occurrences of high-purity dolomite which are of low brightness due to minor content of coloured impurities. The marbles are commonly grey to pale brown, but exhibit considerable widths of dolomite suitable for use as refractory material and flux, applications for which high brightness is not a requirement.

3) Marble belts in Griffith and Brougham townships consist of interlayered calcitic and dolomitic marbles containing narrow widths of very high-purity, high-brightness dolomite. A wide range of filler-grade and, possibly, refractory grade material could be obtained through selective quarrying of these wide calcitic/dolomitic zones.

4) High-purity dolomitic marbles occur adjacent to high-purity calcitic marbles in Belmont, Madoc, Hungerford, and Elzevir townships. The dolomitic marbles vary in colour and in silica content but offer a range of potential applications, from high grade filler and refractory material (BEL-01, MAD-01), to low grade filler and flux (ELZ-01, MAD-02).

5) Isolated occurrences in Blithfield, Clarendon, Palmerston, Olden, and Lutterworth townships suggest that all of the marble belts have some potential as hosts for high-purity dolomite. However, the highest probability of discovery of new occurrences is within the areas mentioned above.

TABLE 5: Classification and Potential Applications of South-eastern Ontario Precambrian Dolomitic Marbles

High Purity (SiO_2 0 - 1.0%)

High Brightness	Moderate Brightness	Low Brightness
(90%)	(88.1 - 90.0%)	(<88.1%)
BEL-02	BRO-01	CLA-01
GRI-02	HUN-01	LAN-01
ROSS-01	LUT-01	LAN-02
ROSS-02	ROSS-04	MAD-01
ROSS-03		RAM-01
high-grade filler, Mg metal, refractory, flux, glass	low-grade filler, refractory, flux	refractory, flux

Moderate Purity (SiO_2 1.1% - 3.0%)

High Brightness	Moderate Brightness	Low Brightness
BLI-01	MAD-02	RAM-02
GRI-01		
OLD-01		
PAL-01		
high-grade filler, flux	low-grade filler, flux	flux

Low Purity (SiO_2> 3.0%)

High Brightness	Moderate Brightness	Low Brightness
ELZ-01	BAT-01	
MAY-01		
low-grade filler	low-grade filler, crushed stone	

6) Based on the criteria of high purity (less than 3% impurities), high density (specific gravity greater than 2.80), and high brightness, southeastern Ontario dolomitic marbles show good potential as sources of high-purity dolomite for use in a wide range of applications. Table 6 lists chemical analyses for several commercial dolomites used in various applications. Comparison of the analyses in Table 6 with those of southeastern Ontario dolomites in Table 4 confirms the potential of the Grenville dolomites.

TABLE 6: CHEMICAL ANALYSES OF TYPICAL COMMERCIAL DOLOMITES (after Goudge 1938, Vos and Storey 1979, Coope 1981b). All values are weight percent.

	MgO	CaO	Fe_2O_3	Al_2O_3	SiO_2	L.O.I.	Application
UK (Steetley)	20.80	30.10	0.50	0.20	0.50	47.20	Refractories
Eire (Quigley)	20.75	30.80	0.80	0.15	1.50	46.00	Seawater magnesia
Belgium (Merlemont)	21.80	30.10	0.35	0.45	0.40	47.00	Refractories or flux
W. Germany (Wulfrath)	20.20	31.50	0.40	0.40	0.50	47.00	Refractories
Norway (Norw. Talc)	21.71	30.31	0.04	0.03	----	47.51	Filler/extenders
France (BMP)	21.11	31.21	0.01	0.02	----	47.42	Filler/extenders
Spain (Iberdol)	21.70	31.10	0.10	0.02	0.05	47.00	Glass
Greece (Sealistiri)	21.11	31.11	0.10	0.08	0.30	46.90	Refractories
India (Tata I and S)	21.15	30.20	0.65	0.45	1.30	46.03	Blast furnace flux
USA (Basic)	21.60	30.50	0.05	0.10	0.20	47.00	Refractories or flux
Ontario (Timminco)	21.04	31.28	0.10	Tr	0.20	-----	Magnesium metal
Ontario (Steetley)	20.78	30.63	0.55	0.28	0.62	-----	Refractories or flux

SUMMARY

High-purity dolomitic marble is defined as a metamorphosed carbonate rock containing less than 3% impurities and having a CaO:MgO ratio within the range of 1.40:1 to 1.67:1. The Precambrian marble belts of the Central Metasedimentary Belt of the Grenville Province in southeastern Ontario are host to bands of high-purity dolomite.

These rocks have potential applications in the mineral filler industry, as refractory and flux material, in the production of magnesium metal, in glass-making, and as dimension stone. Uses for lower-purity material and waste from high-purity dolomite quarries include the production of marble chips, low grade filler, and agricultural applications such as poultry grit.

Southeastern Ontario hosts both high-brightness, high-purity dolomites required by the filler industry and lower-brightness, high-purity dolomites which are suitable for refractories, flux, and magnesium metal production. The high density of dolomitic marble relative to Paleozoic dolostone makes the marble a more desirable raw material for the production of dead-burned doloma.

Many of the high-purity Precambrian dolomites are located close to Highway 7, a major east-west transportation route from which Lake Ontario and the industrialized areas of southern Ontario are easily accessible. Southern Ontario and the northeastern United States offer potential markets in the iron and steel, refractories, glass, filler, and agricultural dolime industries. Other high-purity dolomite areas in the northern part of the

study area are less favourably located to compete with Paleozoic dolostone, but the marbles, such as those in Ross Township, can provide material of very high brightness and purity which cannot be supplied by Paleozoic sources.

PART II

DESCRIPTIONS OF SOUTHEASTERN ONTARIO PRECAMBRIAN DOLOMITE OCCURRENCES

This section contains detailed descriptions of 23 dolomitic marble occurrences located within the study area (Figure 3). Five of these are active quarries and one is a siliceous, relatively impure dolomite which is under development as a source of low-grade filler material (property MAY-01). The active quarries are:

1) GRI-01 Easton Minerals Ltd., Grimsthorpe Township
2) GRI-02 Two Island Marble Corporation, Grimsthorpe Township
3) MAD-01 Stoklosar Marble Quarries Ltd., Madoc Township
4) ROSS-01 Timminco Limited, Ross Township
5) ROSS-02 H & H Aggregates Ltd., Ross Township

In addition to the detailed reports, summary reports on 14 dolomite occurrences which were examined but are not considered to be potential sources of high-purity dolomite are included in Table 7.

The descriptions are based on the results of previous studies, particularly those by Vos and Storey (1979), Storey and Vos (1981), Papertzian and Kingston (1982), and Grant and Kingston (1984), and on field examinations performed by the authors in 1986 and 1989.

Partial chemical analyses are listed for each of the detailed reports (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, L.O.I.) and additional element analyses are listed in Appendix 1. Acid insoluble content and brightness are shown in the reports where available, but in many cases were not determined (shown as "ND").

The reports are arranged in alphabetical order by township. Locations of occurrences described in the reports and in Table 8 are shown on Figure 4 (general location map) and Figures 5a, b, c, d, e, f and g (detailed location maps) on pages 40 to 47.

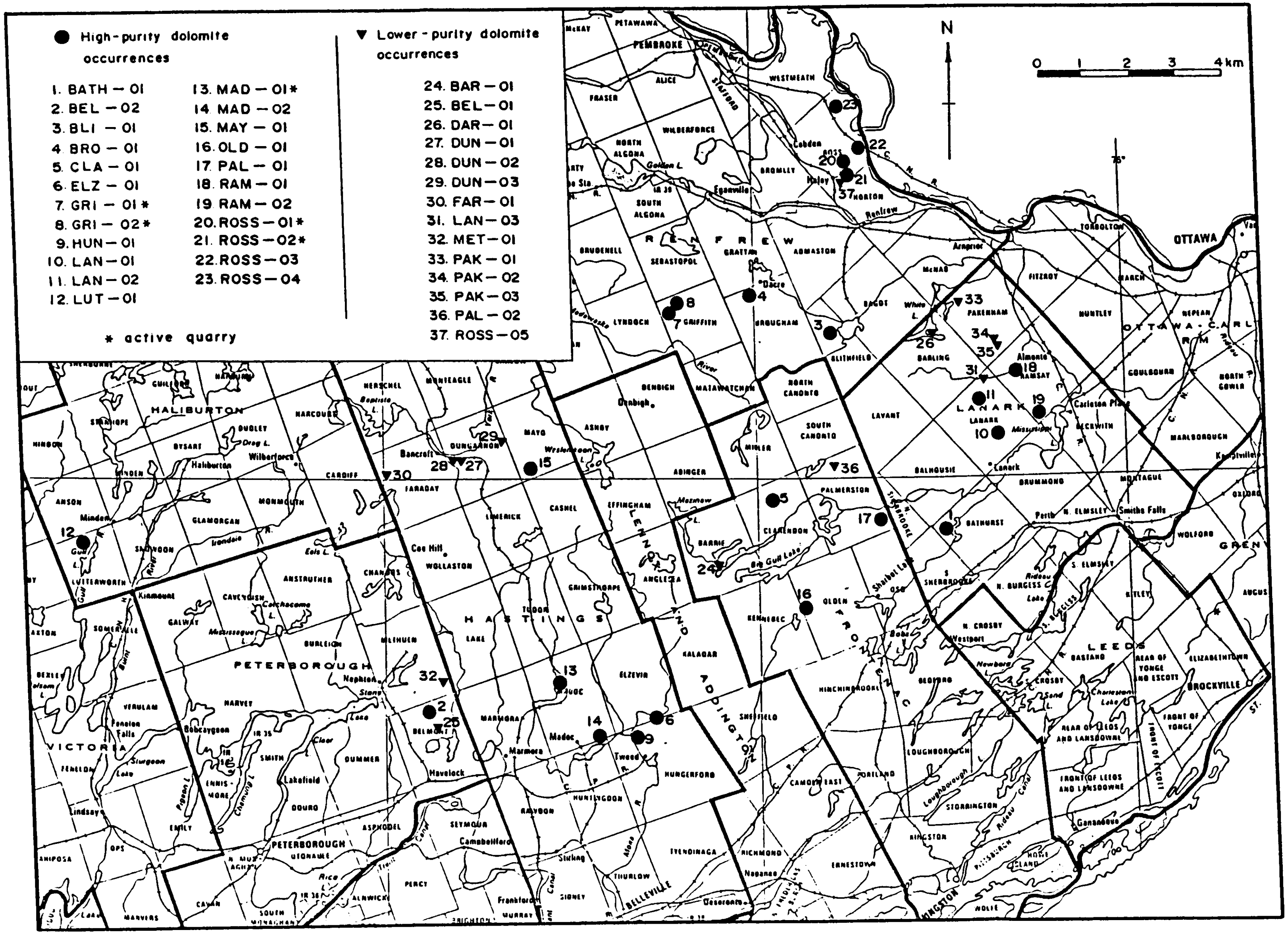

FIGURE 4: Regional location map of the dolomite occurrences.

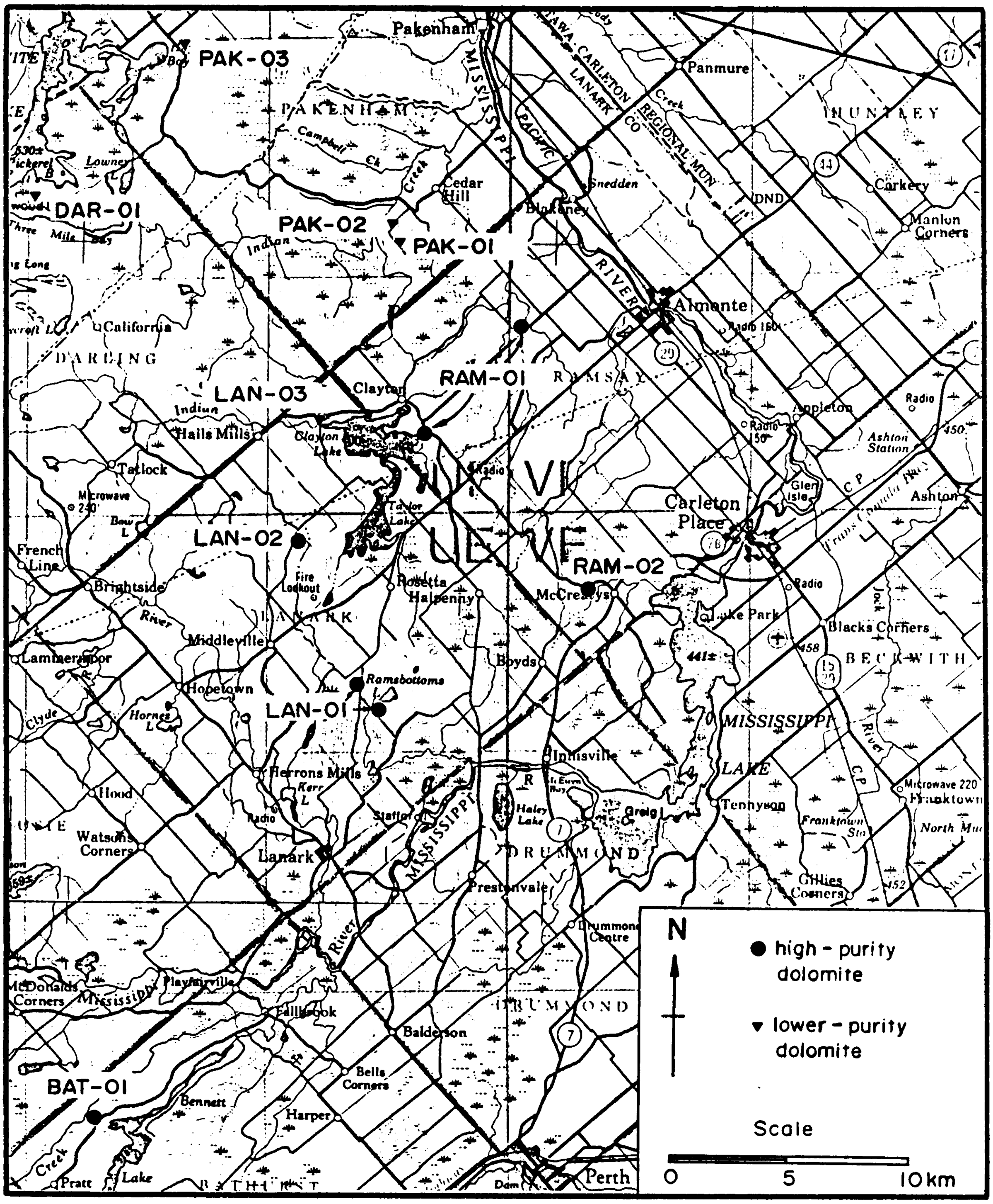

FIGURE 5a: Location map of dolomite occurrences in the townships of Bathurst, Darling, Lanark, Pakenham, and Ramsay, Lanark County.

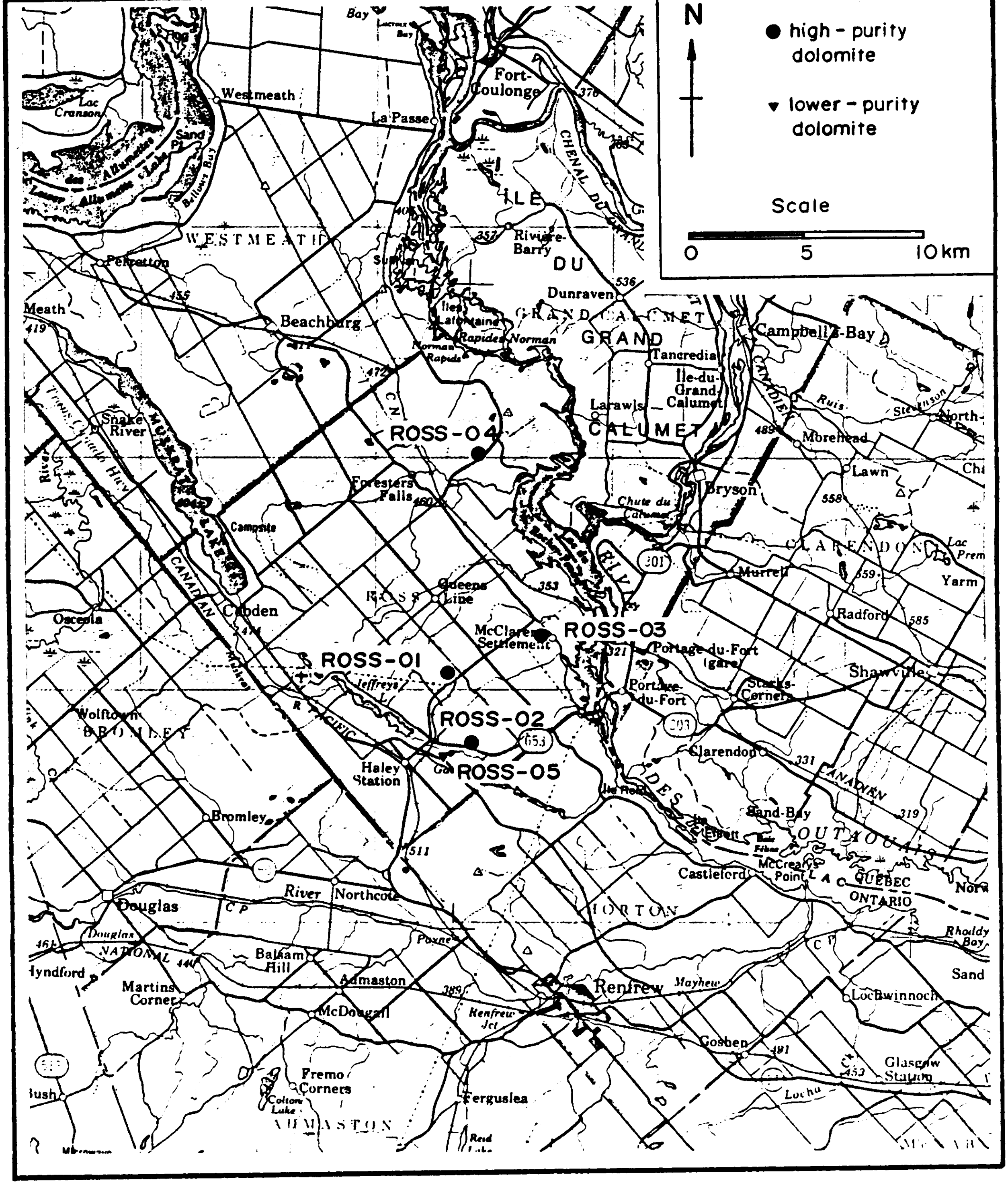

FIGURE 5b: Location map of dolomite occurrences in Ross Township, Renfrew County.

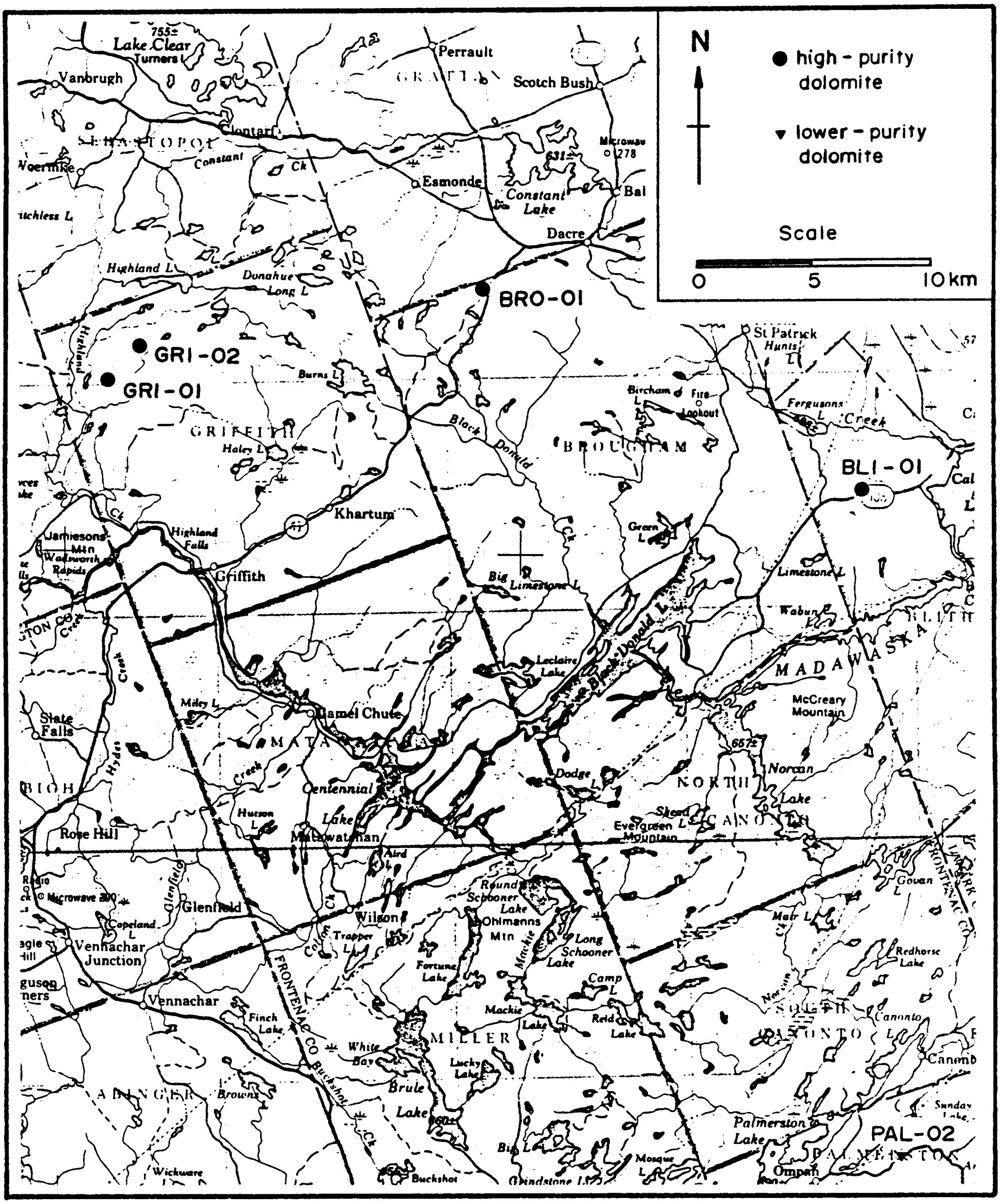

FIGURE 5c: Location map of dolomite occurrences in the townships of Blithfield, Brougham, Griffith, and Palmerston, Renfrew and Frontenac counties.

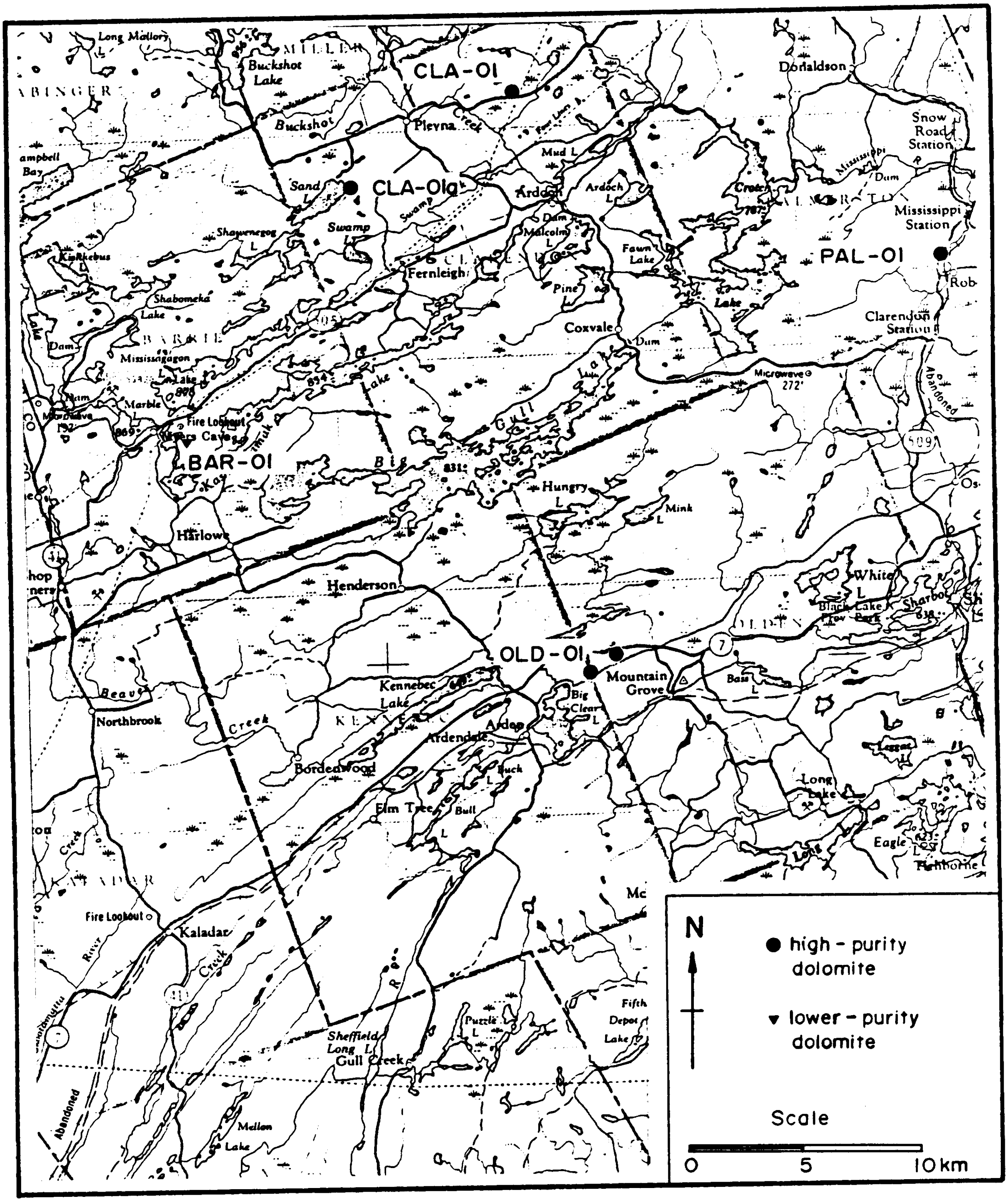

FIGURE 5d: Location map of dolomite occurrences in the townships of Barrie, Clarendon, Olden, and Palmerston, Frontenac County.

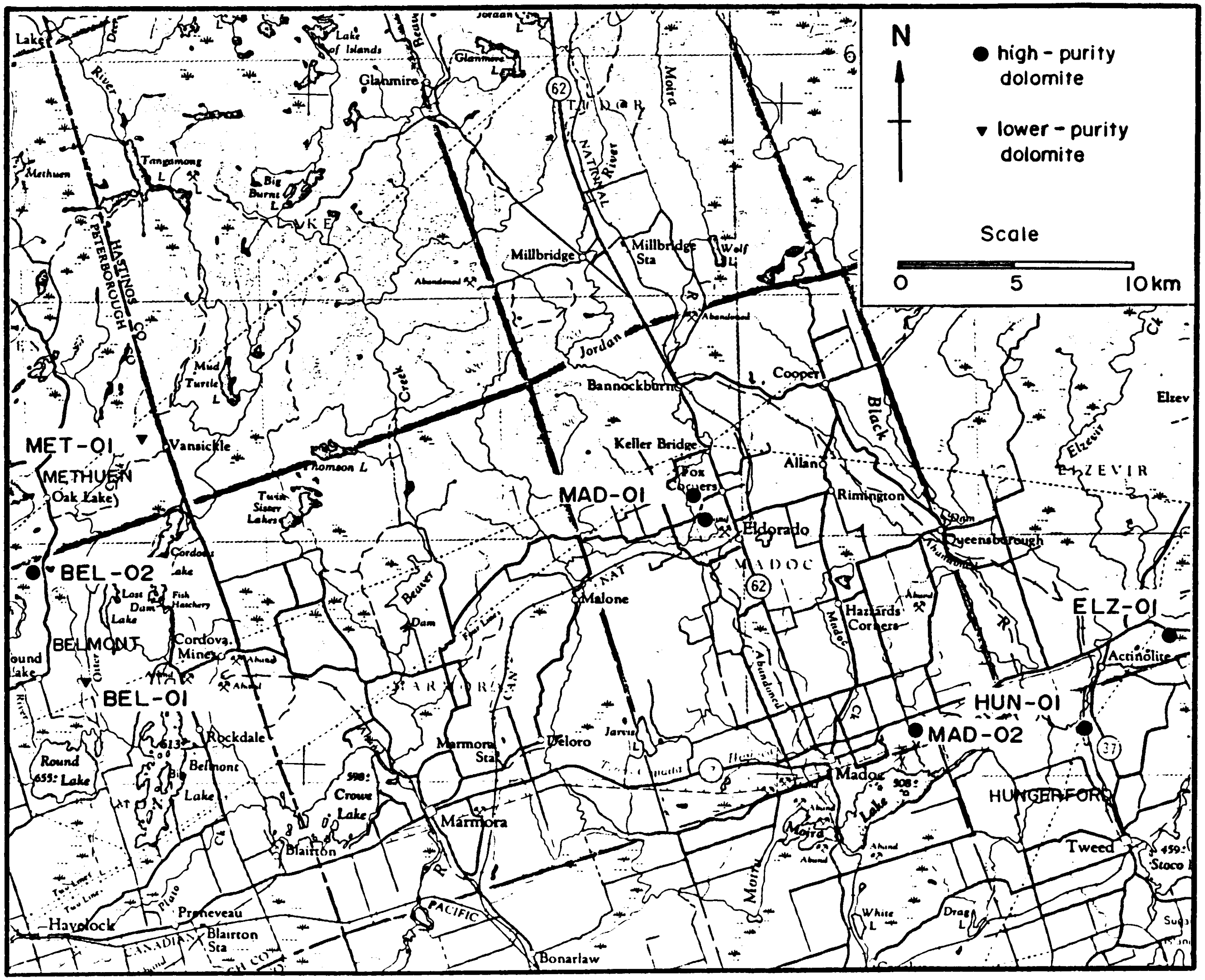

FIGURE 5e: Location map of dolomite occurrences in the townships of Belmont, Elzevir, Hungerford, Madoc, and Methuen, Hastings and Peterborough counties.

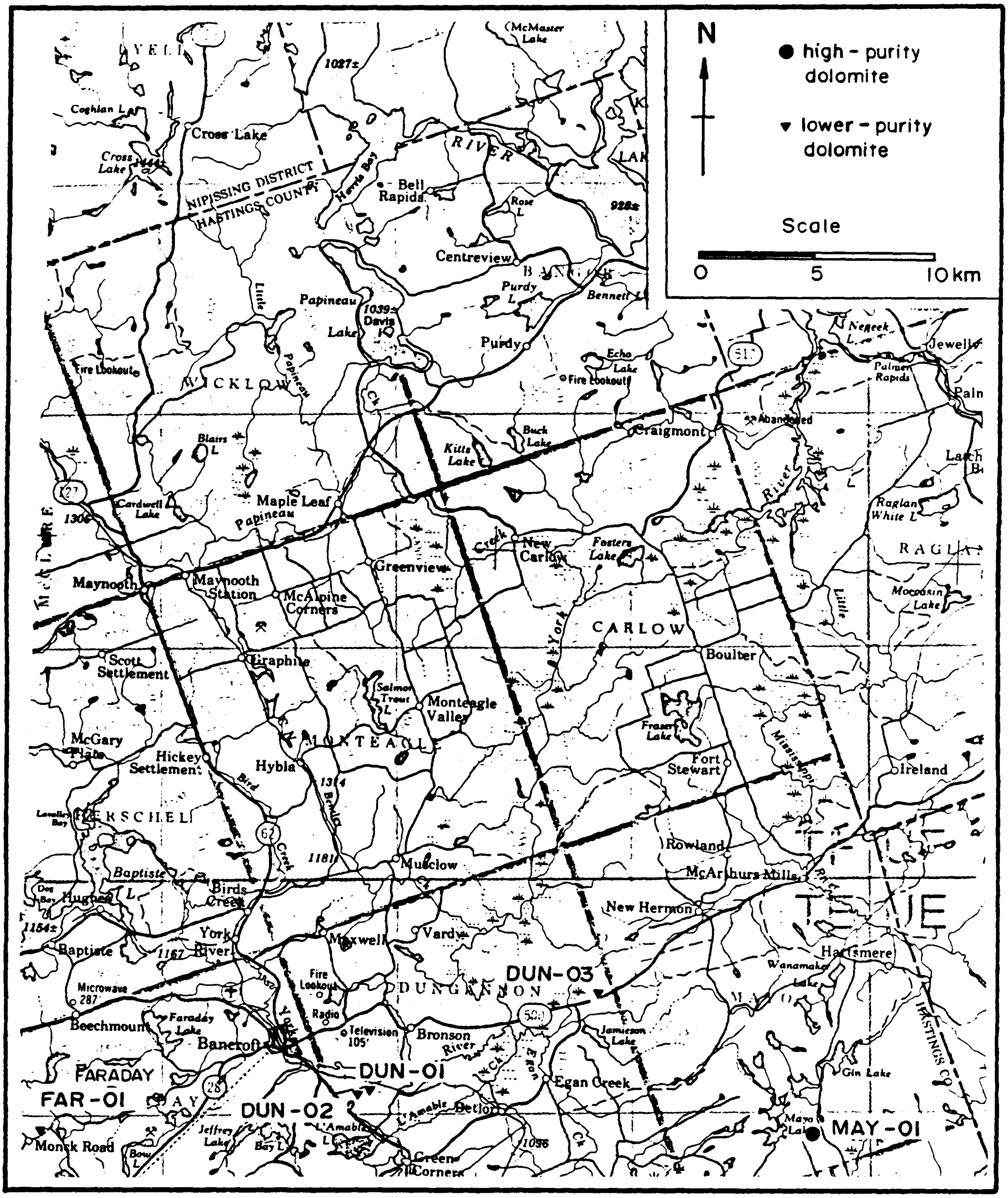

FIGURE 5f: Location map of dolomite occurrences in the townships of Dungannon, Faraday, and Mayo, Hastings County.

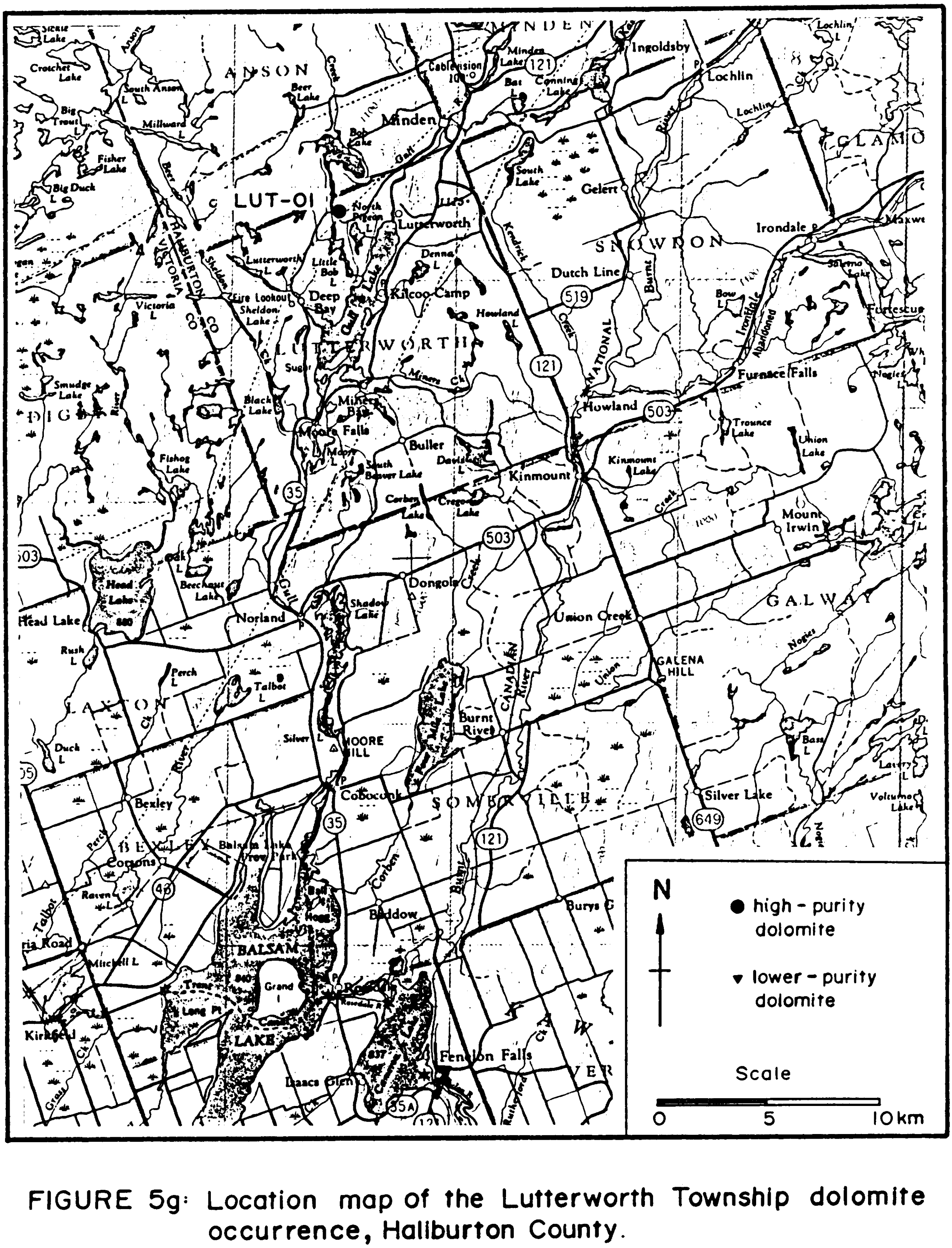

FIGURE 5g: Location map of the Lutterworth Township dolomite occurrence, Haliburton County.

BAT-01 **BATHURST TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 8, concession XI, Bathurst Township, Lanark County; UTM Grid 382890 mE, 4974580 mN, zone 18; NTS 31 C/16

ACCESS

Lanark County Road 19, about 9 km west of Fallbrook. (Figure 5a)

DESCRIPTION

Geological Setting: This prospect is situated near the southern margin of a wide marble belt which extends northeastward through Lanark Township and into Ramsay Township. The belt is flanked to the south by amphibolite, which is also locally interlayered with the marbles (Wilson and Dugas 1961).

Previous Geological Work: GSC Map 1089A, Perth (1961) is a compilation of geology provided by M.E. Wilson (1930) and J. Dugas (1949). The area is also included in a geological compilation map by Hewitt (1964d).

Geology: A rock cut on the north side of County Road 19 at this site (Photo 1) has exposed a wide zone of buff to white, medium to coarse-grained dolomitic marble containing an average of 3 to 5% impurities. The impurities, in decreasing order of abundance, are phlogopite, tremolite, graphite, and garnet. Minor amounts of calcite, diopside, and talc are locally present along fractures. Weathering of the poorly bonded dolomite grains at the eastern end of the rock cut has produced a coarse dolomite sand. Potential width of the zone is about 80 m between calcite outcrop to the east and siliceous dolomite (5-10% tremolite) to the west (Figure 6).

Chemistry: Samples 1915 (from Papertzian and Kingston 1982) and 89 BAT-01 from the rock cut shown in Photo 1 gave the following analyses:

Sample	1915	89 BAT-01
SiO_2%	0.92	3.35
Al_2O_3%	0.31	0.58
FE_2O_3%	0.46	0.40
MgO%	19.05	21.1
CaO%	29.3	29.5

	1915	89 BAT-01
LOI%	45.6	44.0
Total%	95.6	98.9
CaO:MgO	1.54	1.40
Acid Insolubles%	ND	5.9
Brightness%	ND	89

REFERENCES

Papertzian and Kingston (1982)
Wilson and Dugas (1961)
Hewitt (1964d)

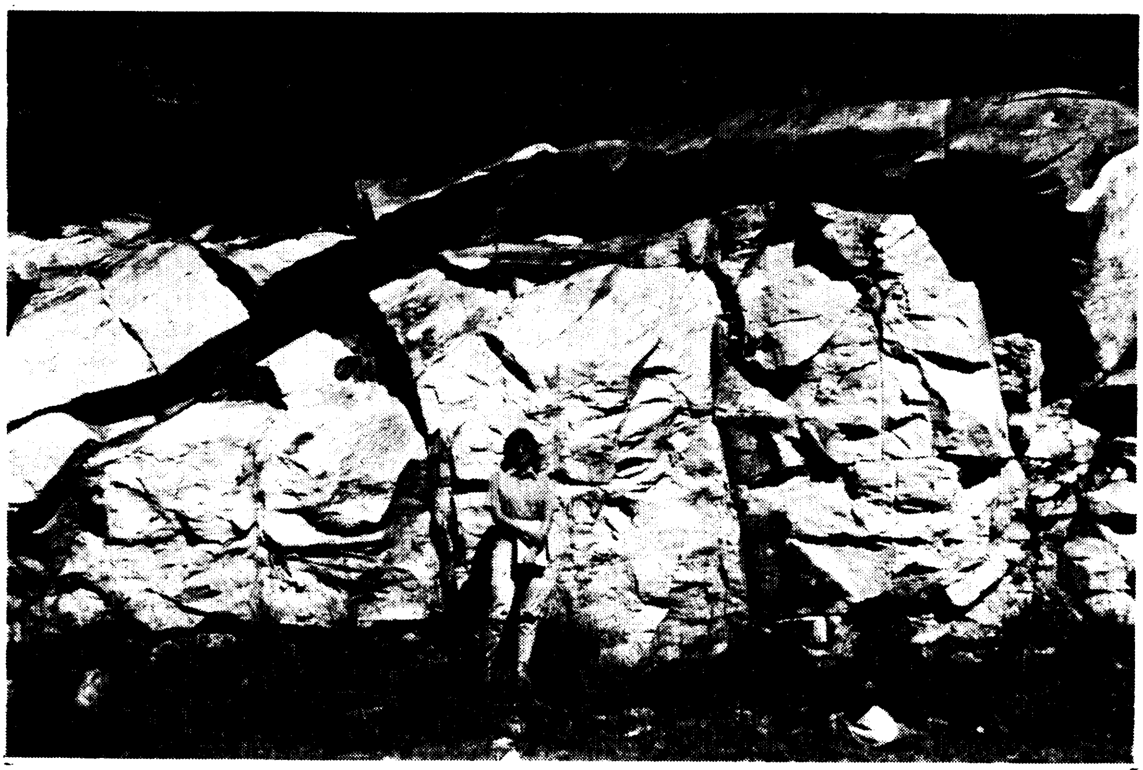

Photo 1: Roadcut on the north side of Lanark County Road 19 (BAT-01) showing white fresh surface and dark grey weathered surface typical of Grenville high-purity dolomite marbles.

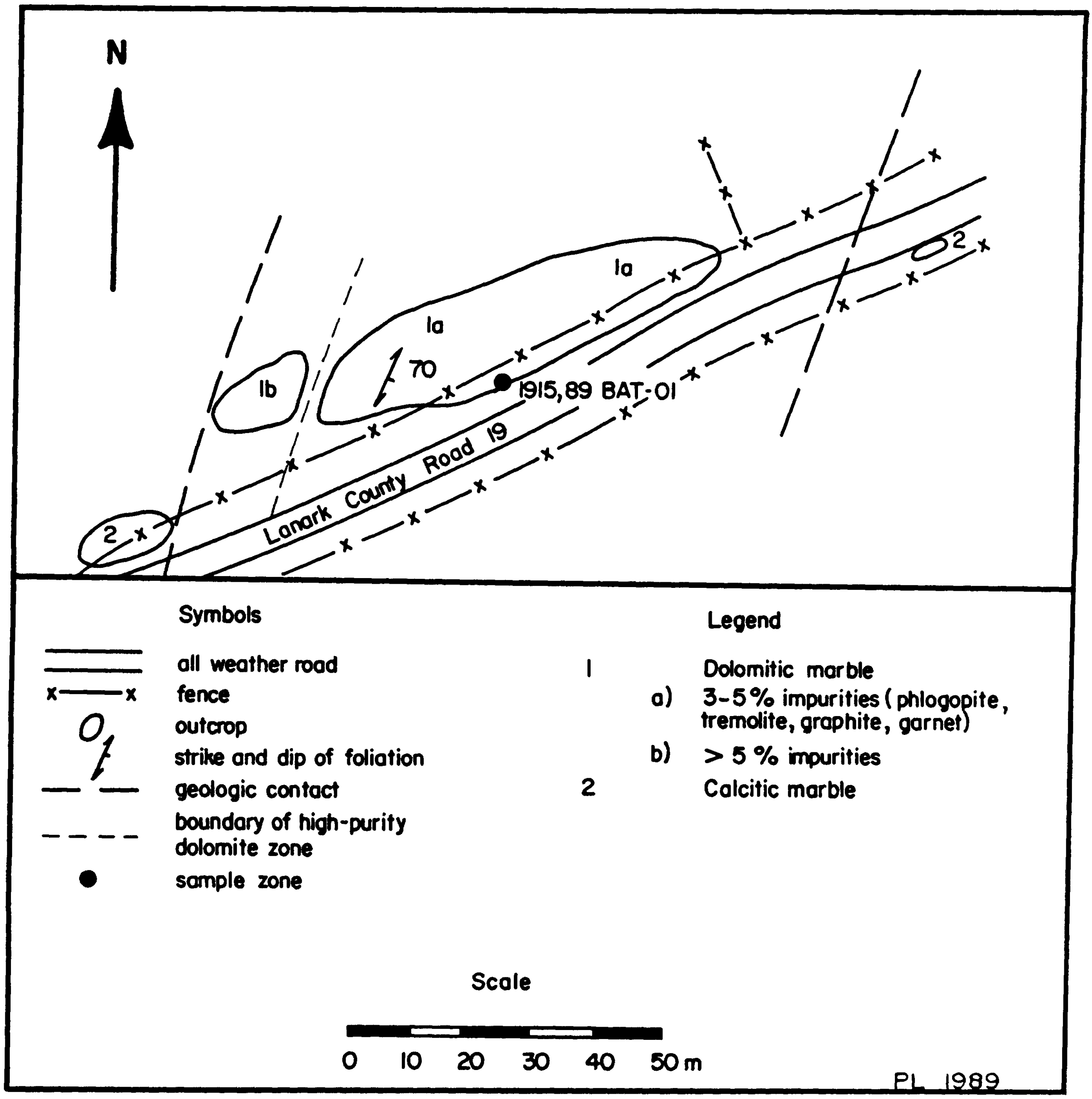

FIGURE 6 : Geological sketch map of occurrence BAT-01, Bathurst Township.

BEL-02 **BELMONT TOWNSHIP**

PROPERTY STATUS

Prospect - advanced exploration stage; two mining leases (E028495 and E028496) held by Novagold Resources Inc. through acquisition of Northumberland Mines Ltd., previous owners of the mining leases.

LOCATION

Lot 31, concession VI, Belmont Township, Peterborough County; UTM Grid 270400mE, 4939000mN, zone 18; NTS 31C/12

ACCESS

County Road 44 north from Havelock 10.5 km to County Road 46; north on County Road 46 about 7 km to Little Whitney Lake; the dolomite zone is about 300 m west of the road. (Figure 5e)

DESCRIPTION

Geological Setting: This prospect lies near the center of a narrow marble belt which has been tectonically thickened near Little Whitney Lake in the core of an easterly-plunging syncline (Bartlett and Moore 1985). The belt, which is about 1 km wide in this area, is overlain to the east by mafic metavolcanics and underlain to the west by intermediate and felsic metavolcanics.

Previous Geological Work: The area has been mapped by Wilson (1940a), Bartlett and Moore (1985), and is included in a compilation map by Hewitt and Satterly (1957).

Geology: This prospect was not examined in the field. The following information was obtained from assessment files and examination of diamond drill core available at the Drill Core Library, Ministry of Northern Development and Mines, Tweed.

This prospect, known as the Whitney calcite property, has undergone extensive evaluation by diamond drilling and chemical analyses by Northumberland Mines Ltd., Englehart Mines Ltd. and Preussag Canada Ltd. in the period 1975-1980. Prior to this, considerable drilling and limited test quarrying had been done by C.R. Young and J.D. Cumming. The property has been idle since 1980. A report by Kilborn Limited (1976) for Northumberland Mines lists reserves of about 1.9 million tonnes of high-calcium marble and 4.7 million tonnes of calcitic/dolomitic marble, both zones containing less than 0.5% SiO_2 + Fe_2O_3 and averaging 93% brightness.

The calcitic/dolomitic zone, located in the southwest corner of leased claim EO 28495 (NW 1/4 of lot 31, con VI), consists of interlayered bands of white to grey, medium-grained, calcitic marble and fine-grained, sugary, white dolomite (Figure 7). A diamond drill hole within this zone by Preussag Canada Limited (1980, hole PR 80-9) contains a 31.7 m section of very pure, white, fine-grained dolomite (Photo 2), from 45.4 m to 77.1 m, representing a true width of about 30 m. The dolomite is flanked on both sides by calcitic marble containing mica, tremolite, quartz, and serpentine.

Chemistry: The results of analysis of a 0.3 m core sample (69.2 to 69.5 m) from diamond drill hole PR 80-9 by Preussag Canada Ltd. (1980) are as follows:

Sample	89 BEL-02
SiO_2%	0.48
Al_2O_3%	0.14
Fe_2O_3%	0.39
MgO%	21.1
CaO%	30.7
LOI%	46.7
Total%	99.5
CaO:MgO	1.45
Acid Insolubles%	0.71
Brightness%	90.1

REFERENCES

Bartlett and Moore (1985)
Hewitt and Satterly (1957)
Kilborn Limited (1976)
Wilson (1940a)

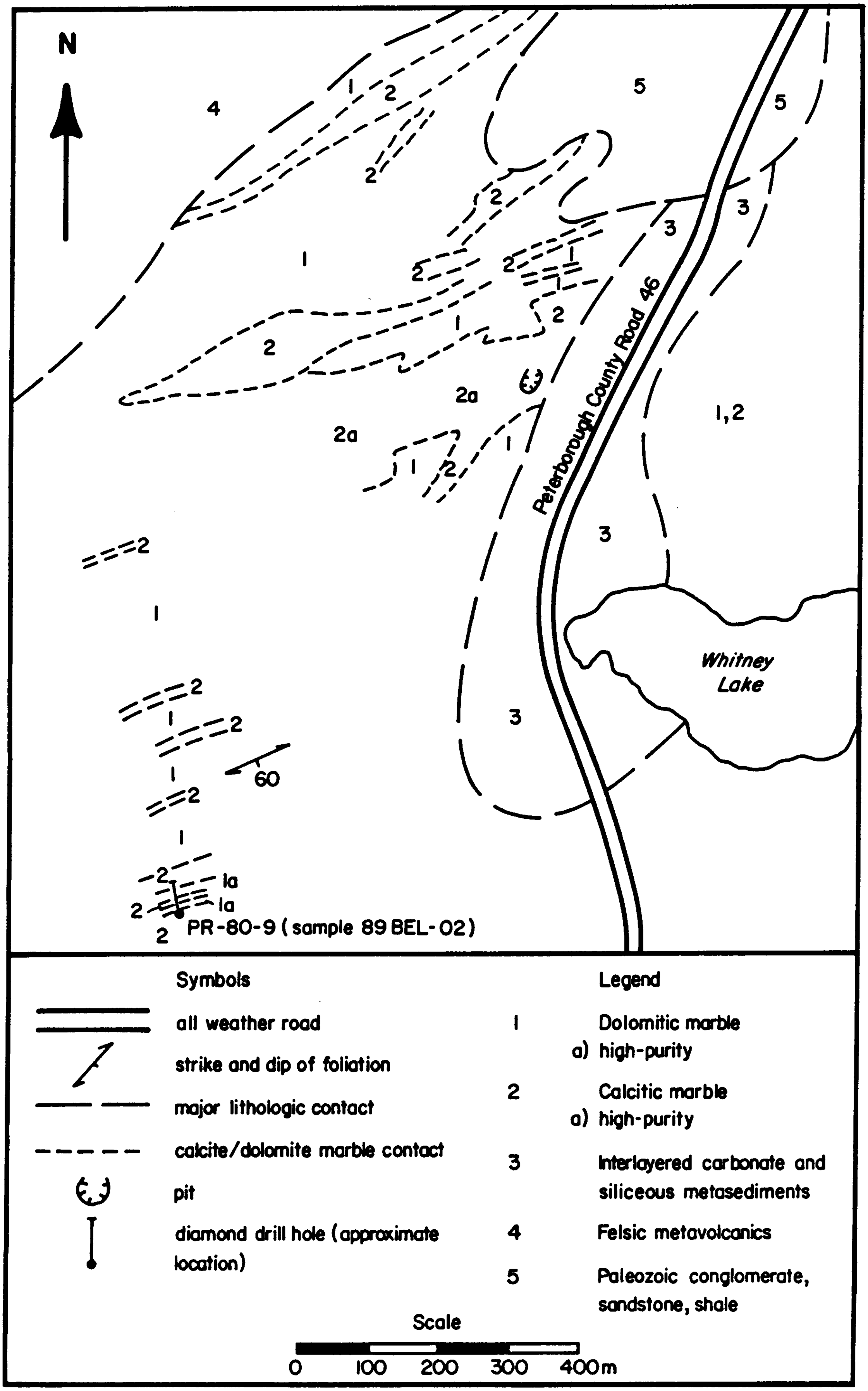

FIGURE 7: Geology in the area of BEL-02, Belmont Township, formerly Northumberland Mines Ltd. calcite prospect. (Geology after Bartlett and Moore 1985 and Young 1975).

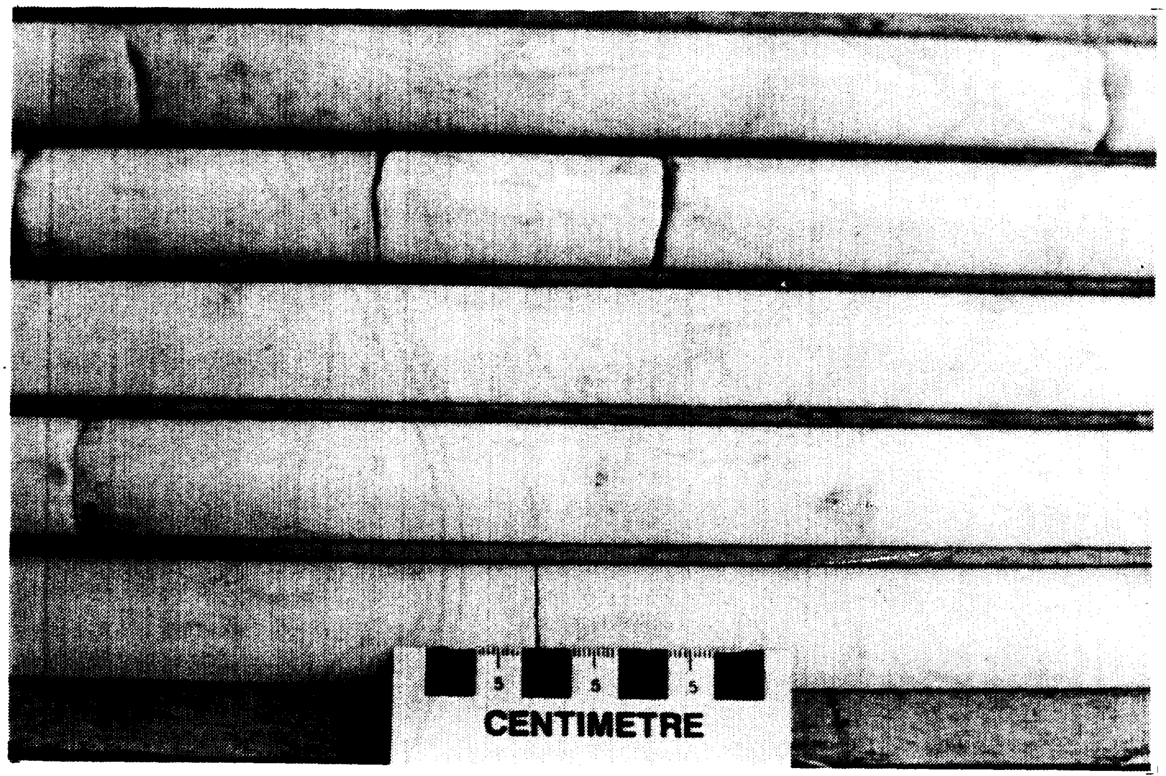

Photo 2: Representative section of a 30 m intersection of white, fine-grained dolomite marble (BEL-02).

BLI-01 **BLITHFIELD TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 21, concession III, Blithfield Township, Renfrew County; UTM Grid 358900mE, 5014750mN, zone 18; NTS 31F/7

ACCESS

The dolomite zone is exposed in a road cut about 6 km west of Calabogie on Highway 508. (Figure 5c)

DESCRIPTION

Geological Setting: The area is underlain by north to northeast-trending paragneiss, marble, amphibolite schist, and quartz monzonite. The marbles host local concentrations of magnetite, hematite, mica, tremolite, and sphalerite (Quinn et al, 1956).

Previous Geological Work: Geological compilation maps of the area have been produced by Quinn (1952), Quinn et al (1956), and Lumbers (1980).

Geology: The marbles are predominantly dolomitic, fine to medium-grained, and white. Accessory minerals include graphite, pyrite, phlogopite, tremolite, and serpentine. Dolomitic units up to 20 m wide, striking 030^{o} and dipping 45^{o} SE are separated by narrow (5 to 10m) bands of calcitic marble, paragneiss, and amphibolite. The calcitic marbles commonly contain minor amounts of hematite and diopside. Thin section studies by Storey and Vos (1981) indicate a few detrital quartz and feldspar grains in the dolomitic marble.

Figure 8 shows a geological section along Highway 508 through the marble zones, as mapped by Storey and Vos (1981), and a detailed section of outcrop mapped by P. LeBaron which includes one of the wider zones of relatively pure dolomite.

Chemistry: The results of analysis of two samples (PM 44 and PM 45, Figure 8) by Storey and Vos (1981) are listed below.

Sample	PM44	PM45
SiO_2%	1.17	0.55
Al_2O_3%	0.1	0.1
Fe_2O_3%	0.2	0.3
MgO%	20.7	21.4

	PM 44	PM 45
CaO%	30.2	30.4
LOI%	47.3	47.2
Total%	99.7	99.9
CaO:MgO	1.46	1.42
Acid Insolubles%	0.7	0.54
Brightness%	93.2	80.5

REFERENCES

Lumbers (1980)
Quinn (1952)
Quinn et al (1956)
Storey and Vos (1981)

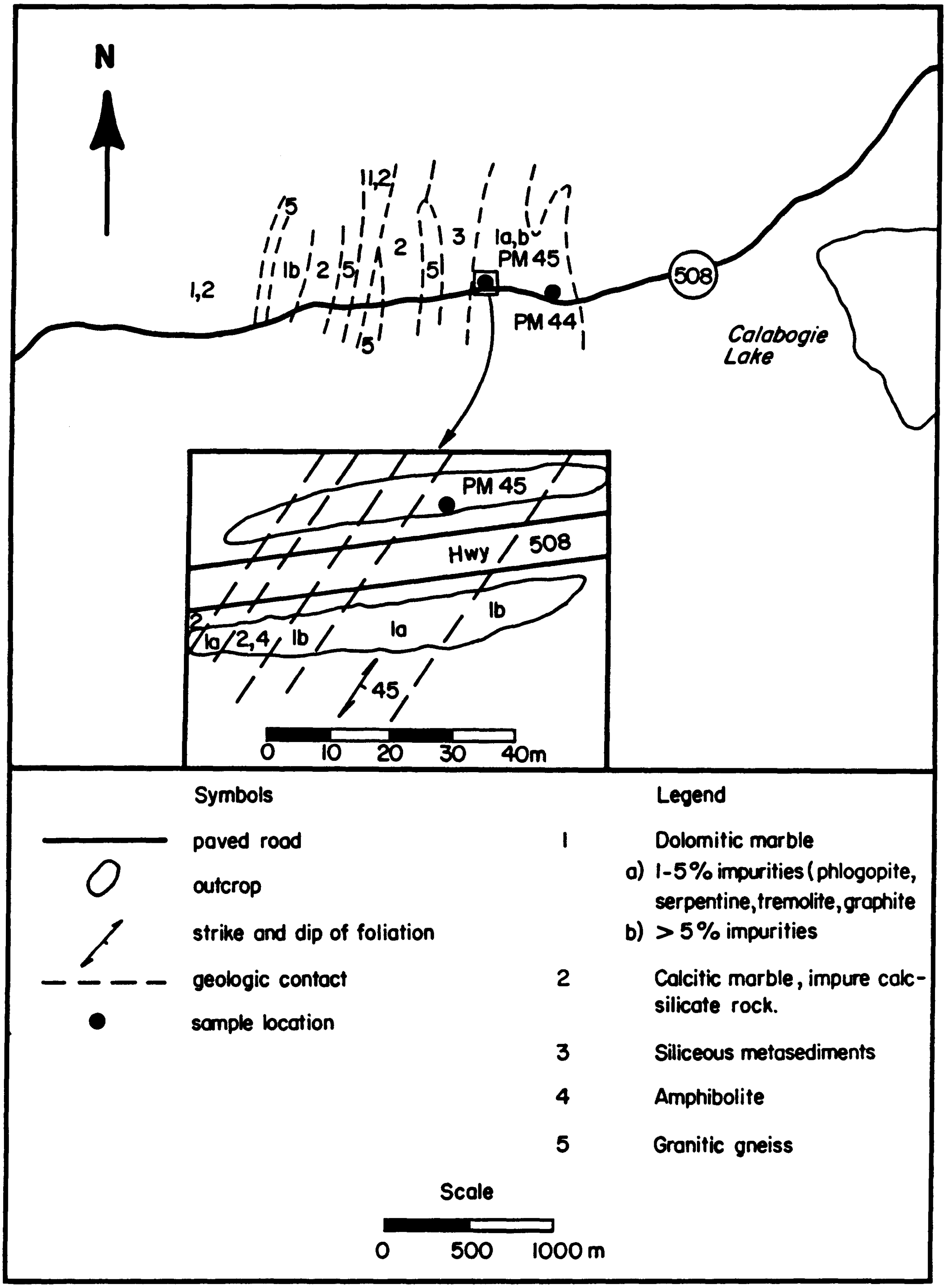

FIGURE 8: Geology in the area of BL1-01, Blithfield Township. (General geology after Storey and Vos 1981; outcrop geology by P. LeBaron, 1989).

BRO-01 **BROUGHAM TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 24, concession XIX, Brougham Township, Renfrew County; UTM Grid 341800mE, 5023700mN, zone 18; NTS 31F/6

ACCESS

The marble is exposed in a large road cut along Highway 41, 7 km north of Griffith. (Figure 5c).

DESCRIPTION

Geological Setting: A northeasterly-trending belt of marble about 1 km wide is flanked to the southeast by the Mount St. Patrick syenite pluton and to the northwest by massive to gneissic, pink potassic syenite. The marble belt contains bands of amphibolite, quartz-feldspar gneiss, and quartz-feldspar pegmatite in addition to calcitic and dolomitic marbles (Themistocleous 1981).

Previous Geological Work: The area has been mapped by Themistocleous (1979, 1981) and was included in a compilation map by Lumbers (1982). Storey and Vos (1981) mapped and sampled the roadcut at this prospect.

Geology: Storey and Vos (1981) indicate a series of calcitic and dolomitic marble units separated by quartz-feldspar gneiss and amphibolitic rocks (Figure 9). The units are generally less than 30 m. wide, striking north to northeast and dipping moderately eastward.

The calcitic marbles are generally pink to red, coarse-grained, and contain variable amounts of phlogopite, tremolite, pyrite, graphite, and serpentine. The dolomitic marbles tend to be more pure and white in colour.

The outcrop from which samples PM-91, PM-93, and MA 13-1 were taken consists of interlayered calcitic and dolomitic marble units from 30 cm to 2 m wide (Photo 3). The layering is most evident on the weathered surface, where the medium-grained calcitic marble weathers slightly lower than the more coarse-grained dolomitic marble. Both types generally contain less than 3% impurititės (phlogopite, diopside, muscovite, pyrite, and graphite). Sample PM-91 is from a narrow dolomitic band; sample PM-93 is from a greenish (diopside-bearing) patch in similar marble, and MA 13-1 is a coarse-grained, pale blue dolomite. PM-

92 is from a 20 m - wide zone of coarse, white dolomite averaging less than 3% impurities. This zone and a dolomitic zone of similar width about 600 m south indicate potential for narrow widths of high-purity dolomite within this area.

Analyses for the samples shown on Figure 9 are tabled below:

Chemistry: The following analyses indicate a zone of dolomitic marbles of variable purity containing local high-purity bands (from Storey and Vos, 1981).

Sample	PM 91	PM 92	PM 93	MA13-1
SiO_2%	3.88	1.09	9.59	0.50
Al_2O_3%	0.1	<0.1	0.1	0.1
Fe_2O_3%	0.1	0.3	0.2	0.2
MgO%	22.8	21.5	18.5	21.1
CaO%	28.8	30.2	33.4	30.7
LOI%	44.7	47.3	38.6	47.0
Total%	100.4	100.4	100.4	99.6
CaO:MgO	1.26	1.40	1.80	1.45
Acid Insolubles%	3.28	0.72	9.00	1.02
Brightness%	56.1	ND	90.1	88.4

REFERENCES

Lumbers (1982)
Themistocleous (1979, 1981)
Storey and Vos (1981)

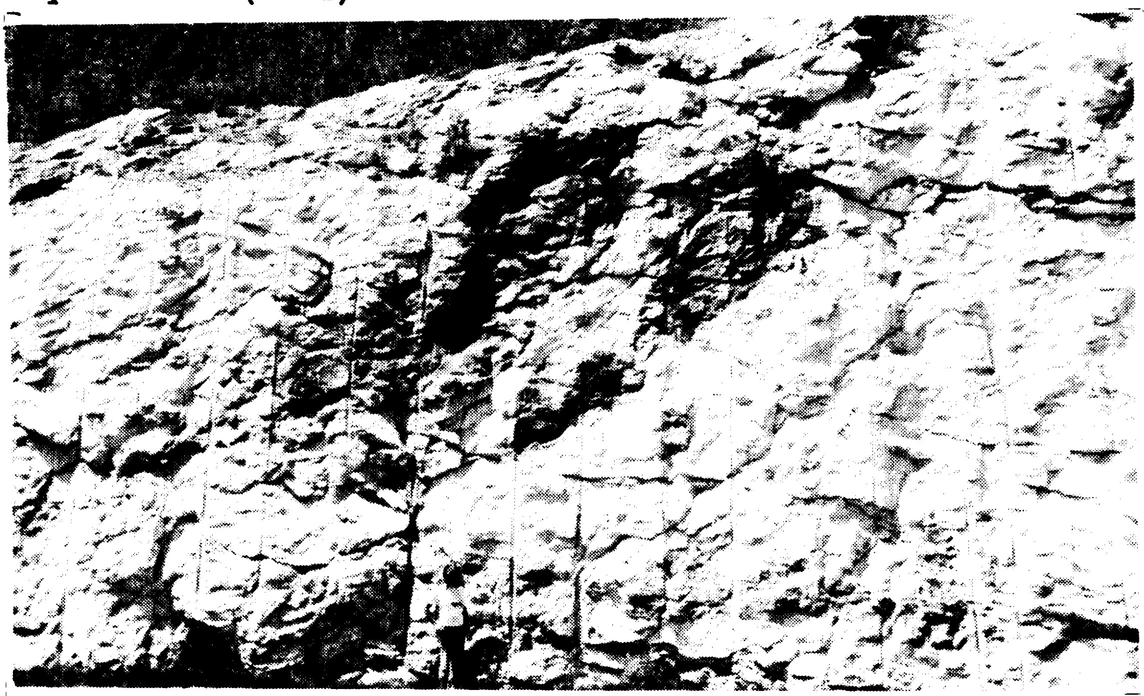

Photo 3: Roadcut on the west side of Hwy 41 (BRO-01) showing boundinaged amphibolite layers in interlayered calcitic and dolomitic marble.

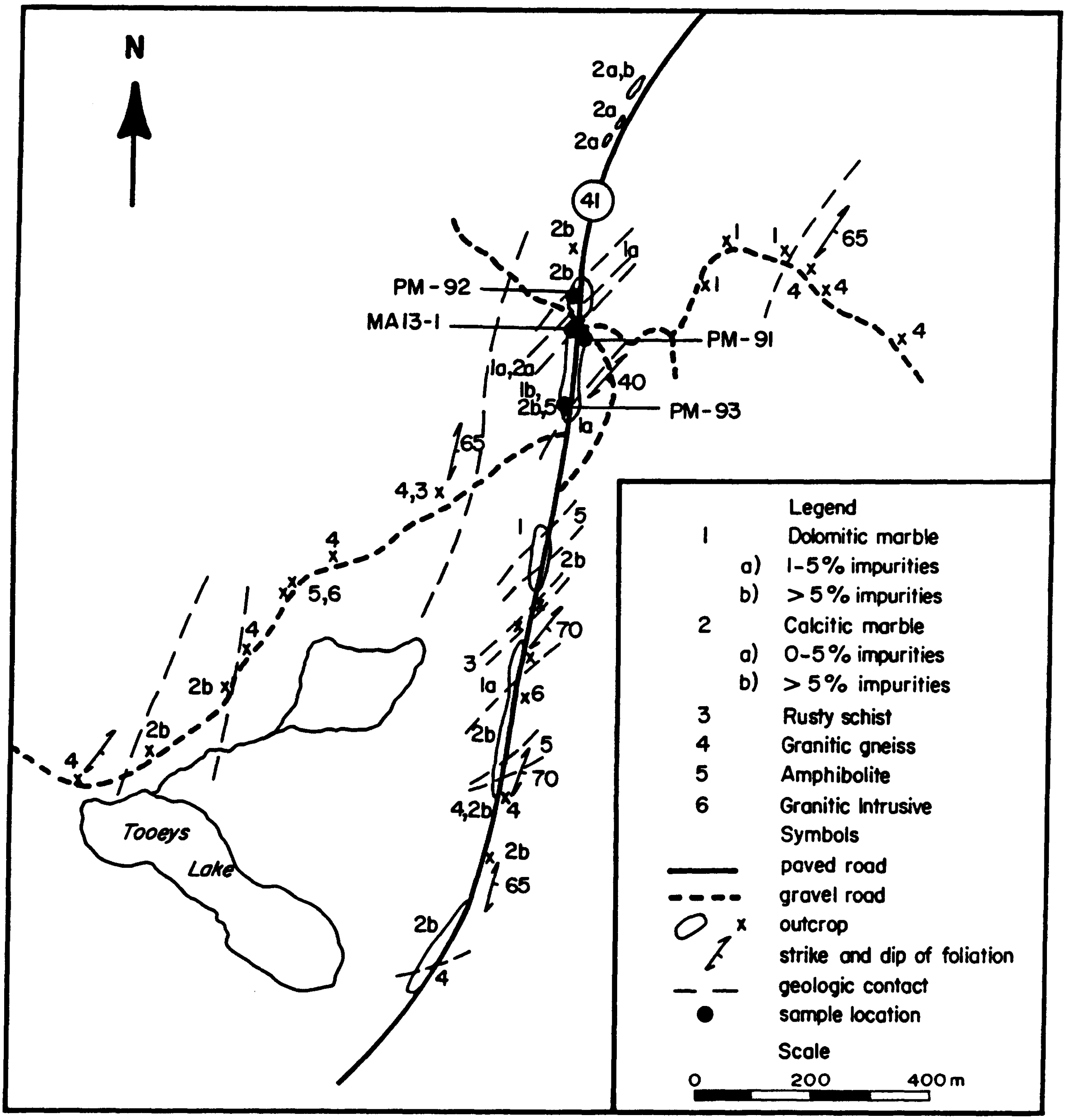

FIGURE 9: Geology of BRO-01, Brougham Township (after Storey and Vos 1981).

CLA-01 **CLARENDON TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 38, concession IV, Clarendon Township, Frontenac County; UTM Grid 348200mE, 4981350mN, zone 18; NTS 31C/15. CLA-01a is in lot 37, concession XII (NTS 31C/14).

ACCESS

Highway 508 between Plevna and Ompah, about 200 m west of the power line. Sample site 89 CLA-01a is located 4 km southwest of Plevna, at the east end of Plevna (Sand) Lake. (Figure 5d)

DESCRIPTION

Geological Setting: This prospect is situated within the central marble unit of the northeasterly-trending Plevna synform (Pauk 1982) which is flanked to the northwest by amphibolite and to the southwest by amphibolite and paragneiss. Similar marble, possibly repeated by folding, is located east of Plevna Lake within the outer marble belt of the Plevna synform (Figure 10).

Previous Geological Work: The geology of Clarendon Township has been mapped by Smith and Peach (1956), Hewitt (1964c), and Pauk (1982).

Geology: A geological map of the area of site CLA-01 by Grant and Kingston (1984) shows a band of relatively pure, fine-grained, grey, dolomitic marble varying in width from about 50 to 200 m, striking about 060^{o} and dipping 75 to 85^{o} S. It is flanked to the north and south by grey dolomitic marble containing from 5 to over 50% siliceous clots and veins, predominantly composed of tremolite and quartz.

Grey banding in the marbles is caused by minor amounts of very fine graphite as inclusions in the carbonate grains (Photo 4). Two samples (Nos. 604 and 89 CLA-01, Figure 11) were analysed and the results, listed below, indicate the rocks to be high-purity dolomite with low brightness.

Similar dolomite occurs at the eastern end of Plevna Lake, as noted by Smith (1956). A brief examination showed outcrops of pale bluish-grey, very fine-grained, sugary-textured dolomite containing minor amounts of muscovite, hematite, and graphite. The rock is very friable and weathers to a fine sand. Width of the zone was not determined, but analysis of sample 89 CLA-01a

(Figure 10), listed below, indicates a dolomite of high purity and low brightness.

Chemistry: Sample 604 was analysed by Papertzian and Kingston (1982).

Sample	604	89 CLA-01	89 CLA-01a
SiO_2%	0.00	0.65	0.91
Al_2O_3%	0.11	0.13	0.08
Fe_2O_3%	0.37	0.28	0.46
MgO%	20.76	21.1	21.2
CaO%	29.89	30.6	30.3
LOI%	46.7	46.5	46.6
Total%	97.8	99.3	99.6
CaO:MgO	1.44	1.45	1.43
Acid Insolubles%	ND	0.76	1.10
Brightness%	ND	79.5	79.3

REFERENCES

Grant and Kingston (1984)
Hewitt (1964c)
Papertzian and Kingston (1982)
Pauk (1982)
Smith (1956)
Smith and Peach (1956)

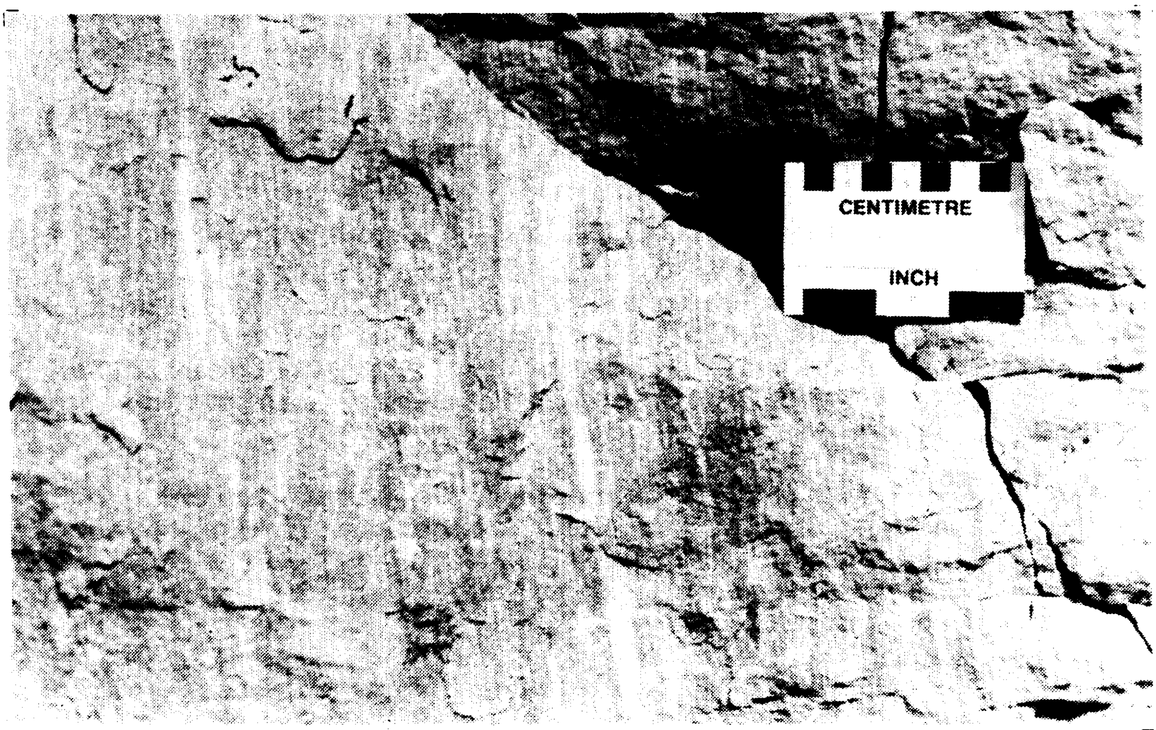

Photo 4: Banding in dolomitic marble caused by concentrations of very fine grains of graphite (CLA-01).

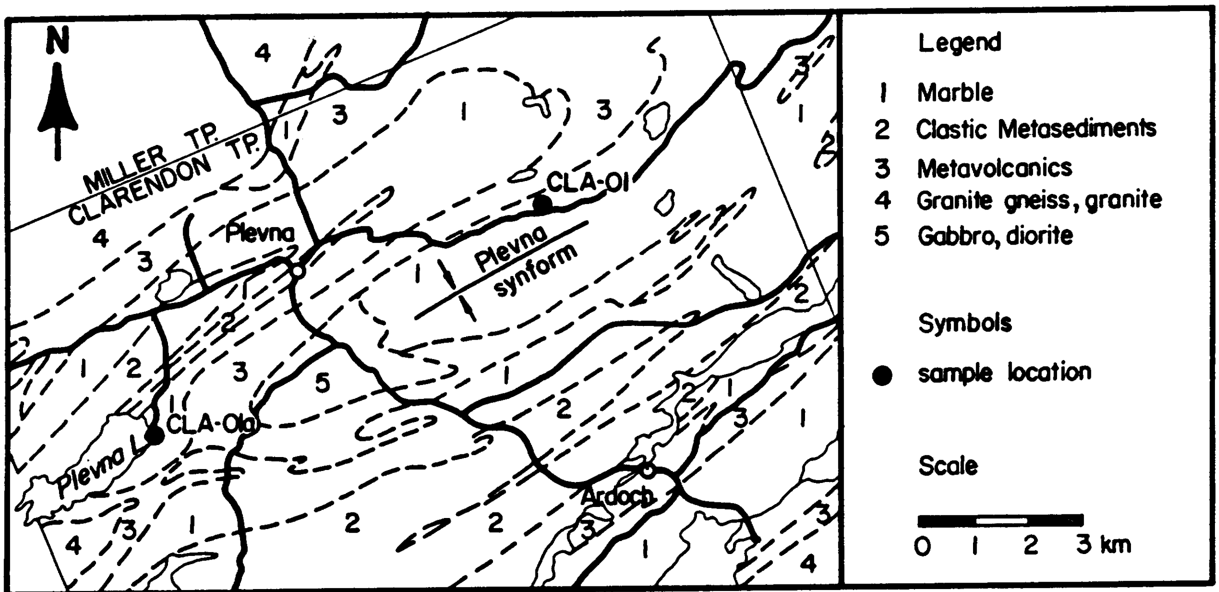

FIGURE 10: Generalized geology in the area of CLA-01 and CLA-01a, Clarendon Township (after Hewitt 1964c).

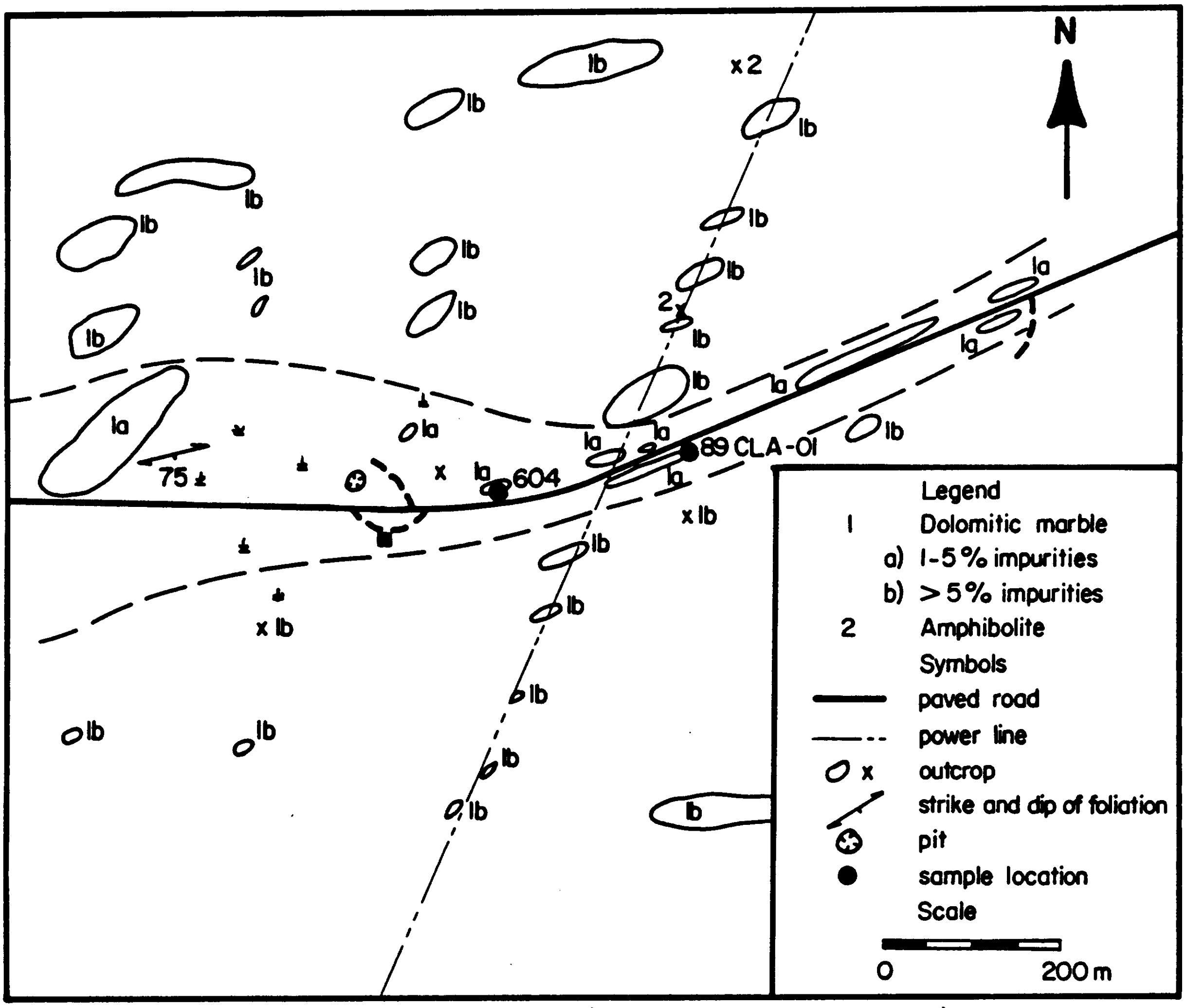

FIGURE 11: Geology of CLA-01, Clarendon Township (after Grant and Kingston 1984).

ELZ-01 **ELZEVIR TOWNSHIP**

PROPERTY STATUS

Past producer (aggregate); Advanced exploration stage; currently under lease to Pleuss-Staufer from C.R. Young of Havelock.

LOCATION

Lot 3, concession VI, Elzevir Township, Hastings County; UTM Grid 317800mE, 4936050mN, zone 18; NTS 31 C/11

ACCESS

About 1.7 km east of County Road No. 2 (Flinton Road) on Highway 7, an old bush road leads southward to the abandoned quarry. The dolomite zone is also exposed in a rock cut on Highway 7 about 100 m east of the quarry road. (Figure 5d)

DESCRIPTION

Geological Setting: This prospect lies within a narrow marble belt, about 300 to 400 m wide, which extends eastward into Kaladar Township and southwestward into Hungerford Township where it attains a maximum width of about 1.5 km. The belt is flanked to the north and west by paragneiss and pelitic schists, and to the south and east by similar metasediments and granitic gneiss. Paleozoic limestone overlies the belt at its southwestern limit, north of Tweed.

Previous Geological Work: The northern part of the belt (Elzevir and Kaladar townships) was mapped by Meen and Harding (1941) and the entire belt is shown on a compilation map by Hewitt (1964c).

Geology: A zone of dolomitic marble at the centre of the marble belt is separated from granitic gneiss to the south by a zone of high-purity calcitic marble, and from paragneiss to the north by a zone of impure, micaceous calcitic marble (Figure 12).

Diamond drilling by Omya Inc. in 1974 outlined about 3 million tonnes of white, high CaO marble containing less than 2% acid insolubles (Dale MacGregor, General Manager, Steep Rock Resources Inc. Perth, Ontario, personal communication 1989). Quarrying of this deposit is presently being considered by Pleuss-Staufer AG, owner of Steep Rock Resources.

Several of the holes drilled by Omya Inc. ended in white, dolomitic marble after passing through the calcitic zone. The dolomite zone is largely overlain by swamp, but is well-exposed in an abandoned quarry just south of Highway 7 in the southeast corner of lot 3, concession 6 (Photo 5). A 50 m width of medium-grained, buff to white dolomite striking 080° and dipping 60°S is estimated to contain an average of about 3% impurities (mainly tremolite with minor diopside, talc, and phlogopite). North of the quarry, the dolomitic marble contains 5 to 10% tremolite as coarse knots and fine, fibrous aggregates between dolomite grains.

Chemistry: Analyses of samples from the quarry (89 ELZ-01) and from a roadcut north of the quarry (89 ELZ-01a) are shown below.

Sample	89 ELZ-01	89 ELZ-01a
SiO_2%	3.77	1.54
Al_2O_3%	0.42	0.08
Fe_2O_3%	0.29	0.35
MgO%	21.6	21.0
CaO%	29.5	30.5
LOI%	43.7	45.7
Total%	99.3	99.2
CaO:MgO	1.36	1.45
Acid Insolubles%	6.7	2.7
Brightness%	90.2	89.8

REFERENCES

Hewitt (1964c)
Meen and Harding (1941)

Photo 5: East wall of dolomitic marble quarry (ELZ-01).

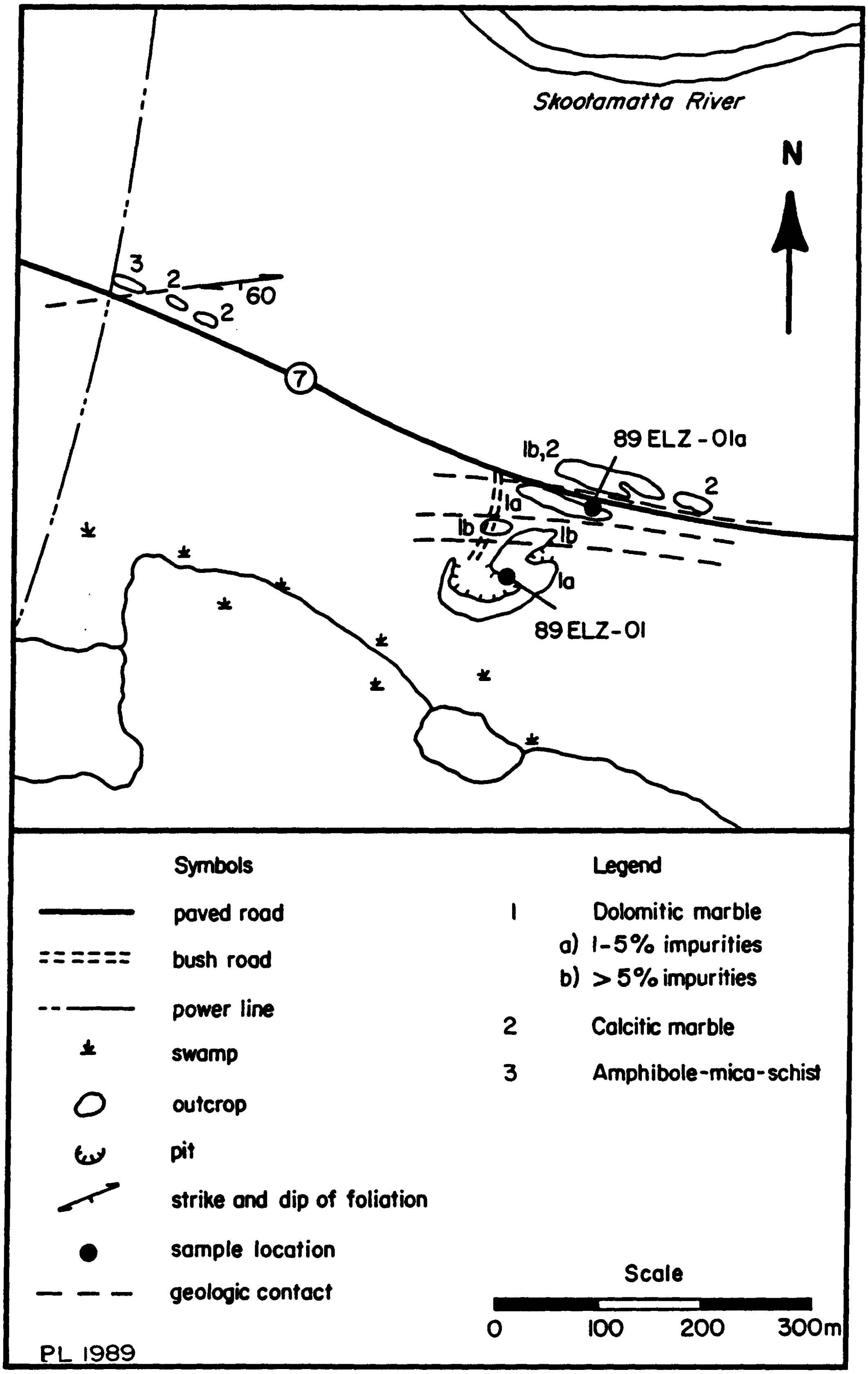

FIGURE 12 : Geological sketch map of occurrence ELZ-01

GRI-01 **GRIFFITH TOWNSHIP**

PROPERTY STATUS

Active quarry; Easton Minerals Ltd. began quarrying in September, 1989. They are trucking dolomite ore to their crushing and grinding plant at Northbrook.

LOCATION

Northwest part of Griffith Township (unsurveyed), Renfrew County; UTM Grid 325700mE, 5020300mN, zone 18; NTS 31F/6

ACCESS

Highway 41 to Griffith; north on a forest access road along the east side of the Madawaska River and along Highland Creek; 800 m north of the third bridge across Highland Creek, a bush road branches south 2 km to the quarry area. (Figure 5c)

HISTORY

1988-89: Easton Minerals drilled 4 diamond drill holes for a total of 548 m, stripped several areas to bedrock, and quarried a bulk sample for processing at their Northbrook mill. There is no record of previous work done on the property.

DESCRIPTION:

Geological Setting: A thick sequence of clastic and carbonate sediments has been metamorphosed to feldspar-quartz-biotite gneiss, amphibole and calc-silicate gneiss, and calcitic and dolomitic marbles. These rocks have been intruded by three prominent plutons, the Mount St. Patrick Syenite, Burns Lake Syenite, and Three Mountains Pluton. Property GRI-01 lies within a belt of interlayered paragneiss and marble along the northwest side of the Three Mountains Pluton. Narrow, foliation-conformable granite and pegmatite bodies have locally intruded the metasediments (Themistocleous, 1981).

Previous Geological Work: The area has been mapped by Hewitt (1954) and Themistocleous (1981).

Geology: The quarry site (Photo 6) is located on the northwest side of a 400 m wide, northeasterly-trending marble ridge known as Graham Mountain. Figure 13 shows the geology of the quarry area, which consists of a 50 m wide band of dolomitic marble striking 030° and dipping 40°E, flanked by calcitic marble and paragneiss on either side. The dolomitic zone consists of white to buff, coarse-grained dolomite with 1 to 5% combined muscovite, phlogopite, serpentine, and tremolite which are locally concentrated in pale green or brown bands (Photo 7). Pink and grey calcitic bands up to 10 cm and pale green, mica-rich bands up to 30 cm wide also occur within the dolomitic zone.

The calcitic marbles are also coarse-grained and vary in colour from white to pale blue-grey, green, and pink. Impurities include serpentine, phlogopite, and traces of graphite and pyrite. A narrow stripped zone extending along the top of the marble ridge for a distance of about 800 m southwest from the quarry site has exposed calcitic marbles and minor calc-silicate gneiss, indicating that the predominant rock type on the ridge is calcitic marble, much of which is white and contains less than 5% impurities (visually estimated).

Analysis of a sample from the quarry (E-2, Figure 13), the results of which are shown below, indicates a high-purity dolomite with high brightness. This rock is used to produce aggregate and industrial filler which consists of about 50% dolomite and 50% calcite with 0.7 to 1.3% acid insolubles (Bob Kirkwood, Manager, Easton Minerals Ltd., Madoc, personal communication, 1989). The high calcite content of the product suggests that Easton Minerals is including white, high-purity calcitic marble from the southeastern margin of the dolomite zone in their mill feed.

Chemistry: Analysis of a sample of white, coarse-grained dolomitic marble containing 1-3% serpentine, phlogopite, and muscovite from the quarry gave the following results:

Sample	E-2
SiO_2%	1.56
Al_2O_3%	0.03
Fe_2O_3%	0.14
MgO%	21.2
CaO%	30.9
LOI%	45.6
Total%	99.4
CaO:MgO	1.46
Acid Insolubles%	1.4
Brightness%	90.3

REFERENCES

Hewitt (1954)
Themistocleous (1981)

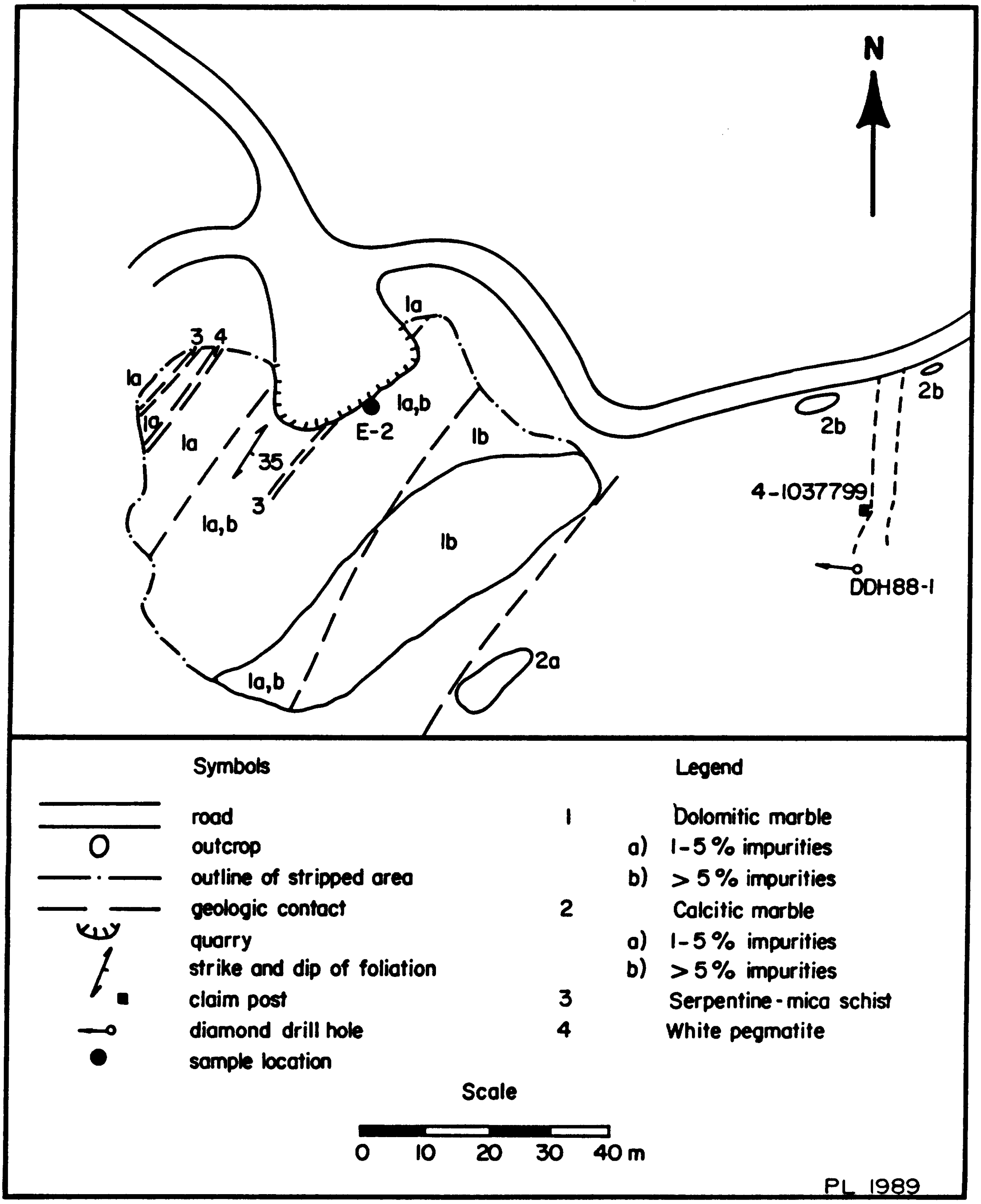

FIGURE 13: Geology of the Easton Minerals Ltd. quarry area (GRI-01), Griffith Township.

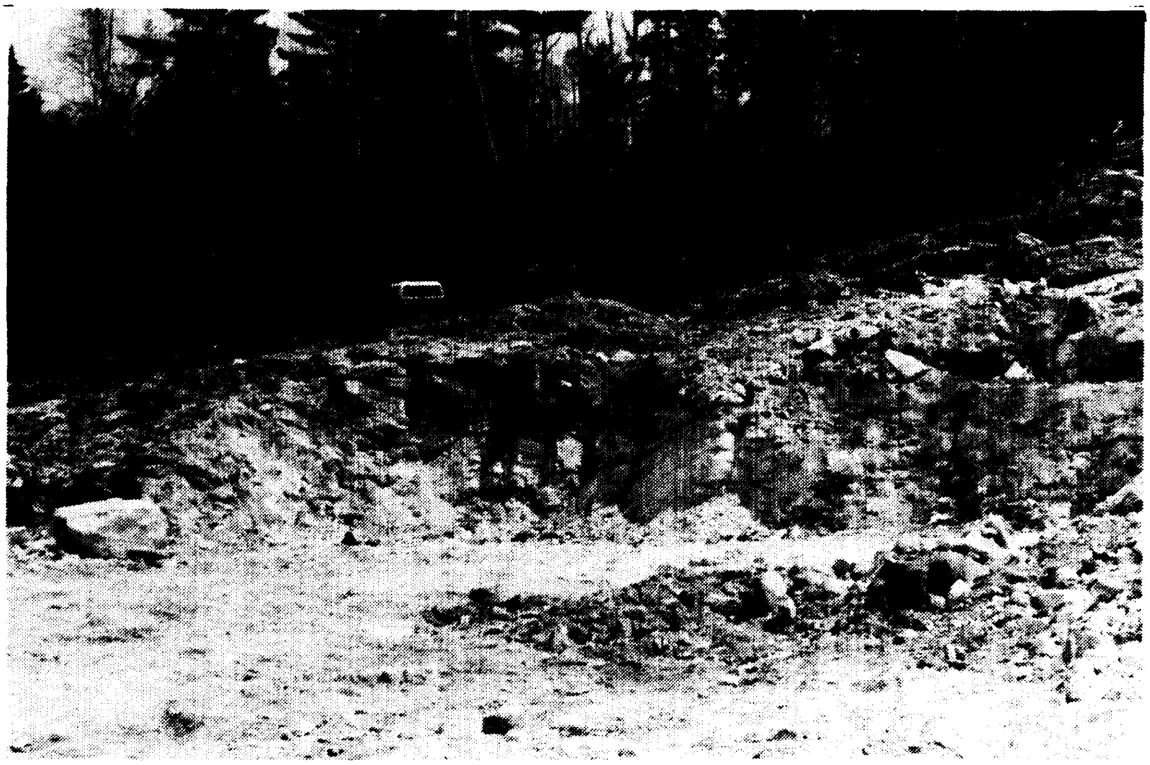

Photo 6: Easton Minerals quarry, May 1989 (GRI-01)

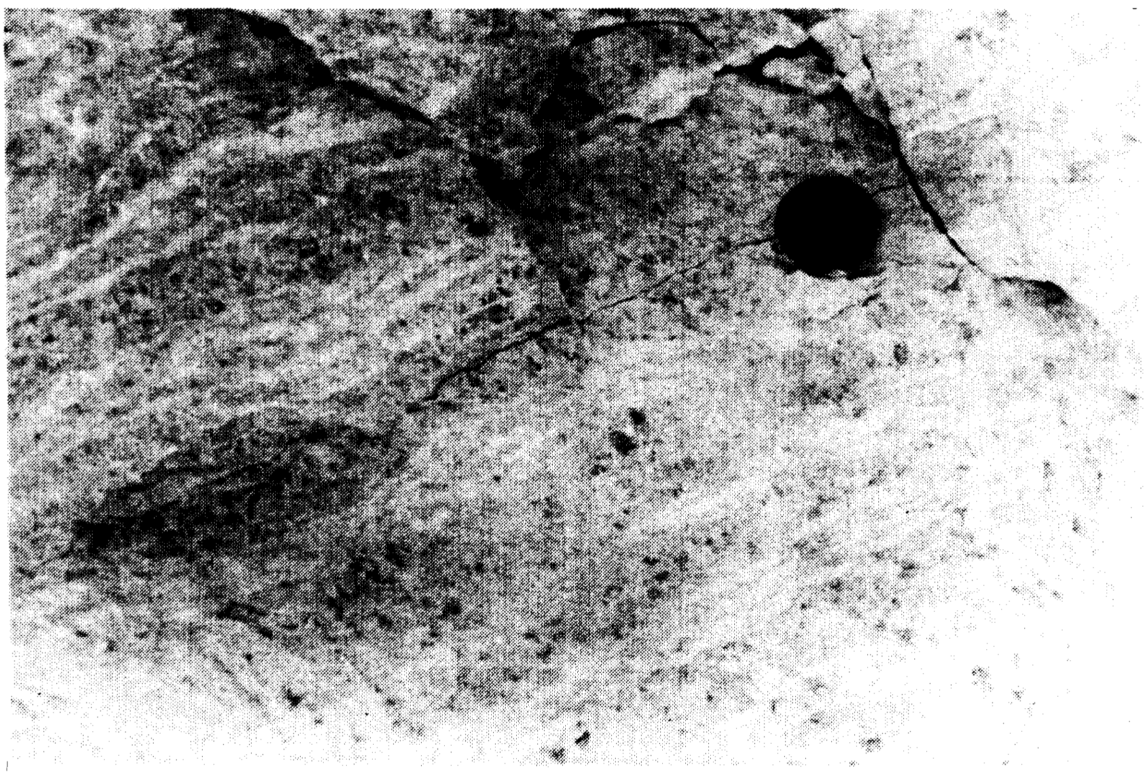

Photo 7: Banded dolomitic marble in the east quarry face (GRI-01). Darker bands contain fine phlogopite and coarse clots of serpentine.

STATUS

Active quarry; Two Island Marble Corporation began intermittent quarrying of dimension stone blocks in 1988. The company plans to be fully operational, quarrying and processing the stone, within two years. Quarry waste will be marketed as aggregate and filler.

LOCATION

Northwest part of Griffith Township (unsurveyed), Renfrew County; UTM Grid 326800mE, 5021800mN, zone 18; NTS 31F/6

ACCESS

Highway 41 to Griffith; north on a forest access road along the east side of the Madawaska River and along Highland Creek; about 3.6 km northeast of the third bridge across Highland Creek, a gravel road leads south about 700 m to the quarry site. (Figure 5c)

HISTORY

1982-85: Trisar Resources carried out stripping, trenching, and diamond drilling (5 holes for a total of 345 m) on a dolomite zone in the area of the present quarry to evaluate the potential of the dolomite as an industrial filler.

1987: Trisar Resources re-examined the 1985 drill core to evaluate the marble zone as a dimension stone prospect.

1988: Two Island Marble Corporation began quarrying dimension stone blocks in the 6 to 11 tonne range.

DESCRIPTION

Geological Setting: The geological setting of this property is the same as that described for property GRI-01. The Two Island Marble quarry (GRI-02) and the Easton Minerals quarry (GRI-01), located about 2 km to the southwest, appear to be within the same belt of marble along the western margin of a northeasterly-trending paragneiss unit.

Previous Geological Work: The area has been mapped by Hewitt (1954) and Themistocleous (1981).

Geology: Figure 14 shows the geology of the quarry and stripped areas. A 40 to 50 m wide zone of white, coarse-grained dolomitic marble (Photo 8) containing less than 3% impurities (phlogopite, serpentine, and pale green mica) is exposed west of the dimension stone quarry and in the eastern part of the stripped area about 250 m northeast of the quarry. This zone, which strikes about 020° and dips 30°E, is flanked to the east by impure calcitic marble containing phlogopite, graphite, hematite, pyrite and local amphibolite bands. Narrow bands of dolomite and pink, granitic gneiss also occur within the calcitic marble area. No outcrop was mapped west of the dolomite zone, but diamond drill logs by Trisar Resources (1985) indicate impure dolomite and calc-silicate rocks with narrow (3 to 5m) bands of white dolomite.

The dimension stone quarry (Photo 9) is located immediately east of the white dolomite zone, within a sequence of interlayered calcitic and dolomitic marbles containing 1 to 3 cm wide pale blue and green bands and cross-cutting, pink calcite veins. Two Island Marble also plans to quarry the white, dolomitic marble for dimension stone and to market the quarry waste as landscaping aggregate and industrial filler. (Gary Pearse, Vice President, Two Island Marble Corporation, Navan, Ont., personal communication 1989).

Chemistry: Analysis of a sample of white, dolomitic marble containing traces of serpentine and pale green mica (G-1, Figure 14) gave the following results:

Sample	G-1
SiO_2%	0.44
Al_2O_3%	<.01
Fe_2O_3%	0.11
MgO%	21.1
CaO%	31.0
LOI%	46.6
Total%	99.2
CaO:MgO	1.47
Acid Insolubles%	0.4
Brightness%	93.6

REFERENCES

Hewitt (1954)
Themistocleous (1981)

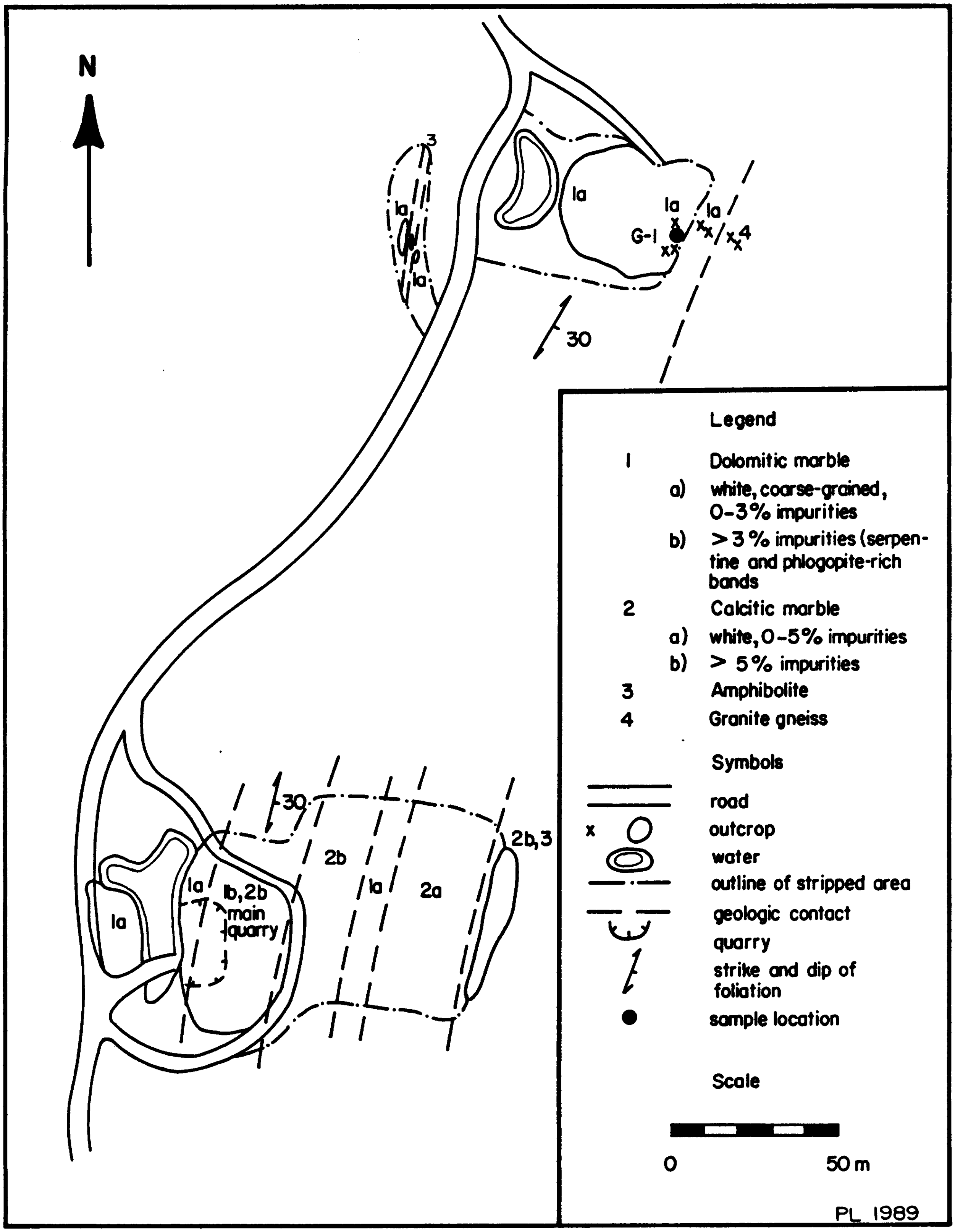

FIGURE 14: Geology of the Two Island Marble Corporation quarry area (GRI - 02), Griffith Township.

Photo 8: Massive, coarse-grained dolomite of very high purity and whiteness (GRI-02).

Photo 9: Dimension stone quarry (GRI-02), May 1989, showing white, calcitic/dolomitic marble with pale green, serpentine-rich bands.

HUN-01 **HUNGERFORD TOWNSHIP**

PROPERTY STATUS

Prospect - Advanced exploration stage; currently under lease to Pleuss-Staufer from C.R. Young of Havelock.

LOCATION

Lot 11, concessions XIII and XIV, Hungerford Township, Hastings County; UTM Grid 314400mE, 4932530mN, zone 18; NTS 31C/11

ACCESS

About 250 m north of the power line crossing Highway 37 between Tweed and Actinolite, a bush road leads westward to the prospect area. (Figure 5e)

DESCRIPTION

Geological Setting: This prospect lies within a narrow marble belt which extends from the Tweed-Actinolite area northeastward along Highway 7 into Elzevir and Kaladar townships. The belt, which ranges in width from about 300 to 1,200 m, is flanked to the north and west by paragneiss and pelitic schists, and to the south and east by similar metasediments and granitic gneiss. Paleozoic limestone overlies the belt at its southwestern limit, north of Tweed.

Previous Geological Work: The northern part of the belt was mapped by Meen and Harding (1941) and the entire belt is shown on a compilation map by Hewitt (1964c).

Geology: Diamond drilling by Vermont Marble Company in 1962 and 1963 intersected a 75 m width of coarse-grained, white, calcitic marble between Highway 37 and the old railway bed 250 m west of the highway. The calcitic band lies between granitic gneiss to the east and a band of dolomitic marble to the west. The dolomitic band, lying between the old railway bed and the Moira River (Figure 15), was estimated to contain about 4 million tonnes of high MgO dolomite (D.G. Ogden, Chief Geologist, Pleuss-Staufer, A.G., Procter, Vermont, personal communication 1989).

A traverse across the marble zone east of the Moira River confirmed the predominance of calcitic marble to the east of the old railway bed and dolomitic marble to the west. The dolomitic band includes a zone about 100 m wide which consists of medium-grained, buff to brown marble with less than 3% impurities (calcite, phlogopite, and tremolite). The true width and uniformity of this zone is questionable, however, due to the presence of narrow calcitic bands and poor outcrop exposure.

Chemistry: Analysis of sample 89 HUN-01 (Figure 15) gave the following results.

Sample	89-HUN-01
SiO_2%	0.84
Al_2O_3%	0.19
Fe_2O_3%	0.42
MgO%	21.3
CaO%	30.6
LOI%	46.2
Total%	99.6
CaO:MgO	1.44
Acid Insolubles	1.6
Brightness	90.0

References

Hewitt (1964c)
Meen and Harding (1941)

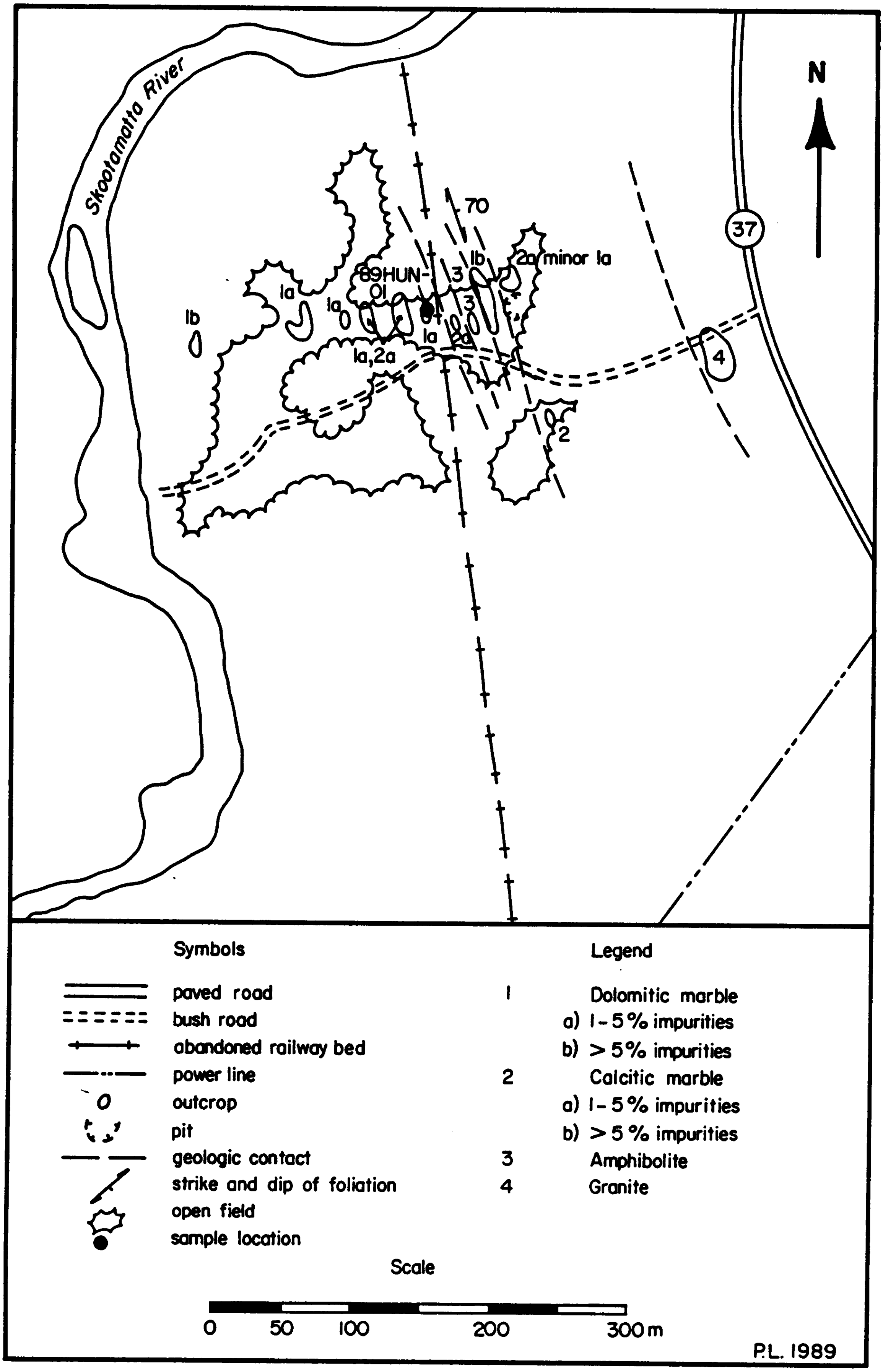

FIGURE 15: Geology of occurrence HUN-01, Hungerford Township.

LAN-01 **LANARK TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lots 8 and 10, concession VII, Lanark Township, Lanark County; UTM Grid 394460mE, 4991670mN (sample 1658) and 393910mE, 4992850mN (sample 1656), zone 18; NTS 31F/1

ACCESS

County Road 12 east from Lanark to Concession Road VI; north on Concession Road VI 1.5 km to location 1658, and an additional 1.5 km north to location 1656. (Figure 5a)

DESCRIPTION

Geological Setting: A wide, northeasterly-trending marble belt containing thin units of intrusive and clastic metasedimentary rocks covers the entire width of Larnark township. The marbles in the vicinity of LAN-01 are flanked to the east by amphibolite, gneiss, and migmatite, and to the west by metagabbro. Dolomitic and calcitic marbles are intercalated with layered amphibolite and coarse, pink granite and pegmatite (Reinhardt and Liberty 1973).

Previous Geological Work: A geological map of the area (NTS sheet 31F/1, Carleton Place) was produced by Reinhardt and Liberty (1973).

Geology: The marbles in this area are dolomitic, pale brown to white, and medium to coarse-grained, containing minor amounts of hematite, graphite, pyrite, and tremolite.

Samples 1656 and 89 LAN-01a are from a zone of pale grey to buff, medium-grained dolomite containing less than 3% tremolite and trace amounts of pyrite and graphite. The zone is poorly exposed (Figure 16) but has a potential width of about 90 m between outcrops of calcitic marble.

Samples 1658 and 89 LAN-01 (Figure 17) are from a dolomite zone of unknown width flanked to the west by granitic gneiss and overlain by swamp to the east. A single outcrop area about 10 m in diameter consists of pale grey, coarse-grained dolomite containing trace amounts of very fine-grained graphite and pyrite.

Chemistry: Analyses 1656 and 1658 are taken from Papertzian and

Kingston (1982). Samples 89 LAN-01a and 89 LAN-01 were taken from the same outcrop areas, respectively, by the authors.

Sample	1656	1658	89 LAN-01	89-LAN-01a
SiO_2%	0.29	0.06	0.59	1.13
Al_2O_3%	0.12	0.13	0.14	0.29
Fe_2O_3%	0.27	0.17	0.23	0.31
MgO%	20.5	20.1	20.9	21.2
CaO%	29.8	29.8	30.8	30.3
LOI%	45.5	45.2	46.5	46.1
Total%	96.5	95.5	99.2	99.3
CaO:MgO	1.44	1.48	1.47	1.43
Acid Insolubles	ND	ND	0.95	1.7
Brightness	ND	ND	87.4	85.6

REFERENCES

Papertzian and Kingston (1982)
Reinhardt and Liberty (1973)

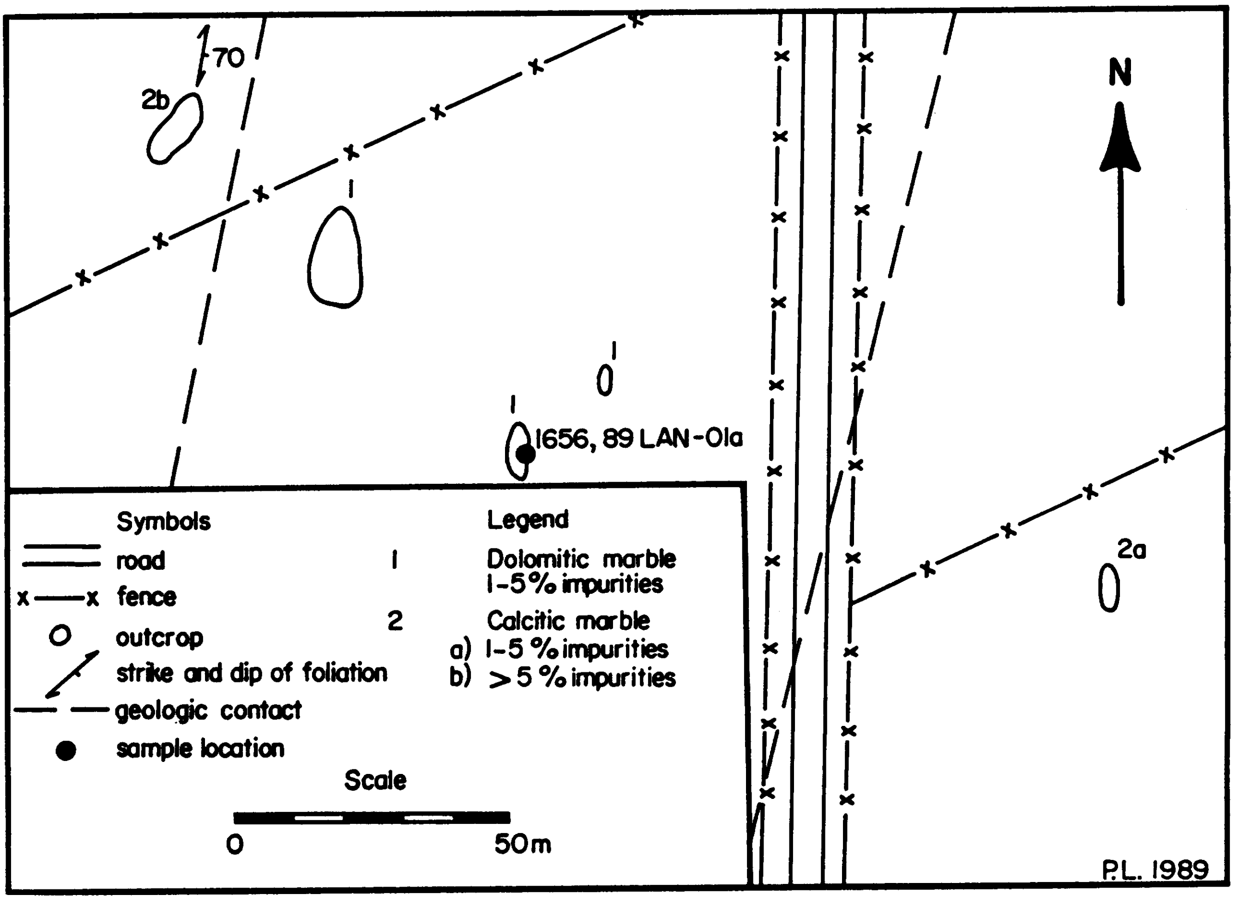

FIGURE 16 : Geological sketch map of the northern exposure of occurrence LAN - 01, Lanark Township.

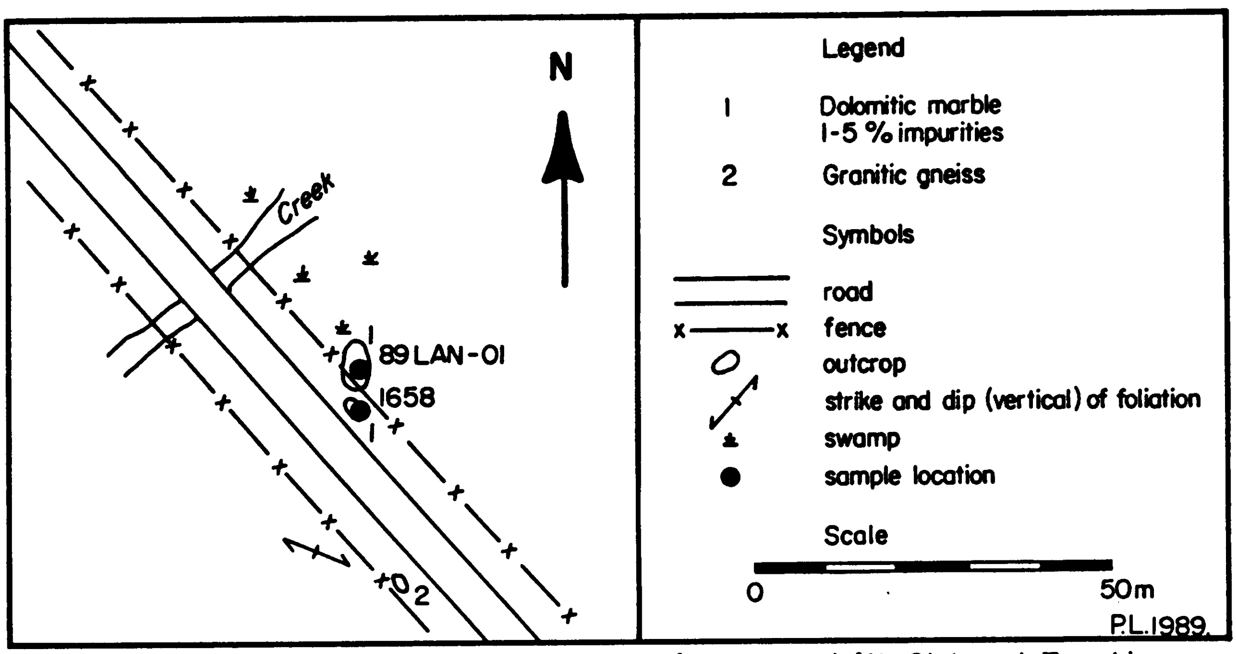

FIGURE 17: Geological sketch of the southern exposure of occurrence LAN - 01, Lanark Township.

LAN-02 **LANARK TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 20, concession VIII, Lanark Township, Lanark County; UTM Grid 391150mE, 4999300mN, zone 18; NTS 31 F/1

ACCESS

Highway 511 north from Perth, through Lanark to Hopetown; east on County Road 16 to Middleville; north to a four-way intersection, and continue an additional 3 km on County Road 16 to site LAN-02. (Figure 5a)

DESCRIPTION

Geological Setting: LAN-02 is located in the western half of a northeasterly-trending carbonate belt which underlies the entire width of Lanark Township. It is flanked to the east by metagabbro and to the west by metadiorite and white granite and pegmatite (Reinhardt and Liberty 1973).

Previous Geological Work: A geological map of the area (NTS sheet 31F/1, Carleton Place) was produced by Reinhardt and Liberty (1973).

Geology: This thick sequence of carbonate rocks consists of interbedded dolomitic and calcitic marbles which are generally banded white and pale grey, fine to medium-grained, and contain accessory phlogopite, hematite, and traces of pyrite and graphite. Outcrop exposure is poor, but outcrops sampled by Papertzian and Kingston (1982) and by the authors are high-purity dolomite as indicated by the analyses below. Several small outcrops of similar dolomitic marble scattered between outcrop areas of grey, graphitic, calcite marble indicate a potential width of about 60 m of high-purity dolomite (Figure 18).

Chemistry: Papertzian and Kingston (1982a) reported the following results from analysis of sample 1553, a buff and grey banded marble from site LAN-02. Sample 89 LAN-03 was taken about 30 m south of No. 1553 by the authors. (Photo 10)

Sample	1553	89 LAN-03
SiO_2%	0.35	0.37
Al_2O_3%	0.20	0.11
Fe_2O_3%	0.25	0.28
MgO%	19.5	21.1

	1553	89 LAN-03
CaO%	30.4	30.1
LOI%	48.6	46.6
Total%	99.3	98.6
CaO:MgO	1.56	1.43
Acid Insolubles	ND	0.60
Brightness%	ND	87.5

REFERENCES

Papertzian and Kingston (1982)
Reinhardt and Liberty (1973)

Photo 10: Strongly jointed dolomitic marble at sample site 89 LAN-03, prospect LAN-02.

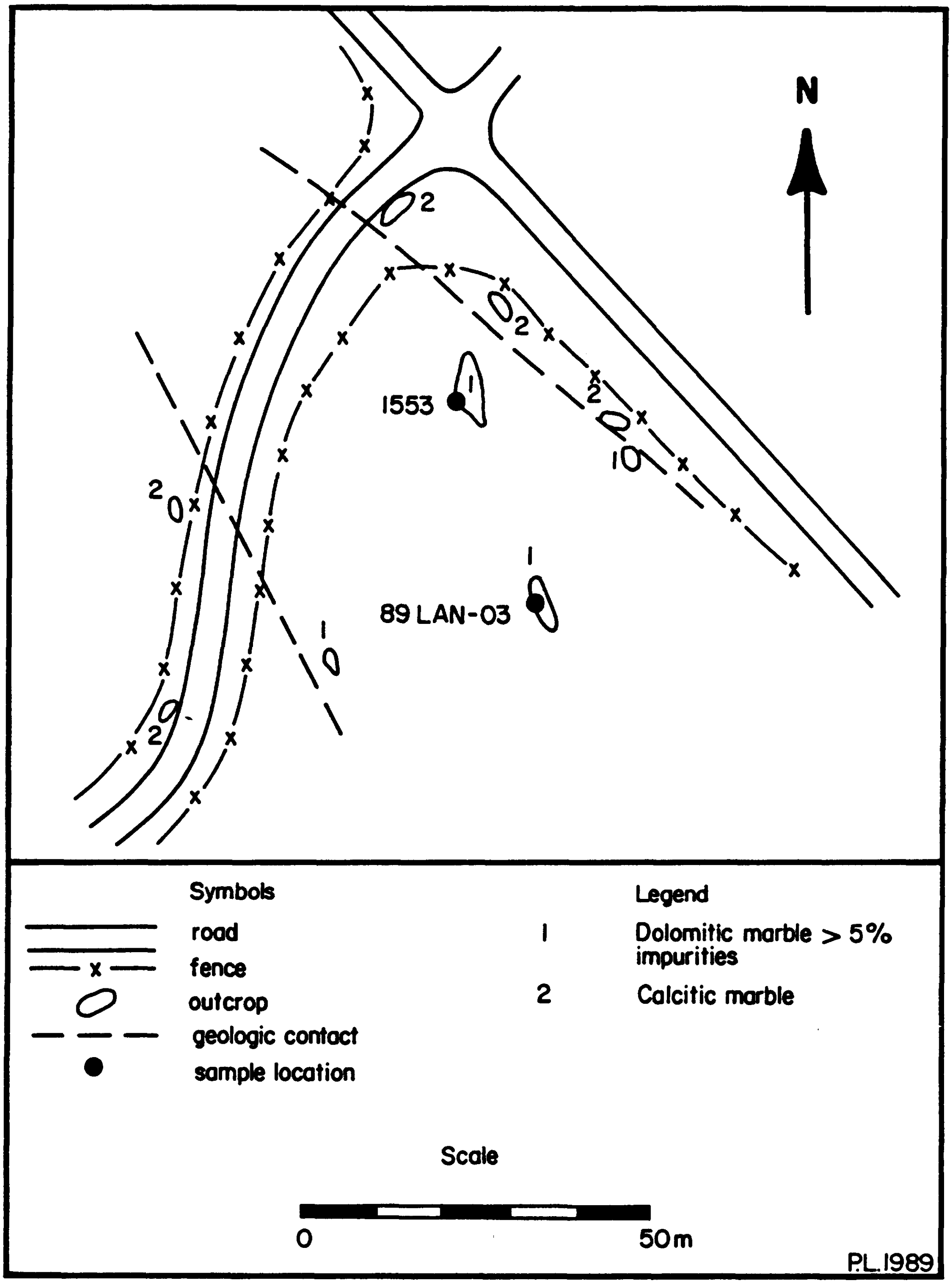

FIGURE 18 : Geology of occurrence LAN-02, Lanark Township.

LUT-01 **LUTTERWORTH TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 13, concession XIV, Lutterworth Township, Haliburton County; UTM Grid 674550 mE, 4973850 mN, zone 18; NTS 31D/15

ACCESS

West from Minden on County Road 2 for a distance of about 7.6 km; the outcrop is on the north side of the road, about 250 m west of the powerline crossing County Road 2. (Figure 5g)

DESCRIPTION

Geological Setting: This narrow marble band lies within the Central Metasedimentary Belt Boundary Zone, a zone of tectonically disrupted gneisses which separates the Central Gneiss Belt from the Central Metasedimentary Belt (Easton 1986).

Previous Geological Work: The area has been mapped by Adams and Barlow (1910), Satterly (1943), and Easton (1986).

Geology: A north-trending wedge of dolomitic marble up to 100 m wide is in fault contact with granitoid gneiss to the east and garnet-sillimanite rock to the west, as shown in Figure 19 (Easton 1986). Analyses of three samples from an outcrop area on the north side of County Road 2 indicate the rock to be high-purity dolomitic marble.

Easton (1986) also reports that dolomite on the south shore of Buller Lake in south-central Lutterworth Township contains less than 5% siliceous impurities.

Chemistry: The following analyses are reported by Easton (1986). Sample location is shown on Figure 19.

Sample	16B	16C	16D
SiO_2	1.0	0.6	2.9
Al_2O_3	0.2	0.2	0.2
Fe_2O_3	0.19	0.04	0.17
FeO	0.73	0.51	1.02
MgO	19.7	19.6	20.6
CaO	28.3	28.4	26.8
CO_2	46.9	47.7	45.3

	16B	16C	16D
Total	97.0	97.0	96.8
CaO:MgO	1.44	1.45	1.30
Acid Insolubles	ND	ND	ND
Brightness	ND	ND	ND

REFERENCES:

Adams and Barlow (1910)
Easton (1986)
Satterly (1943)

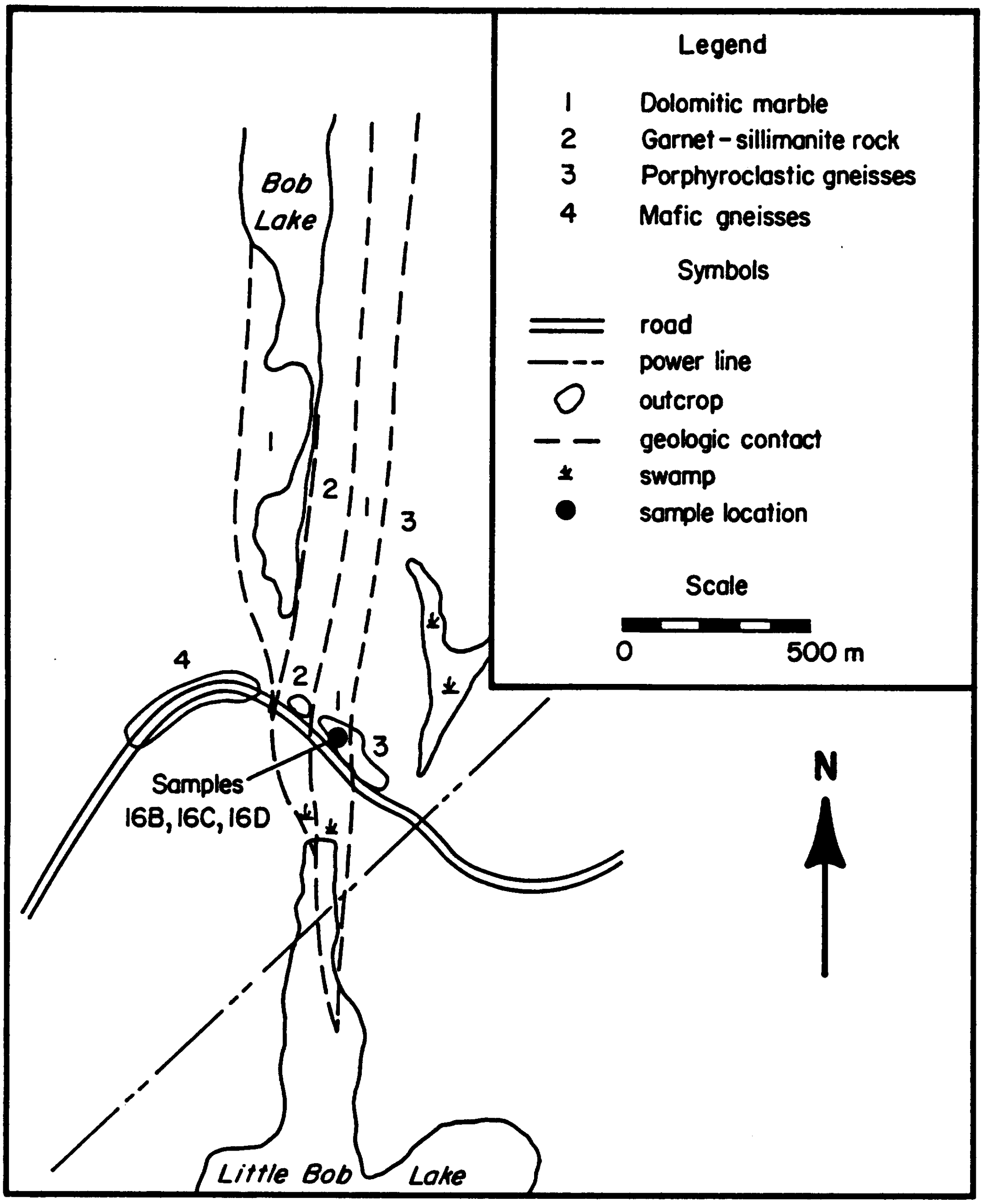

FIGURE 19: Geology in the area of occurrence LUT-01, Lutterworth Township (after Easton 1986).

MAD-01 **MADOC TOWNSHIP**

PROPERTY STATUS

Prospect; past producers (aggregate) and one intermittently active quarry operated by Stoklosar Marble Quarries Ltd.

LOCATION

Lots 19 to 21 inclusive, concession V, Madoc Township, Hastings County; UTM Grid 298100mE, 4941200 mN, zone 18; NTS 31C/12

ACCESS

Three quarries on lot 21 can be reached by following a bush road north from County Road 11 about 1 km west of Highway 62. Several old pits are also found near the boundary between lots 19 and 20 on the southeast side of County Road 11 about 1.5 km west of Highway 62. (Figure 5e)

DESCRIPTION

Geological Setting: Central Madoc Township is underlain by a wide marble belt containing narrow units of clastic metasedimentary rocks and metavolcanic rocks. In the Eldorado area, dolomitic marble is exposed along the limbs of a synformal fold plunging about 60^{o} NE (Figure 20). The dolomitic units contain argillaceous and siliceous beds in addition to bands of high-purity dolomite. Sheets and laminations of quartz within dolomitic marble near the former Eldorado Talc Mine represent relict patches of algal stromatolites (Bourque 1982).

Previous Geological Work: Geological mapping of the area has been done by Miller and Knight (1913), Wilson (1940b), Hewitt and Satterly (1957) and Hewitt (1968).

Geology: Both calcitic and dolomitic marbles are exposed in the area. Calcitic marbles are white to grey and commonly banded, striking north to northwest and dipping eastward. They are fine to medium grained and may contain up to 30% siliceous impurities. The dolomitic units are fine grained, massive, buff to yellowish, and contain up to 20% impurities, predominantly quartz and tremolite with lesser amounts of phlogopite, talc, calcite, and hematite.

Samples taken from three quarries were analysed. The locations are shown on Figure 20 and the results listed below. Sample 89 MAD-01 from pit #1 is a buff to pale pink, fine-grained, sugary dolomite containing trace amounts of phlogopite and hematite (Photo 11). The quarry is intermittently operated by Stoklosar Marble Quarries Ltd. for the production of terrazo chips. The exposed width of the high-purity dolomite zone is about 30 m (Figure 21), underlain to the west by grey, siliceous, calcitic and dolomitic marbles. The eastern and southern limits of the zone were not determined due to lack of outcrop exposure. To the north, the zone is exposed along strike in pit #2, where it contains 3 to 5% quartz knots and seams.

Sample analyses 42a and 42b from pit #3 illustrate the variable silica content within this dolomitic marble. Average silica content in this quarry appears to be about 10%, occurring as quartz knots and foliation-parallel seams and as closely-spaced quartz-filled fractures cutting across the foliation with a shallow, eastward dip.

Sample 44, from pit #4, is a white, fine-grained, sugary dolomite containing less than 3% combined hematite, phlogopite, and calcite. The zone is exposed for a width of 12 m. Grant and Kingston (1984) indicate a potential width of 50 m, flanked by calcitic marble to the northeast and southwest (Figure 22).

Chemistry: Samples 42a, 42b, and 44 were analysed by Papertzian and Kingston (1982). Sample 89 MAD-01 was taken by the authors.

Sample	42a	42b	44	89 MAD-01
SiO_2%	12.5	0.88	0.00	0.90
Al_2O_3%	0.10	0.27	0.18	0.19
Fe_2O_3%	0.00	0.16	0.10	0.18
MgO%	19.06	20.89	21.03	21.6
CaO%	27.01	29.62	29.96	30.3
LOI%	36.8	45.1	46.6	46.3
Total%	95.5	96.9	97.9	99.5
CaO:MgO	1.42	1.42	1.42	1.40
Acid Insolubles%	ND	ND	ND	1.2
Brightness%	ND	ND	ND	87.4

REFERENCES

Bourque (1982)
Grant and Kingston (1984)
Hewitt (1968)
Hewitt and Satterly (1957)
Miller and Knight (1913)
Papertzian and Kingston (1982)
Springer (1983)
Wilson (1940b)

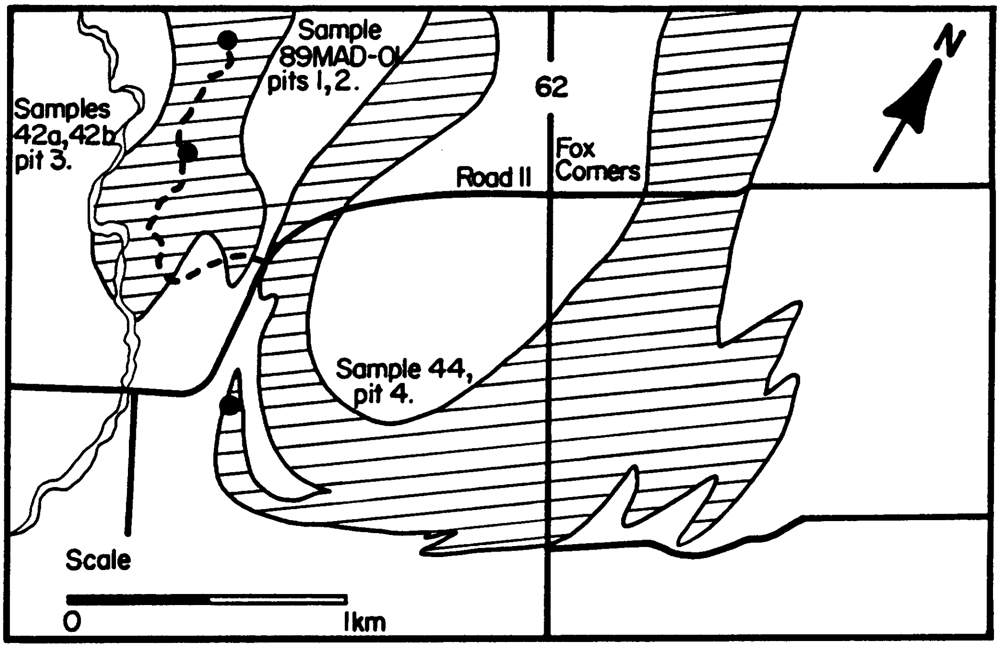

FIGURE 20: Areas of predominantly dolomitic marble in the Fox Corners area, Madoc Township, also showing quarry and sample locations (MAD-01); after Springer (1983).

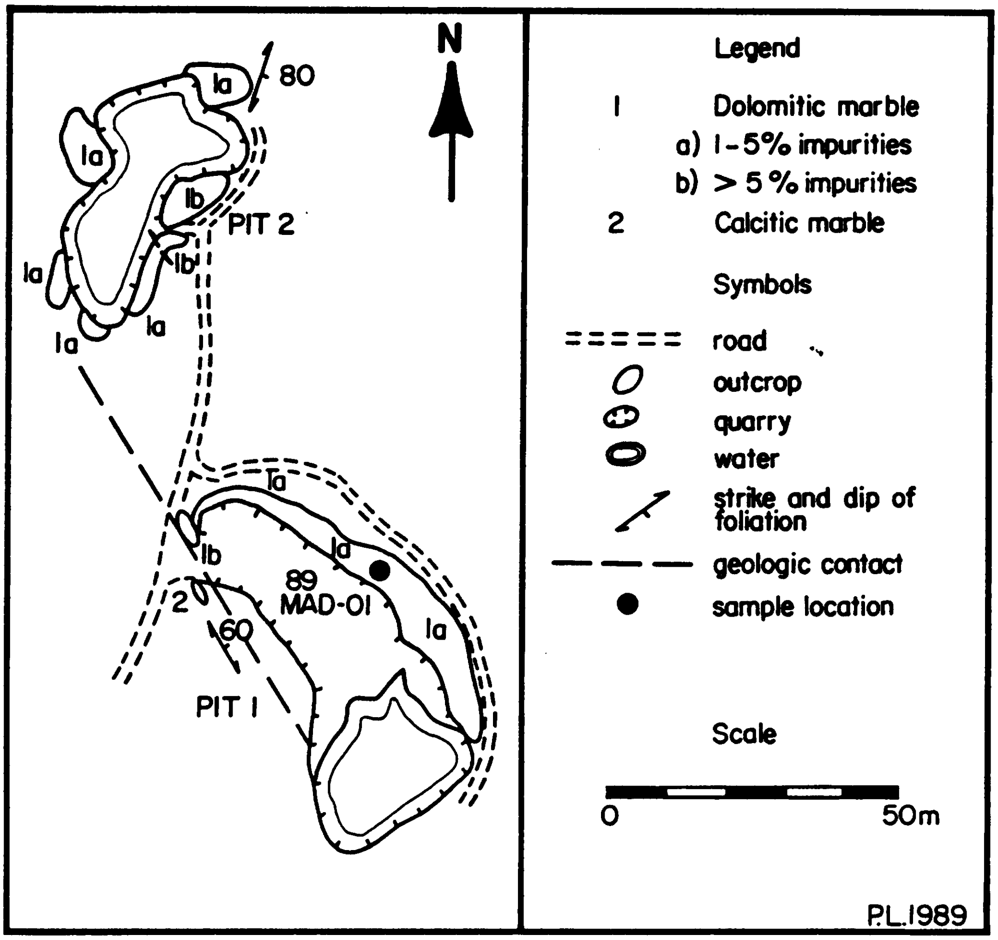

FIGURE 21: Geology of pits 1 and 2, occurrence MAD-01, Madoc Township.

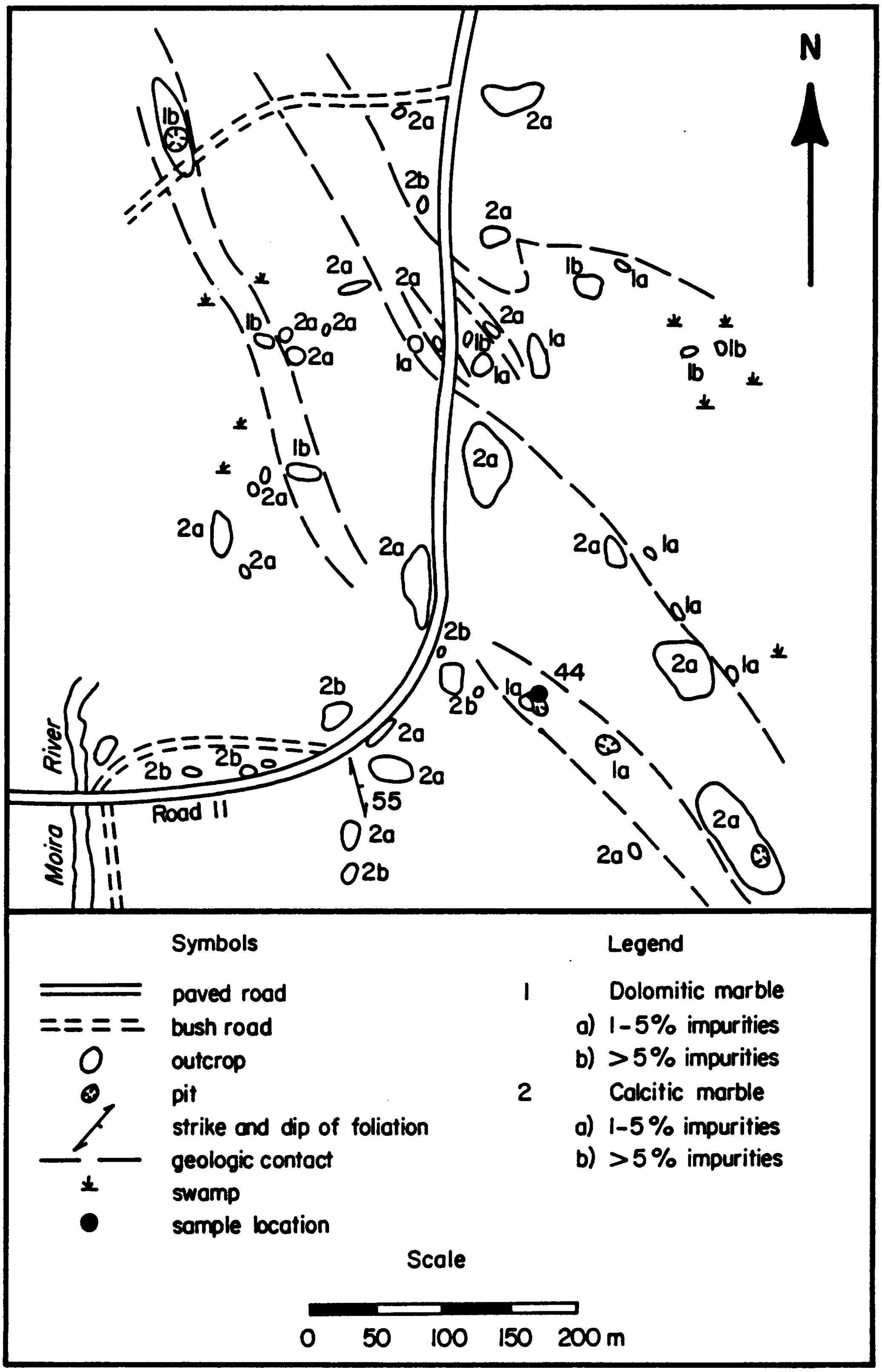

FIGURE 22 : Geology in the area of sample location 44, occurrence MAD - 01, Madoc Township (after Grant and Kingston 1984).

Photo 11: Entrance to the Stoklosar marble quarry (pit #1 in Figure 20).

MAD-02 **MADOC TOWNSHIP**

PROPERTY STATUS

Prospect; past producers (aggregate). Marble has been quarried for aggregate by the Bonter Marble Company and Hastings Marble Products (Hewitt 1964).

LOCATION

Lots 1 and 2, concession IX, Madoc Township, Hastings County; UTM Grid 306900 mE, 4932200mN (sample 2) and 307050mE, 4931700mN (sample 3), zone 18; NTS 31C/11

ACCESS

The sample areas are located along the east side of the Pinewood Park Lake Road, which runs south from Highway 7, about 3 km east of Madoc. (Figure 5e)

DESCRIPTION

Geological Setting: This area of marble in southeastern Madoc Township lies between the Moira Granite to the south and metavolcanic and clastic metasedimentary rocks to the north. Hewitt (1968) shows several small outliers of Paleozoic limestone overlying the Precambrian carbonate rocks. The area sampled is located about 2 km northeast of the Canada Talc Industries mine, where highly talcose dolomite occurs within a sequence of metasediments which includes phyllite, micaceous-tremolitic dolomite, laminated siliceous dolomite (stromatolitic), quartzite, and grey-white mottled dolomite (Simandl and Ogden 1982). Strikes are east to northeast, and dips are vertical to steeply northward.

Previous Geological Work: Geological mapping of the area has been done by Miller and Knight (1913), Wilson (1940b), Hewitt and Satterly (1957) and Hewitt (1968).

Geology: Grant and Kingston (1984, p. 220) report: "...the area is underlain chiefly by dolomitic marble with some calcareous bands. The majority of carbonate is white with lesser amounts of fine-grained grey marble. Impurities within the dolomite can total up to 20% occurring as clots and bands of silicate." Several outcrops of high-purity dolomitic marble are present, intercalated with impure and calcitic marbles, in widths of up to 20 m in the area of sample #3 (Figure 23).

Sample #2 is not representative of the rocks exposed in the quarry at which the sample was taken (Photo 12). Although bands of buff, fine-grained, sugary dolomite containing less than 3%

impurities (quartz, tremolite, and phlogopite) are present in widths of less than 3 m, most of the rocks average from 5 to 20% siliceous impurities over widths in the order of 10 m.

Chemistry: Samples 2 and 3, (Figure 23) were analyzed by Papertzian and Kingston (1982).

Sample No.	2	3
SiO_2%	1.28	0.00
Al_2O_3%	0.08	0.07
Fe_2O_3%	0.08	0.12
MgO%	20.55	20.81
CaO%	29.62	29.85
LOI%	39.2	40.4
Total%	90.8	91.3
CaO:MgO	1.44	1.43
Acid Insolubles%	ND	ND
Brightness%	ND	ND

REFERENCES

Grant and Kingston (1984)
Hewitt (1964a, 1968)
Hewitt and Satterly (1957)
Miller and Knight (1913)
Papertzian and Kingston (1982)
Simandl and Ogden (1982)
Wilson (1940b)

Photo 12: East quarry wall, sample location #2 (MAD-02).

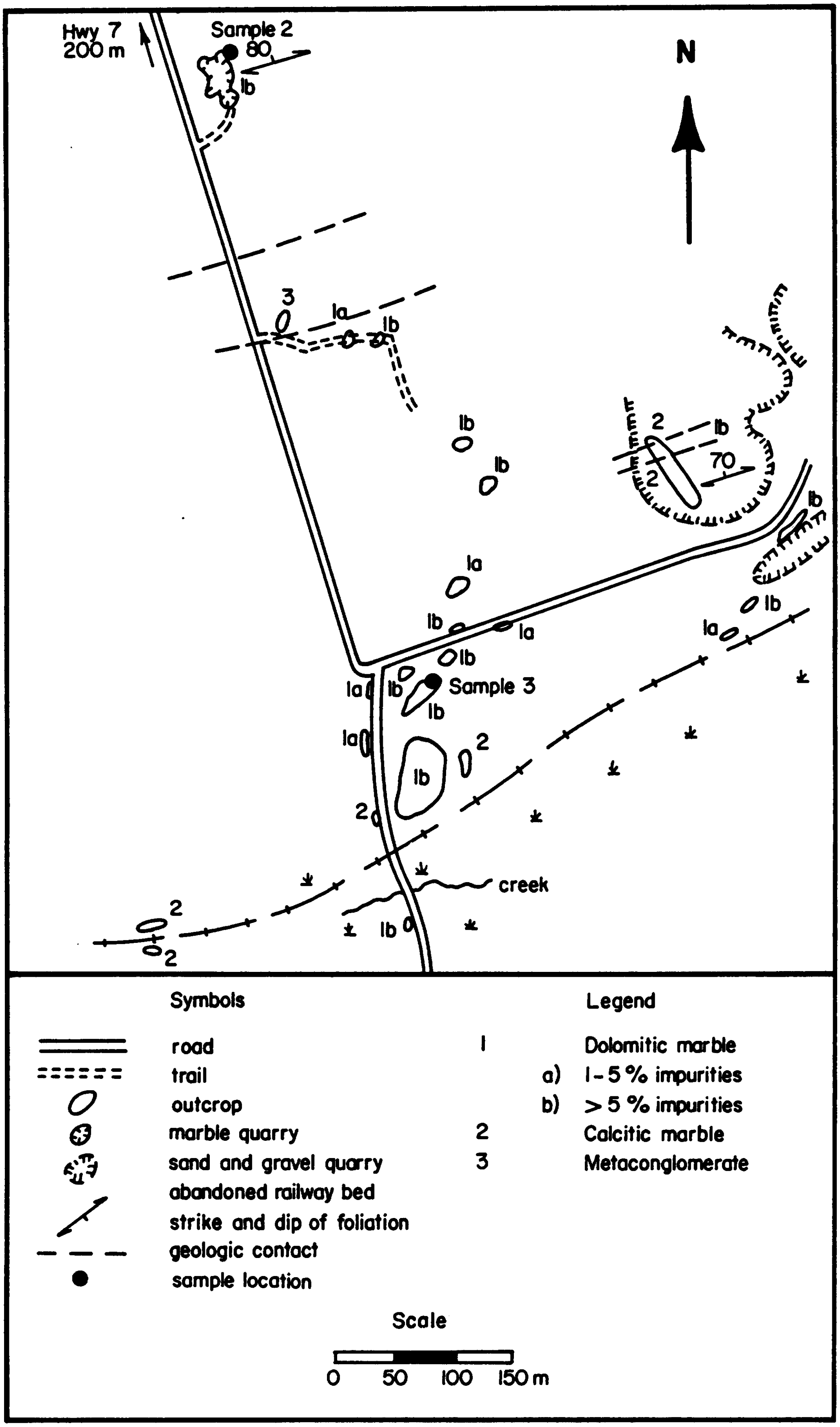

FIGURE 23: Geology in the area of MAD-02, Madoc Township (after Grant and Kingston 1984).

MAY-01 **MAYO TOWNSHIP**

STATUS

Developed prospect - Mangrove Bay Resources Inc. has applied for a quarry permit to begin production in the fall of 1989.

LOCATION

Lots 14 and 15, concession II, Mayo Township, Hastings County; Proposed quarry location on mining lease E0592378 (N 1/2 lot 15, concession II); UTM grid 297600mE, 4989200mN, zone 18; NTS 31F/4

ACCESS

Highway 62 north from Highway 7 to the Gilmour-Gunter road; east to a forest access road about 5 km east of Gunter; north about 15 km on the forest access road to a bush road leading west to the property. (Figure 5f)

HISTORY

1985-87: diamond drilling, stripping, and bulk sampling by A. Dubblestein of Maple Leaf

1988: geological mapping, diamond drilling, trenching, and channel sampling by Derry Michener Booth and Wahl on behalf of Mangrove Bay Resources Inc.

DESCRIPTION

Geological Setting: Mayo Township is underlain by a wide belt of carbonate and clastic metasediments of the Mayo Group, flanked by the Weslemkoon granitic batholith to the southeast and by the Hastings Highland Gneiss Complex to the north. Property MAY-01 is situated at the southern margin of the metasedimentary belt within a northeasterly-trending, 500 m wide band of marble bordered by paragneiss on either side (Hewitt and James 1955).

Previous Geological Work: The area has been mapped by Hewitt and James (1955).

Geology: A narrow band of dolomitic marble striking 020° and dipping 80°W is bordered on either side by biotite-quartz-plagioclase paragneiss and schist as shown in Figure 24. The dolomite band varies in width from 100 to 200 m, is well-exposed by stripping over a 400 m strike length, and continues beyond the stripped area for a strike length of over 700 m. The marble is white to buff, fine-grained with a sugary texture, and contains from 1 to 30% impurities, the most common of which are quartz, tremolite, and phlogopite (Photo 13). Quartz and tremolite occur as coarse knots and stringers (Photo 14); phlogopite is disseminated or concentrated in bands 1 to 5 mm wide.

About 500 m north of the proposed quarry site, where the forest access road crosses an outcrop area west of Smith Lake, a small number of dimension stone blocks were removed from two small quarries in white, dolomitic marble. This marble is the northeastern strike extension of the MAY-01 dolomite zone. A description and sample analysis of this marble by Storey and Vos (1981) indicate a composition very similar to that of the MAY-01 zone.

Based on the results of diamond drilling and trenching, Derry Michener Booth and Wahl have outlined a zone in the center of the dolomite band which is about 300 m long and from 50 to 100 m wide averaging 6% acid insolubles and 93.5% brightness (Dickson and Trinder 1988). Mangrove Bay Resources Inc. proposes to quarry this material to produce construction aggregate, landscaping stone, terrazzo chips, line marker, and low to medium specification filler for products such as carpet backing, vinyl tile, and agricultural products. The production of high specification fillers from this material would require beneficiation to reduce the acid insoluble content.

Chemistry: Analyses of two samples, M-1 and M-2, taken from within the proposed quarry area (Figure 24) are shown below. The brightness values for these samples are lower than those reported by Dickson and Trinder (1988) for the proposed quarry area, reflecting the difference in sample preparation procedure. Brightness tests for samples M-1 and M-2 were done on the whole rock analysis pulps ground in a chrome steel mill. The samples analysed by Dickson and Trinder (1988) were ground to 45 micron particle size in an agate mill. The latter process introduces fewer coloured impurities and produces a more uniform grain size, resulting in higher brightness measurements.

Sample MQ 10 from Storey and Vos (1981), taken at the west side of Smith Lake, 500 m northeast of sample M-2, indicates the uniformity of composition of the dolomitic zone along strike.

Sample	M-1	M-2	MQ 10
SiO_2%	6.73	3.76	5.07
Al_2O_3%	0.34	0.61	1.02
Fe_2O_3%	0.58	0.76	0.33
MgO%	19.7	20.3	20.7
CaO%	28.3	29.1	28.2
LOI%	43.2	44.5	43.9
Total%	98.8	99.0	99.2
CaO:MgO	1.44	1.43	1.36
Acid Insolubles%	7.9	5.9	ND
Brightness%	90.3	89.3	93.1

REFERENCES

Dickson and Trinder (1988)
Hewitt and James (1955)
Storey and Vos (1981)

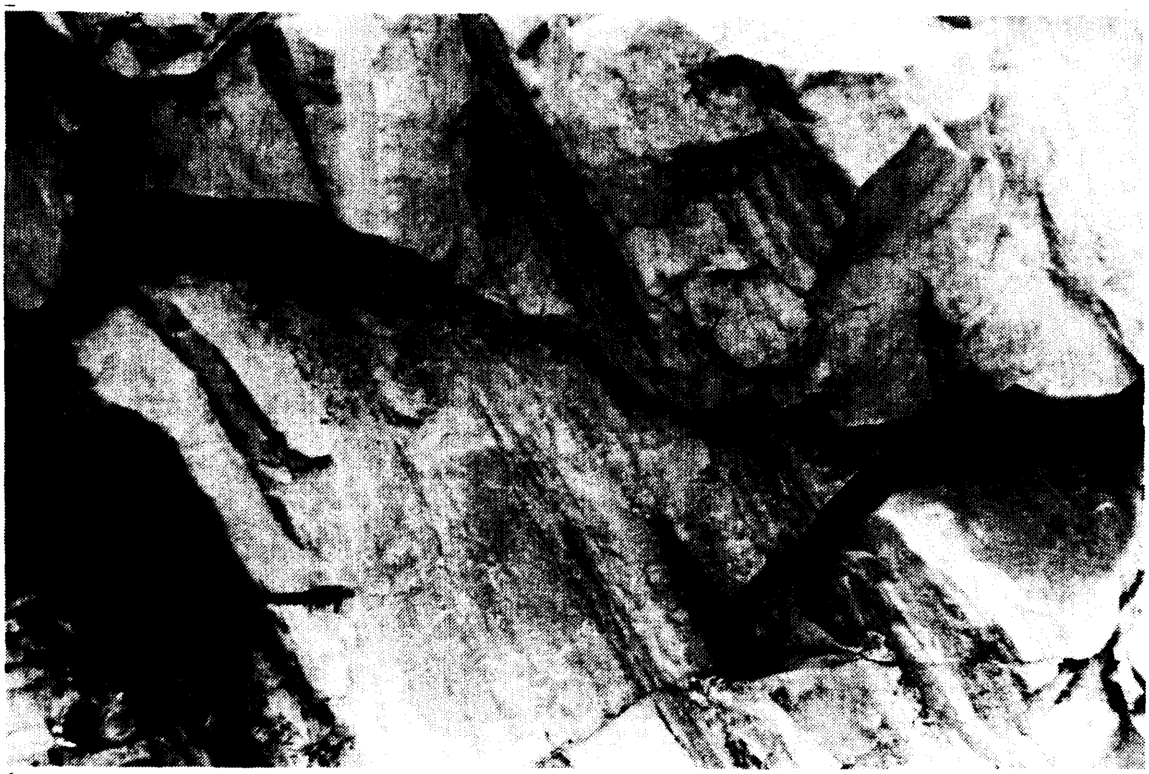

Photo 13: White, fine-grained dolomitic marble with narrow phlogopite-rich bands, sample location M-1 (MAY-01).

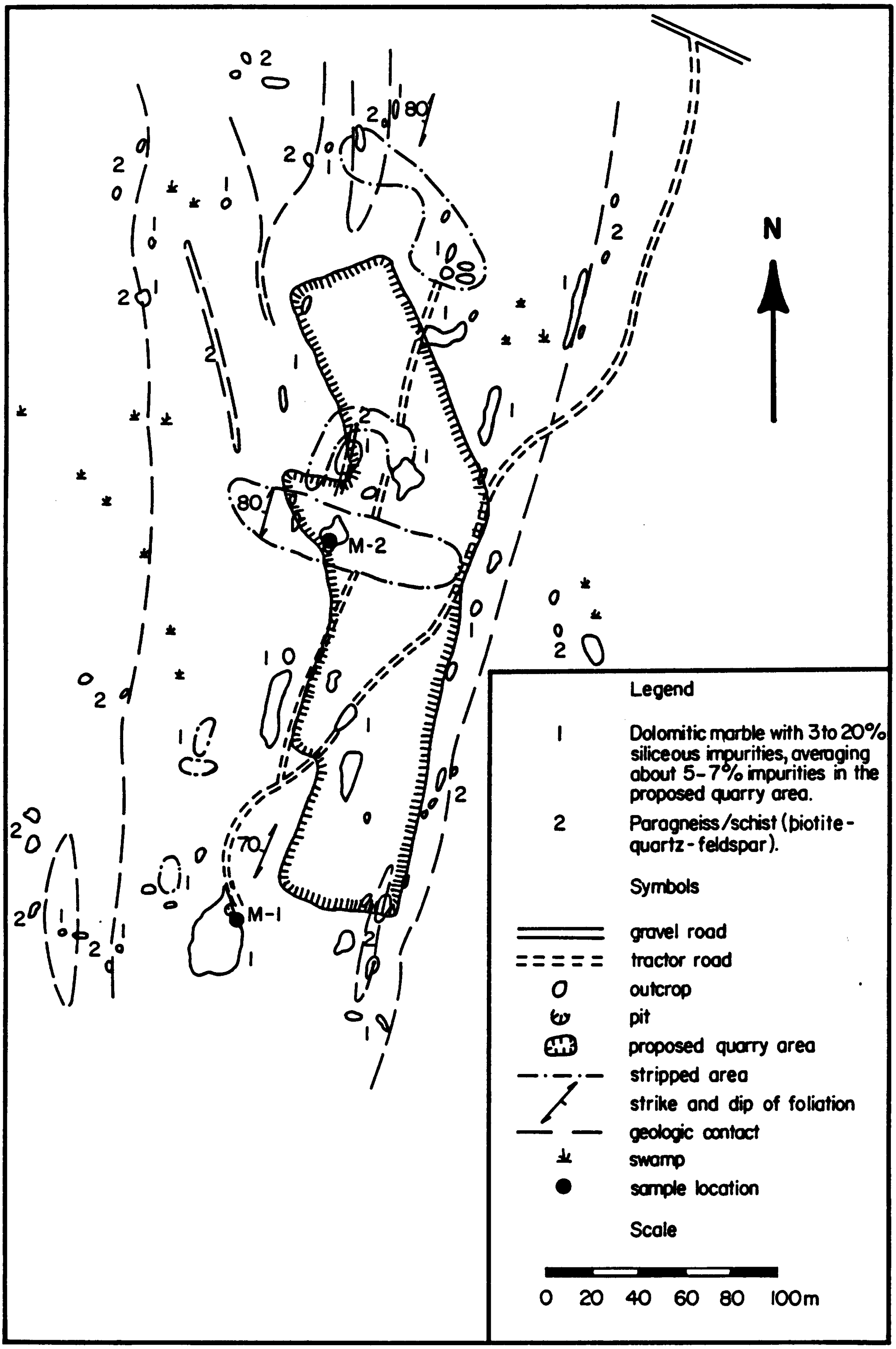

FIGURE 24: Geology of the Mangrove Bay Resources Inc. dolomite prospect (MAY-01), Mayo Township (after Dickson and Trinder 1988).

Photo 14: Resistant weathering of quartz-tremolite knots in white dolomitic marble (MAY-01). Lens cap is 55 mm in diameter.

OLD-01 **OLDEN TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 17, concession I and lot 18, concession II, Olden Township, Frontenac County; UTM Grid 350550mE, 4956000mN and 351800mE, 4957100mN, zone 18; NTS 31C/10 and 31C/15

ACCESS

Two outcrop areas were examined and sampled. One is located along Highway 7 about 1.5 km west of the road to Mountain Grove and the other is along the Price Road between the Mountain Grove road and the north end of Big Clear Lake, in the area of the Olden-Kennebec township line. (Figure 5d)

DESCRIPTION

Geological Setting: This prospect is located near the southern margin of a northeasterly-trending marble belt. The belt, which is up to 3 km wide in Kennebec Township to the west, is flanked to the north and south by clastic metasediments (biotite-amphibolite schists and gneisses) and granitic rocks. Narrow units of para-amphibolite and paragneiss also occur within the marble belt (Harding 1947).

Previous Geological Work: The geology of Olden Township has been mapped by Harding (1947) and is included in a compilation map by Hewitt (1964c).

Geology: Figure 25 shows the geology in the areas of samples 455 and 460 as mapped by Grant and Kingston (1984). All of the marble in these areas is dolomitic, commonly containing from 5 to 50% tremolite knots and bands and minor amounts of phlogopite, serpentine, and pyrite. However, zones of white, medium-grained, dolomitic marble containing less than 5% impurities are present in widths up to 20m, and in both sample areas, outcrops of this dolomite are adjacent to swampy ground which may overlie greater widths of relatively pure marble.

Chemistry: Analyses of samples 455 and 460, reported by Papertzian and Kingston (1982), are as follows:

Sample	455	460
SiO_2%	0.57	1.39
Al_2O_3%	0.10	0.23

	455	460
Fe_2O_3%	0.49	0.21
MgO%	20.73	20.93
CaO%	29.70	29.33
LOI%	46.0	44.9
Total%	97.6	97.0
CaO:MgO	1.43	1.40
Acid Insolubles%	ND	ND
Brightness%	ND	ND

REFERENCES

Grant and Kingston (1984)
Harding (1947)
Hewitt (1964c)
Papertzian and Kingston (1982)

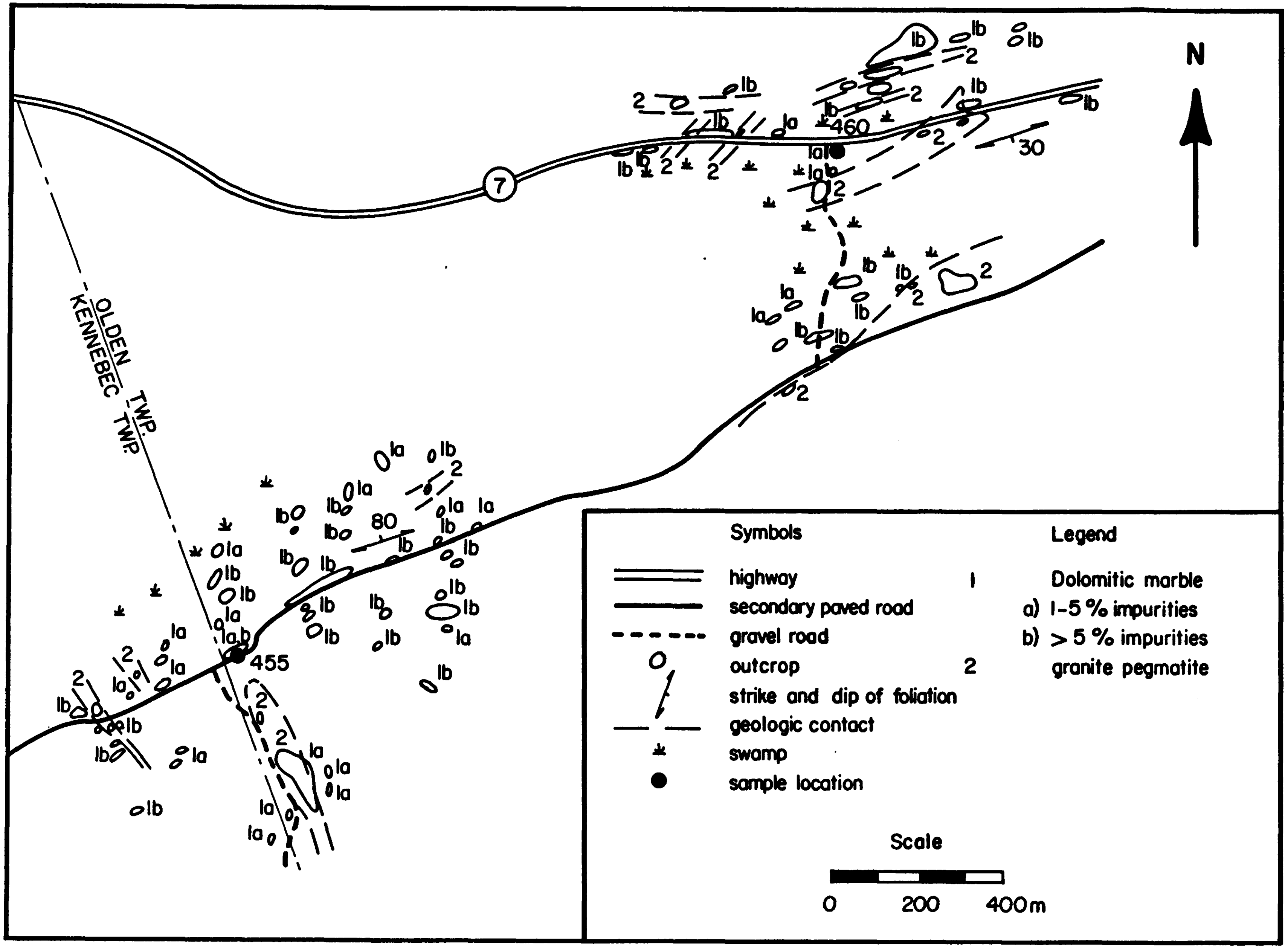

FIGURE 25: Geology in the area of samples 455 and 460 (OLD-01), Olden Township (after Grant and Kingston).

PAL-01 **PALMERSTON TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lots 4 and 5, concession VIII, Palmerston Township, Frontenac County; UTM Grid 366300mE, 4973300mN, zone 18; NTS 31 C/15

ACCESS

The dolomite zone is exposed in road cuts on Highway 509 about 3 km north of Clarendon Station. (Figure 5d)

DESCRIPTION

Geological Setting: This prospect is located near the southern end of a narrow marble belt which extends northward from Palmerston township into North Sherbrooke, Dalhousie, and Lavant townships. The belt is generally less than 1.5 km wide and, along with intercalated biotite-hornblende schist, lies between granitic gneiss to the west and dioritic/gabbroic intrusive rocks to the east in a zone of intense shearing and microbrecciation known as the Robertson Lake Shear Zone (Smith 1956).

Previous Geological Work: Geological maps of Palmerston Township have been produced by Peach and Smith (1956), Hewitt (1964c), and Pauk (1982).

Geology: Figure 2b shows the geology of this prospect as mapped by Grant and Kingston (1984). An area of dolomitic marble bordered by hornblende amphibolite to the south, east, and west extends northward into an area of predominantly calcitic marble. Both calcitic and dolomitic marbles are white and commonly contain from 10 to 50% knots and bands of quartz and tremolite. However, a zone of dolomitic marble about 50 m wide, exposed along the east side of Highway 509 (Photo 15), contains less than 3% impurities and has a potential strike length in the order of 400 m.

Chemistry: The chemistry of sample 709 (from Papertzian and Kingston 1982), shown below, indicates the high purity of the dolomite in this zone.

Sample	709
SiO_2%	0.80
Al_2O_3%	0.09
Fe_2O_3%	0.26

	709
MgO%	20.6
CaO%	29.6
LOI%	45.8
Total%	97.2
CaO:MgO	1.44
Acid Insolubles%	ND
Brightness%	ND

REFERENCES

Grant and Kingston (1984)
Hewitt (1964c)
Papertzian and Kington (1982)
Pauk (1982)
Peach and Smith (1956)

Photo 15: High-purity, white dolomitic marble exposed along Hwy 509 about 3 km north of Clarendon Station (PAL-01).

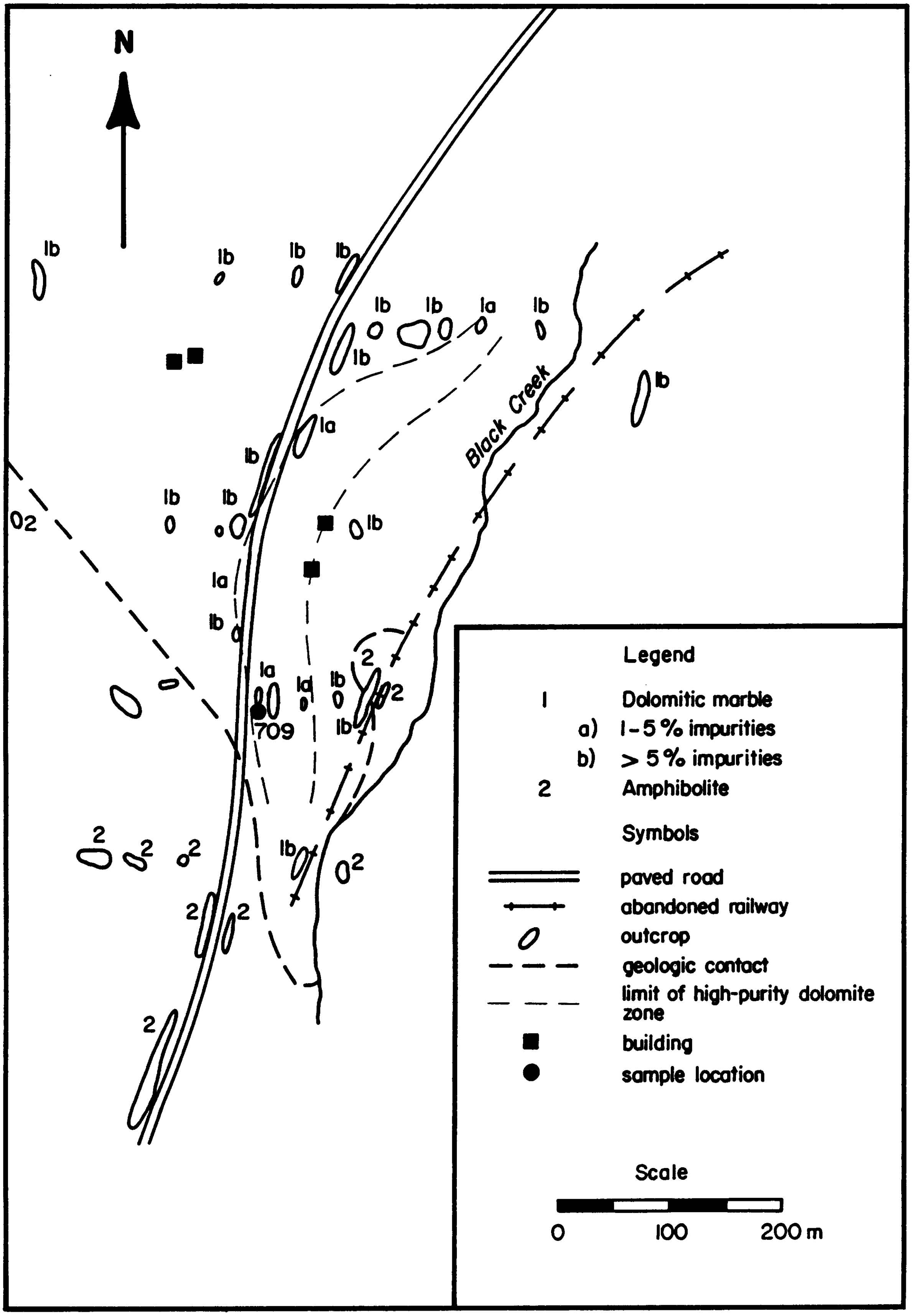

FIGURE 26: Geology of occurrence PAL-01, Palmerston Township (after Grant and Kingston 1984).

RAM-01 **RAMSAY TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 20, concession I and lot 21, concession VI, Ramsay Township, Lanark County; UTM Grid 396650mE, 5003290mN (sample 1758) and 400760mE, 5007950mN (sample 1745), zone 18; NTS 31F/1

ACCESS

Sample site 1745 is 800 m west of Concession Road 7 on County Road 21, which runs west from Highway 29 about 3 km north of Almonte. Sample site 1758 is located on County Road 9, about 700 m south of the western end of County Road 21, at the junction with the Clayton Lake Road. (Figure 5a)

DESCRIPTION

Geological Setting: The area is underlain by a belt of marble which extends through Lanark and Dalhousie townships to the southwest and beneath Paleozoic cover (Ordovician sandstone, limestone, and dolostone) to the northeast in the eastern half of Ramsay township. The marble belt contains both calcitic and dolomitic varieties and intercalated layers of amphibolite and gneiss. It is flanked to the northwest and southeast by amphibolitic and granitic gneisses and migmatites (Reinhardt and Liberty 1973).

Previous Geological Work: A geological map of the area (NTS sheet 31F/1, Carleton Place) was produced by Reinhardt and Liberty (1973).

Geology: Marbles at the two sample locations in this area are pale grey to white, medium-grained, massive dolomite containing minor amounts of calcite, hematite, tremolite, mica, pyrite, and graphite. Samples 1745 and 1758 from Papertzian and Kingston (1982) are high-purity dolomites as indicated by the analyses below.

Sample 1745 is a pale grey, medium-grained dolomitic marble containing less than 1% tremolite and trace amounts of very fine graphite, which gives the marble its grey colour. The exposed width is about 12 m (Figure 27). Lack of outcrop prevents estimation of the complete width of the dolomite zone.

Sample 1758 is from a dolomitic marble zone with an exposed width of about 70 m (Figure 28). The marble is pale grey, medium-grained, and faintly banded, containing less than 3% impurities in the form of calcite blebs and veinlets, tremolite, phlogopite, and very fine-grained graphite. The high-purity zone is overlain to the southwest by interlayered calcitic marble and dolomitic marble containing greater than 10% calcite and tremolite.

Chemistry: Samples 89 RAM-01 and 89 RAM-01a were taken by the authors at the same sites as samples 1758 and 1745, (Papertzian and Kingston 1982), respectively, in order to confirm the rock composition and obtain brightness values and acid insoluble content.

Sample	1745	1758	89 RAM-01	89 RAM-01a
SiO_2%	0.85	0.43	0.85	1.00
Al_2O_3%	0.29	0.23	0.19	0.25
Fe_2O_3%	0.21	0.19	0.25	0.41
MgO%	19.1	20.5	20.6	21.4
CaO%	29.4	29.5	30.1	30.3
LOI%	46.3	48.0	46.3	46.2
Total%	96.2	98.9	98.3	99.6
CaO:MgO	1.54	1.44	1.46	1.42
Acid Insolubles%	ND	ND	1.1	1.6
Brightness%	ND	ND	86.3	82.5

REFERENCES

Papertzian and Kingston (1982)
Reinhardt and Liberty (1973)

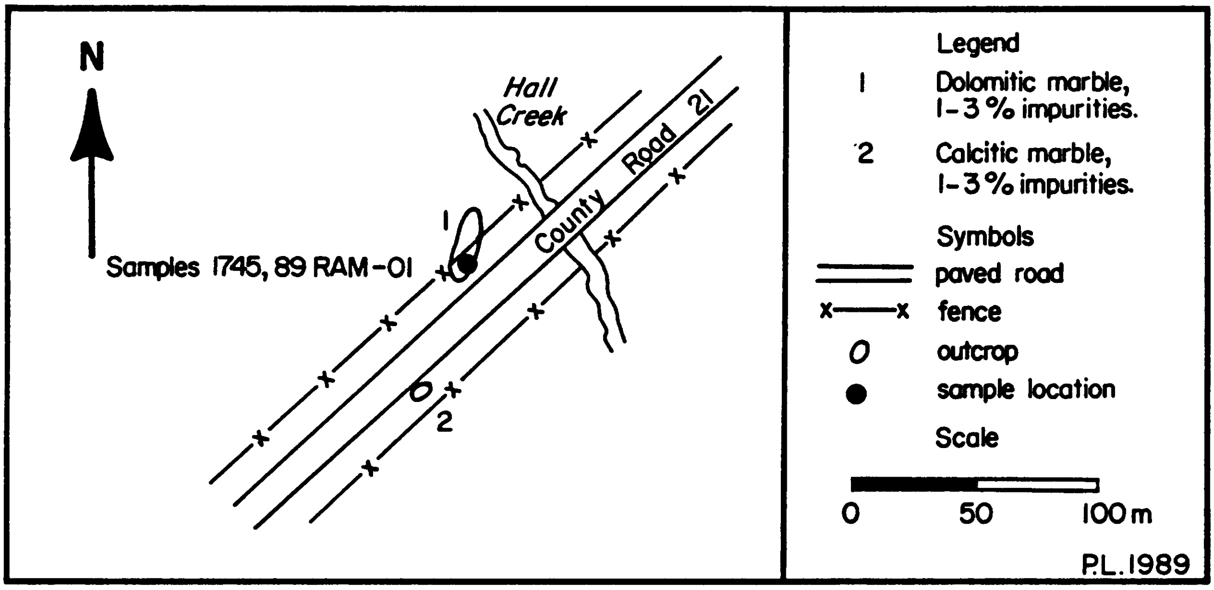

FIGURE 27: Sketch map of occurrence RAM-01, eastern exposure, Ramsay Township.

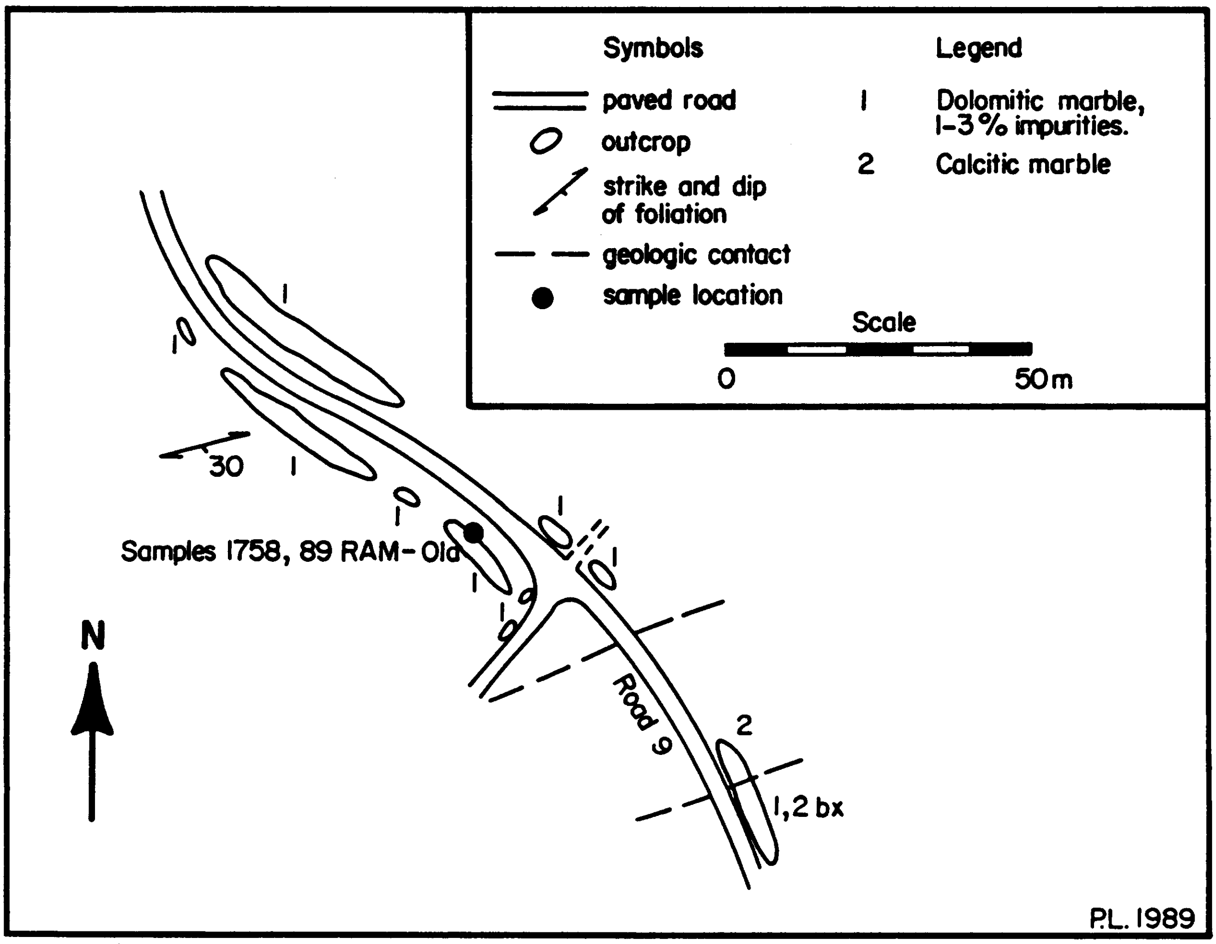

FIGURE 28: Sketch map of occurrence RAM-01, western exposure, Ramsay Township.

RAM-02 **RAMSAY TOWNSHIP**

PROPERTY STATUS

Prospect

LOCATION

Lot 4, concession II, Ramsay Township, Lanark County; UTM Grid 403400mE, 4996900mN, zone 18; NTS 31F/1

ACCESS

The sample site is about 1.5 km north of Highway 7 on County Road 9, which intersects Highway 7 about 8 km north of Innisville. (Figure 5a)

DESCRIPTION

Geological Setting: Site RAM-02 is located at the southern margin of a wide marble belt extending through Dalhousie, Lanark, and Ramsay townships. This part of the belt is flanked to the southeast by biotite-granite migmatite and to the northwest by amphibolite and granitic migmatite. It contains intercalated units of calcitic and dolomitic marble, quartzofeldspathic gneiss, and minor granitic pegmatite and gabbro. The belt extends northeastward below Ordovician sandstone, limestone, and dolostone (Reinhardt and Liberty 1973).

Previous Geological Work: The area was mapped by Reinhardt and Liberty (1973).

Geology: The outcrop at site RAM-02 is about 50 m X 12 m in area, with a blocky surface caused by deep weathering along joint planes (Photo 16). The rock is a white, fine to medium grained dolomite with minor amounts of hematite, mica, graphite, tremolite, pyrite, and calcite. The chemistry of samples 1804 from Papertzian and Kingston (1982) and 89 RAM-02, shown below, indicate the high purity of this dolomite. The width of the dolomite zone appears to be about 15 m, flanked by calcitic marble and diorite to the north and by impure dolomite containing greater than 5% tremolite and serpentine to the south. (Figure 29)

Chemistry: Papertzian and Kingston (1982) report the following results from analysis of sample 1804, a fine to medium grained, pale grey marble with trace pyrite and graphite. Sample 89 RAM-02 is from the same outcrop area as sample 1804.

Sample	1804	89 RAM-02
SiO_2%	0.32	1.02
Al_2O_3	0.16	0.24
Fe_2O_3%	0.08	0.27
MgO%	20.2	21.5
CaO%	30.0	30.3
LOI%	45.7	46.0
Total%	96.5	99.3
CaO:MgO	1.49	1.41
Acid Insolubles%	ND	1.6
Brightness%	ND	88.0

REFERENCES

Papertzian and Kingston (1982)
Reinhardt and Liberty (1973)

Photo 16: Blocky weathered surface in strongly jointed dolomitic marble (RAM-02).

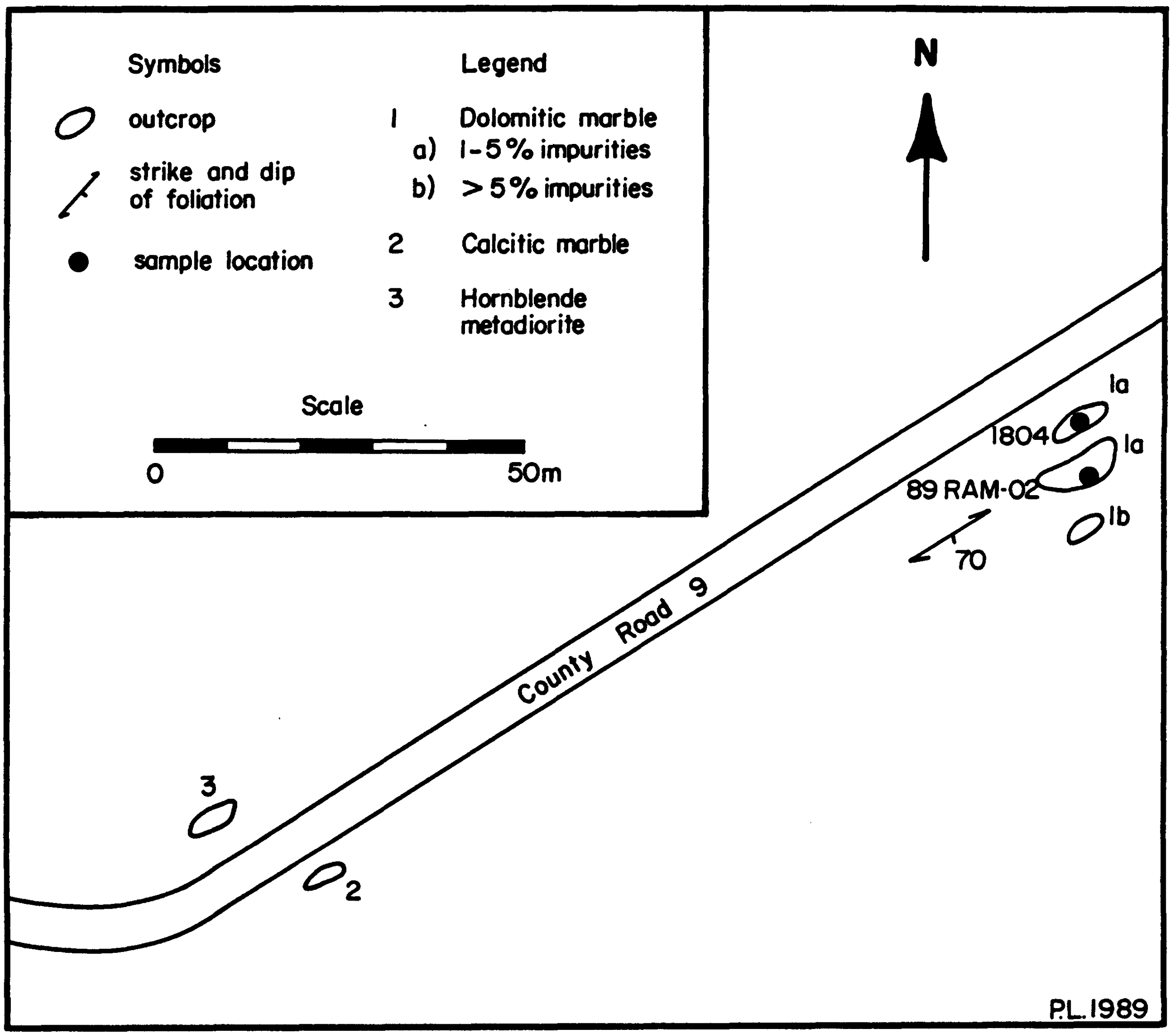

FIGURE 29 : Sketch map of occurrence RAM - 02, Ramsay Township.

ROSS-01 **ROSS TOWNSHIP**

PROPERTY STATUS

Active quarry - Timminco Limited (formerly Chromasco Limited) quarries dolomitic marble for the production of magnesium metal.

LOCATION

Lot 20, concessions V and VI, Ross Township, Renfrew County; UTM Grid 363300mE, 5050900mN, zone 18; NTS 31F/10

ACCESS

Highway 17 to Highway 653, 13 km north of Renfrew; east on Highway 653 about 1 km to County Road 7, and north on County Road 7, 2.5 km to the Timminco plant and quarry site. (Figure 5b)

HISTORY

1900-1907: The deposit was quarried for building stone.
1907-1942: Intermittent production of building stone aggregate.
1942 to present: Production of magnesium metal from dolomitic marble, originally by Dominion Magnesium Limited; later by Chromasco Limited, and currently by Timminco Metals, a division of Timminco Limited.

DESCRIPTION

Geological Setting: The area is underlain by a northerly-trending belt of carbonate and clastic metasediments which varies in width from 4 to 8 km, flanked to the east by gneissic granitic/dioritic rocks, amphibolite schist, and gabbro and to the west by gneissic granitic/syenitic rocks. Large areas of calcitic and dolomitic marble occur in the eastern half of Ross Township, but outcrop exposure is poor.

Previous Geological Work: The area has been mapped at a 1:100,000 scale by Lumbers (1982). No detailed geological maps of Ross Township have been produced. The deposit has been decribed by Parks (1912), Goudge (1938), Pidgeon (1944), Satterly (1945), Hewitt (1964a), and Storey and Vos (1981).

Geology: The deposit consists of a band of very pure, white, coarsely crystalline dolomitic marble (Photo 17) which is about 75 m wide, striking north and dipping 50°E (Figure 30). The rock contains less than 1% impurities, which are pale, yellowish-green chondrodite, pale green talc, very fine, grey tourmaline needles, and tremolite.

The eastern limit of the high-purity dolomite zone is marked by a unit of weakly-banded, blue-grey, medium-grained dolomite containing very fine-grained, disseminated graphite and traces of tremolite, talc, and pyrite. These impurities total less than 1%, and small amounts of this rock are included as mill feed with the white dolomite ore. The graphitic unit is several meters wide and is overlain by impure, white dolomitic marble containing up to 20% irregular clots and bands of quartz, tremolite, and serpentine (Photo 18).

The ore zone is underlain by a thin (1 m) band of black, fine-grained amphibolite schist containing phlogopite and traces of pyrite. Below the amphibolite is a band of red, hematitic calcite several centimeters wide in contact with underlying impure dolomite similar to that in the hanging-wall of the ore zone. The entire dolomitic sequence is flanked on either side by banded, grey-buff, calcitic marble containing fine, disseminated graphite.

The ore zone has been mined in two quarries (Figure 30) over a strike length of 700 m and diamond drilling north of quarry No. 2 has extended the ore zone northward. All production is currently from quarry No. 2 (Larry Ball, Quality Control Metallurgist, Timminco Metals, Haley, personal communication 1988).

Chemistry: A sample of dolomite ore from quarry No. 2 had the following analysis:

Sample	T-2
SiO_2%	0.31
Al_2O_3%	<0.01
Fe_2O_3%	0.05
MgO%	21.2
CaO%	30.8
LOI%	47.1
Total%	99.5
CaO:MgO	1.45
Acid Insolubles%	0.4
Brightness%	91.5

REFERENCES

Goudge (1938)
Hewitt (1964a)
Parks (1912)
Pidgeon (1944)
Satterly (1945)
Storey and Vos (1981)

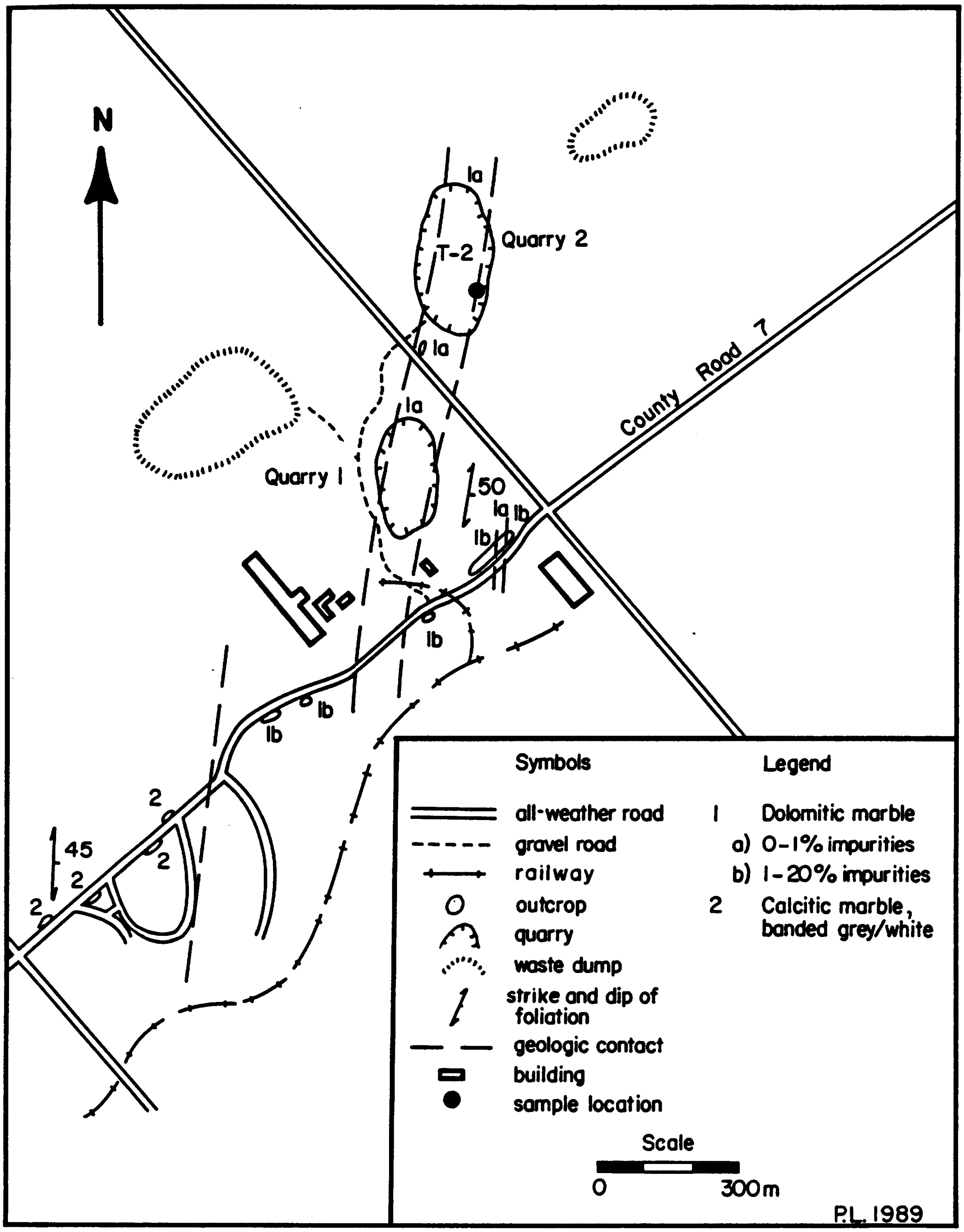

FIGURE 30: Geology in the area of the Timminco Limited dolomite quarries (ROSS-01), Ross Township.

Photo 17: Outcrop of very high-purity dolomitic marble on the east side of the concession road between Timminco No. 1 and No. 2 quarries (ROSS-01).

Photo 18: Outcrop of impure dolomitic marble containing irregular knots of quartz and tremolite. This unit forms the hanging wall of the Timminco ore zone; County Road 7, east of the Timminco gatehouse (ROSS-01).

PROPERTY STATUS

Active quarry; H & H Aggregates of Petawawa intermittently quarry dolomite for the production of concrete brick and landscaping stone. Production is estimated to be in the range of 5,000 tpa (Kevin Hoffman, Sales Manager, H & H Aggregates, Petawawa, personal communication, 1989).

LOCATION

Lot 24, concession IV, Ross Township, Renfrew County; UTM Grid 363850mE, 5047800mN, zone 18; NTS 31F/10

ACCESS

From Highway 653, 2.1 km east of Highway 17, a dirt road leads north for a distance of 300 m to the quarry. (Figure 5b)

HISTORY

1960s: Canadian Dolomite Company quarried dolomitic marble for the production of marble chips and stucco plaster filler. The marble was shipped to a plant at Portage du Fort, Quebec for crushing and screening (Hewitt 1964c). The quarry was known as the Smith quarry.

1985 to present: H & H Aggregates produce white dolomite from a small quarry about 50 m northwest of the old Smith quarry and, in 1989, began producing crushed marble for landscaping stone from a quarry in serpentinized dolomitic marble about 50 m east of the old quarry.

DESCRIPTION

Geological Setting: The general geology of the area is as described for property ROSS-01. This occurrence is located about 2.5 km south of the Timminco dolomite deposit and appears to be within the same band of dolomitic marble, flanked by banded calcitic marble on both sides.

Previous Geological Work: The area has been mapped at a reconnaissance scale (1:100,000) by Lumbers (1982).

Geology: A 30 m wide band of high-purity dolomitic marble striking 320^{o} and dipping 45^{o}E is exposed in the old Smith quarry (Photo 19) and in the eastern side of the H & H Aggregates quarry to the northwest (Figure 31). The high-purity band is flanked on either side by interlayered calcitic and dolomitic marbles containing up to 10% serpentine and minor amounts of graphite and hematite. A ridge of serpentine-bearing marble about 50 m east of the old quarry is being quarried for decorative aggregate.

The high-purity dolomitic marble is very similar to the Timminco dolomite ore to the north, consisting of 99% coarse, white, crystalline dolomite with 1% combined tremolite, pale green mica, and traces of graphite.

Chemistry: A sample of marble from the old Smith quarry gave the following analysis:

Sample	89 ROSS-02
SiO_2%	0.39
Al_2O_3%	<0.01
Fe_2O_3%	0.08
MgO%	21.4
CaO%	30.8
LOI%	46.9
Total%	99.6
CaO:MgO	1.44
Acid Insolubles%	0.2
Brightness%	90.7

REFERENCES

Hewitt (1964c)
Lumbers (1982)

Photo 19: Old Smith dolomite quarry and stockpile of crushed dolomitic marble, H & H Aggregates quarry (ROSS-02).

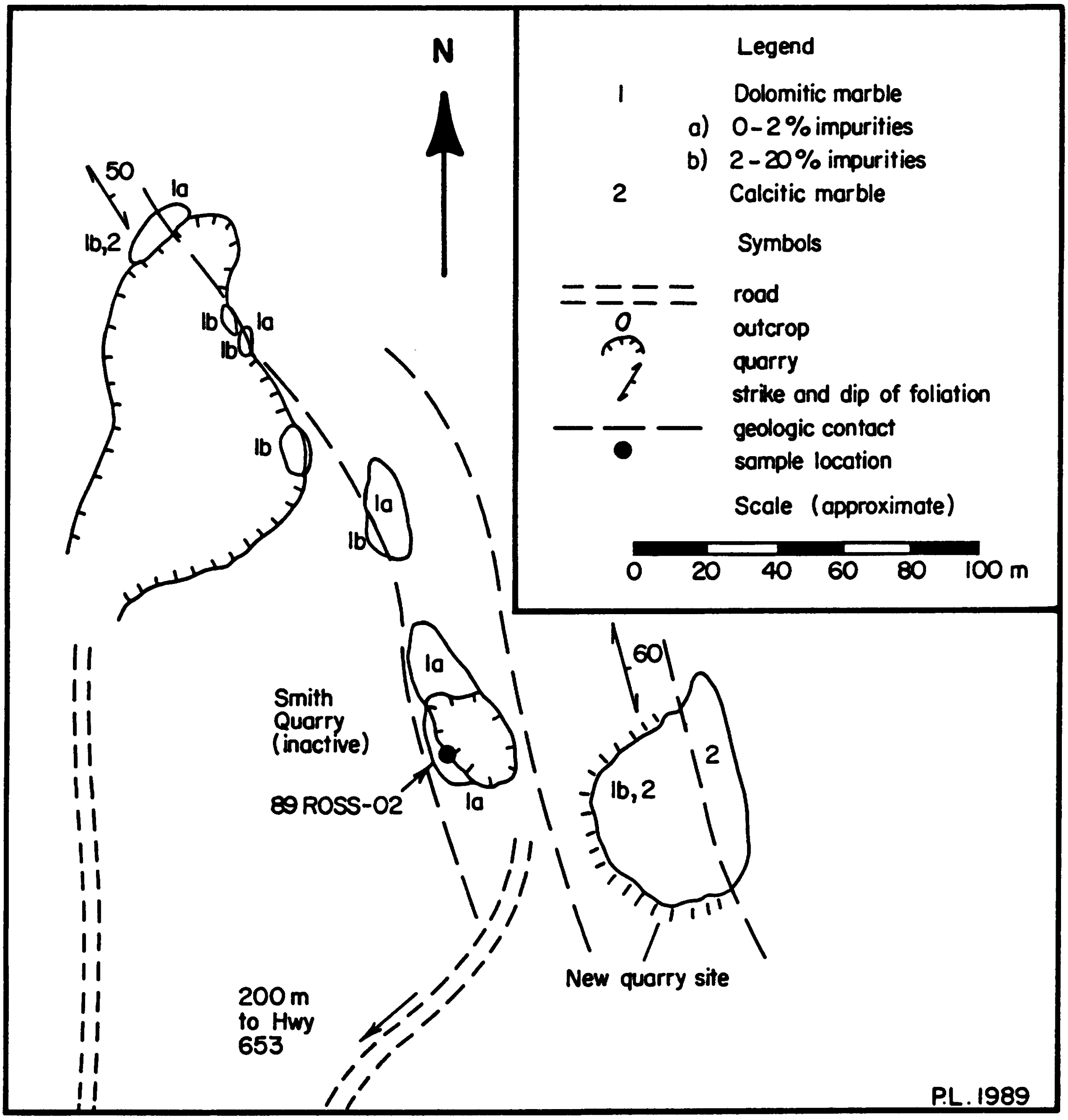

FIGURE 31: Geology of the H & H Aggregates quarries (ROSS-02), Ross Township.

ROSS-03 **ROSS TOWNSHIP**

PROPERTY STATUS

Occurrence; lies within a park reserve area which is withdrawn from disposition.

LOCATION

Lot 22, concession VIII, Ross Township, Renfrew County; UTM Grid 367200mE, 5052300mN, zone 18; NTS 31F/10

ACCESS

Highway 17 to Highway 653, 13 km north of Renfrew; east on Highway 653 to County Road 7, and east on Road 7 about 5.5 km to a T-intersection; about 1 km south on the concession road to an old farmhouse; the dolomite outcrop area is in the field behind the farm house. (Figure 5b)

DESCRIPTION

Geological Setting: The area is underlain by a northerly-trending belt of carbonate and clastic metasediments. This occurrence lies near the eastern margin of the belt within a 1 km wide band of marble which trends easterly between granitic gneiss to the north and gabbroic rocks to the south. About 4 km east of site ROSS-03, in the province of Quebec, is a former producer of dolomite. The quarry, located near Portage du Fort Station, has been closed since 1958. A Montreal-based company, Exploration Aster, estimates that 18 million tonnes of high-purity, white dolomite remain on the property and they plan to begin production in 1990 (The Ottawa Citizen, May 12, 1989).

Previous Geological Work: The area has been mapped at a reconnaissance scale (1:100,000) by Lumbers (1982).

Geology: Detailed mapping of the outcrop area shows a 30 to 40 m wide band of high-purity dolomitic marble which has undergone complex folding (Figure 32). The general trend of the band is northwesterly with a steep eastward dip, but strikes are locally highly variable around tight fold closures. The high-purity dolomite is overlain and underlain by siliceous dolomite which contains up to 25% combined quartz, tremolite, and serpentine as coarse knots and bands (Photo 20). The high-purity dolomite (Photos 21 and 22) contains about 1% combined yellowish chondrodite, pale green talc, and traces of very fine graphite.

Chemistry: Analysis of sample 89 ROSS-03, located as shown on Figure 32, gave the following results:

Sample	89 ROSS-03
SiO_2%	0.73
Al_2O_3%	0.04
Fe_2O_3%	0.10
MgO%	21.3
CaO%	30.8
LOI%	46.4
Total%	99.4
CaO:MgO	1.45
Acid Insolubles%	0.9
Brightness%	90.6

REFERENCES

Lumbers (1982)
The Ottawa Citizen (May 12, 1989)

Photo 20: High-relief weathering of quartz knots in impure dolomitic marble (ROSS-03).

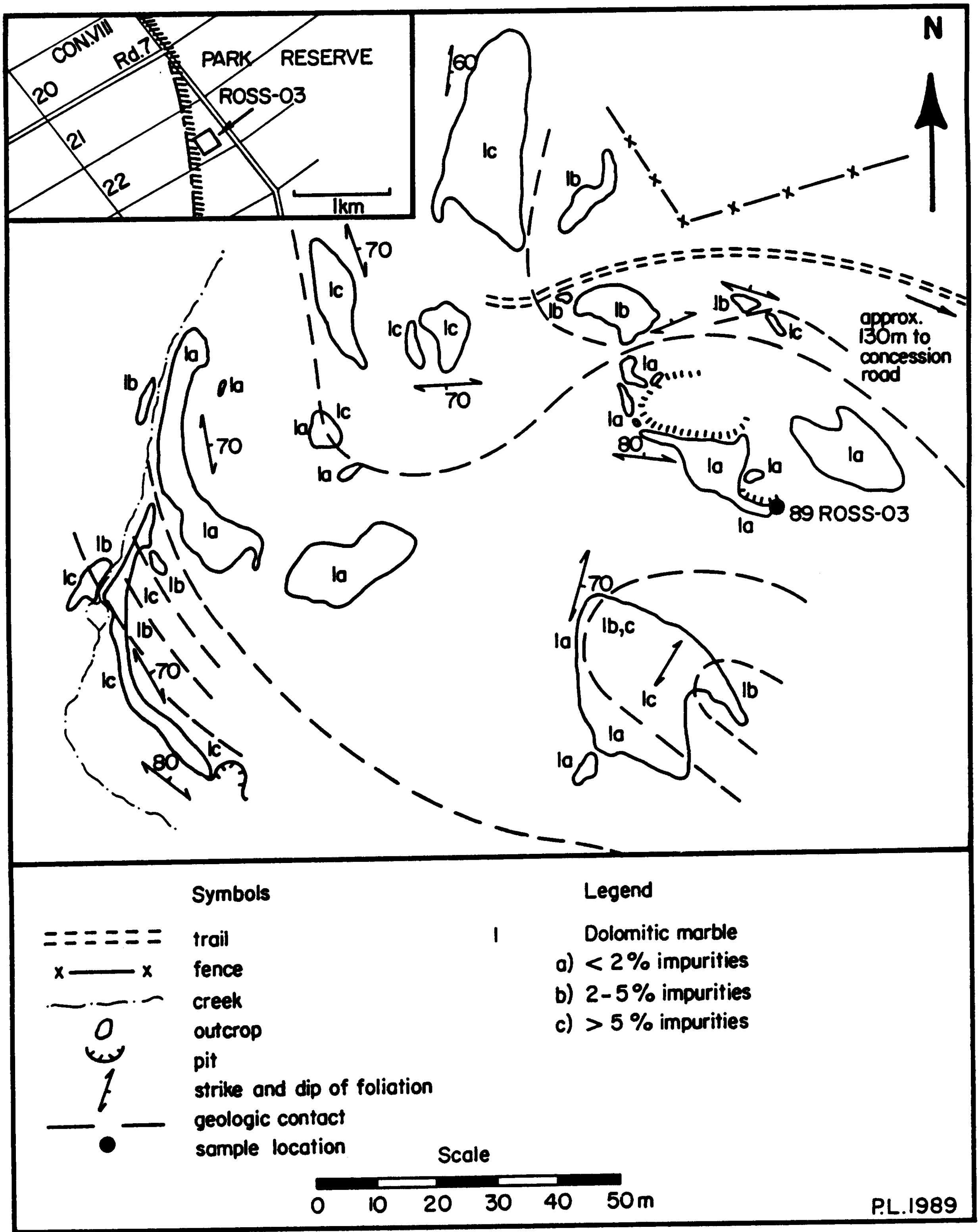

FIGURE 32: Geological map of occurrence ROSS-03, Ross Township. Inset shows location of park reserve boundary, from claim map M. 2296, Ross Township.

Photo 21: Outcrop of high-purity dolomitic marble (ROSS-03).

Photo 22: Dark grey weathering and white fresh surface of high-purity dolomitic marble (ROSS-03).

PROPERTY STATUS

Occurrence; lies partially within a park reserve area which is withdrawn from disposition.

LOCATION

Lot 10, concession XI, Ross Township, Renfrew County; UTM Grid 364700mE, 5060400mN, zone 18; NTS 31F/10

ACCESS

Highway 17 to Highway 653, 13 km north of Renfrew; Highway 653 east to County Road 7 (0.5 km); County Road 7 north to the four-way stop at Millars Corner. Dolomitic marble is exposed from 3.7 to 5.2 km east of Millars Corner on the Grants Settlement Road. (Figure 5b)

DESCRIPTION

Geological Setting: This occurrence lies within a 200 m wide marble band flanked on either side by granitic to dioritic gneiss, within a 4 to 8 km wide, northerly-trending belt of clastic and carbonate metasediments.

Previous Geological Work: The area has been mapped at a reconnaissance scale (1:100,000) by Lumbers (1982).

Geology: This occurrence was described by MacKinnon (1986, p. 359) as follows:

"A narrow band of fairly pure dolomitic marble, trending roughly parallel to the road, occurs here. Flanking both sides is a highly siliceous dolomitic marble containing abundant quartz and tremolitic veins and knots up to 0.5 m in thickness."

"The dolomitic marble is fine grained and white in colour, with a granular, massive texture. Acicular tremolite occurs as a minor constituent within this unit. The width of this band appears to be 50 m at this locality."

Figure 33 is a sketch map of the prospect, showing the location of sample 89 ROSS-04, an analysis of which is presented below.

Chemistry: Sample 89 ROSS-04, a white dolomitic marble containing about 1% combined tremolite, chondrodite, and pyrite, gave the following analysis:

Sample	89 ROSS-04
SiO2%	0.70
Al2O3%	0.01
Fe2O3%	0.19
MgO%	21.3
CaO%	30.7
LOI%	46.4
Total%	99.3
CaO:MgO	1.44
Acid Insolubles%	0.8
Brightness%	88.1

REFERENCES:

Lumbers (1982)
MacKinnon (1986)

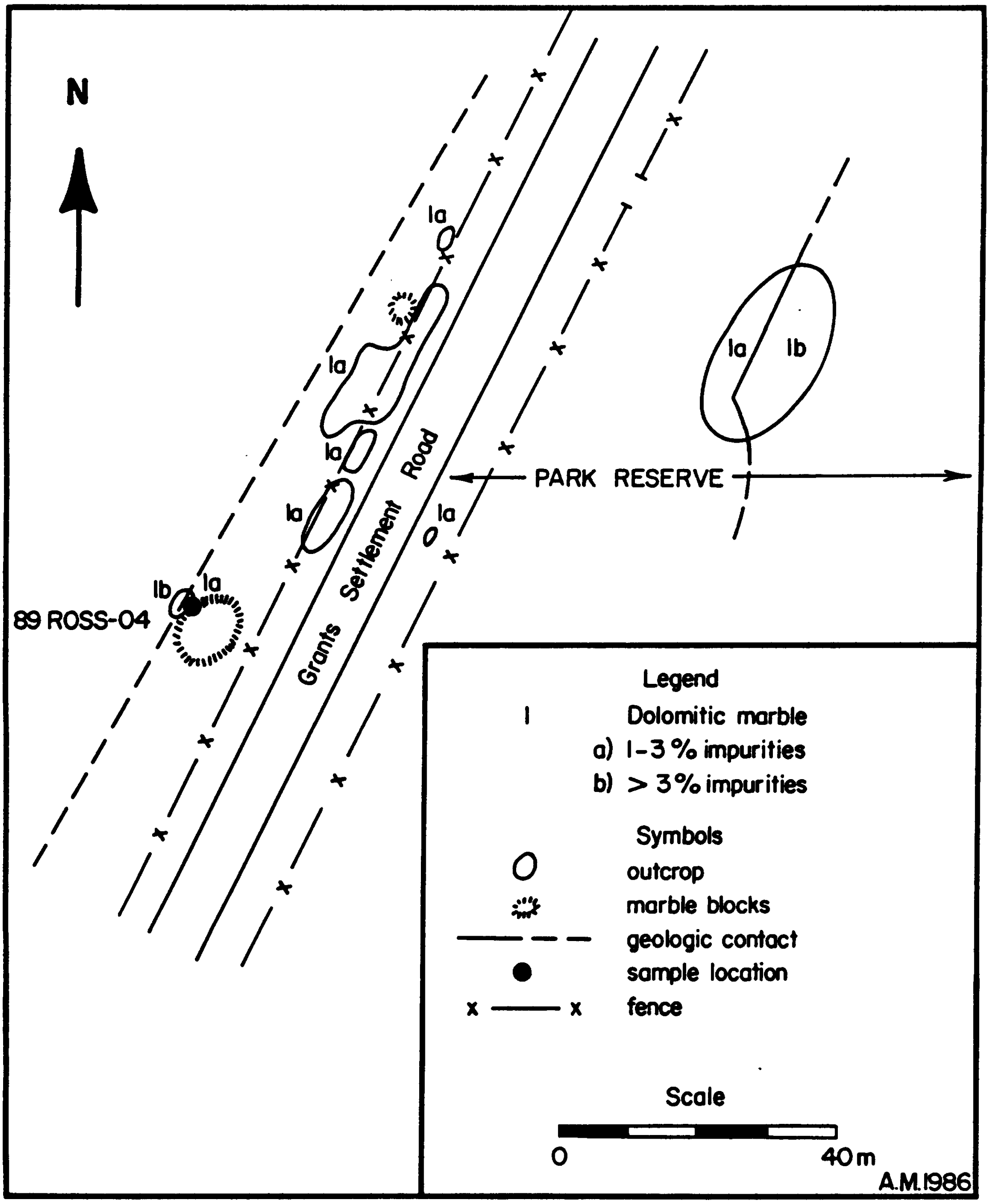

FIGURE 33: Sketch map of occurrence ROSS - 04, Ross Township. Land east of the road is classified as park reserve (claim map M. 2296, Ross Township).

TABLE 7: Summary of Marble Prospects Not Classified as Sources of High-Purity Dolomite

Map No. refers to prospect locations in Figure 4; sample numbers refer to analyses reported in Papertzian and Kingston 1982 (P & K), Grant and Kingston 1984 (G & K), and Vos and Storey 1979 (V & S)

Location	Map No., Name	Description
Barrie Twp. lots 19, 20 con VI (Fig. 5d)	24. BAR-01 (Helena Occurrence)	Mined in 1900 for Cu and Au in quartz veins in marble; fine-grained, white, sugary dolomite marble contains extensive tremolite seams and knots; Sample 528b (P & K). Ref: Meen (1942), Moore and Morton 1985, Papertzian and Kingston (1982).
Belmont Twp. lots 23, 24, con. VI (Fig. 5e)	25. BEL-01 (Round Lake Dolomite)	Fine-grained, sugary, dolomitic marble, buff to pink, contains estimated 5% quartz seams and knots; sample 89 BEL-01 analysis: SiO_2 5.16%, Al_2O_3<0.01%, Fe_2O_3 0.55%, MgO 20.2%, CaO 29.0%, LOI 44.0%, Acid Insol. 5.7%, Brightness 83.7%. Ref: Bartlett and Moore (1985)
Darling Twp. lot 22, con. IX (Fig. 5a)	26. DAR-01	Minor exposure of high-purity dolomite in a belt of predominantly calcitic marble within a cottage area; low development potential; Sample 1675 (P & K). Ref: Papertzian and Kingston (1985), Peach and Smith (1956)
Dungannon Twp. lot 28, con. X (Fig. 5f)	27. DUN-01 (McMillan Quarry)	High-purity, white dolomite was quarried for dimension stone in the early 1900's; however, the high-purity zone is limited to the area of the quarry (20 X 40 m). Sample 419 (G & K). Ref: Grant and Kingston (1984), Hewitt and James (1955), Verschuren et al (1986).

Location	Map No., Name	Description
Dungannon Twp. lots 29 and 30, con. X (Fig. 5f)	28. DUN-02 (Stewart Quarry)	Siliceous, dolomitic marble (>5% SiO_2) was quarried for dimension stone in the early 1900's; varieties include blue, brownish-pink, and green. Ref: Goudge (1938), Hewitt and James (1955), Verschuren et al (1986).
Dungannon Twp. lot 2, con XI (Fig. 5f)	29. DUN-03	Fine-grained, pale grey, dolomitic marble with bands of tremolite and phlogopite and traces of calcite, quartz, and graphite. Ref: Hewitt and James (1955), Verschuren et al (1986)
Faraday Twp. lot 28, con. B (Fig. 5f)	30. FAR-01	Minor exposure of high-purity dolomite in a zone of predominantly tremolitic dolomite; Sample 835 (G & K). Ref: Grant and Kingston (1984), Hewitt (1958)
Lanark Twp lot 25, con II (Fig. 5a)	31. LAN-03	Banded calcitic and dolomitic marble; no significant widths of dolmite; Sample 1580 (P & K). Ref: Papertzian and Kingston (1982), Reinhardt and Liberty (1973)
Methuen Twp. lots 3, 4, con. II (Fig. 5e)	32. MET-01 (Vansickle Dolomite)	Large zone of high-purity calcitic marble is flanked to the east by siliceous dolomitic marble (>3% SiO_2); 3 diamond drill holes by Preussag Canada Limited, 1980 (stored at MNDM Drill Core Library, Tweed). Ref: Bartlett and Moore (1985)
Pakenham Twp. lot 4, con. V (Fig. 5a)	33. PAK-01	Calcitic marble, locally dolomitized; Sample 1819 (P & K). Ref: Papertzian and Kingston (1982), Reinhardt and Liberty (1973)

Location	Map. No., Name		Description
Pakenham Twp. lot 5, con. IV (Fig. 5a)	34.	PAK-02	Dolomitic marble containing >5% tremolite seams and knots; Sample 1817 (P & K). Ref: Papertzian and Kingston (1982), Reinhardt and Liberty (1973).
Pakenham Twp. lot 24, con IV (Fig. 5a)	35.	PAK-03	Dolomitic marble containing >5% tremolite seams and knots; Sample PM-117 (V & S). Ref: Reinhardt and Liberty (1973), Vos and Storey (1979)
Palmerston Twp. lot 27, con. VII (Fig. 5c)	36.	PAL-02	Dolomitic marble containing >5% tremolite seams and knots; Sample PM-135 (V & S). Ref: Peach and Smith (1956), Vos and Storey (1979)
Ross Twp. lot 24, con III (Fig. 5b)	37.	ROSS-05	Dolomitic marble containing bands of calcite and averaging >5% siliceous impurities (tremolite, serpentine, mica, diopside); 2 m of high-purity dolomite at the northern end of a 97 m long roadcut (Hwy 17).

REFERENCES

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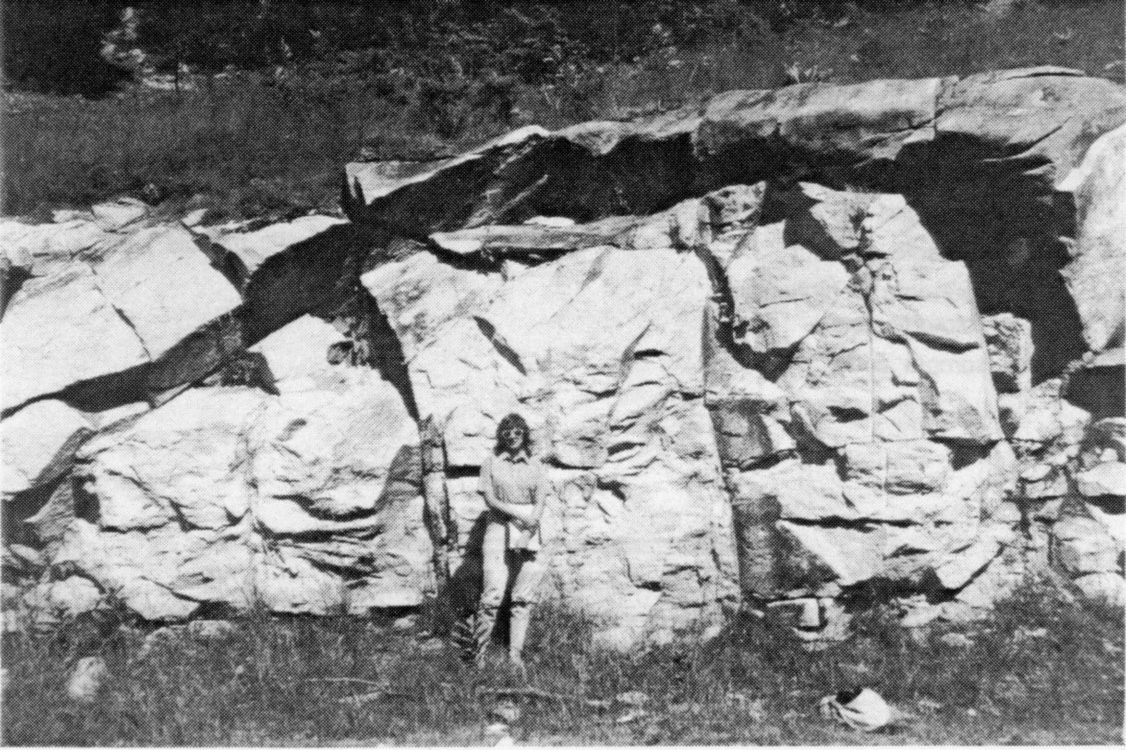
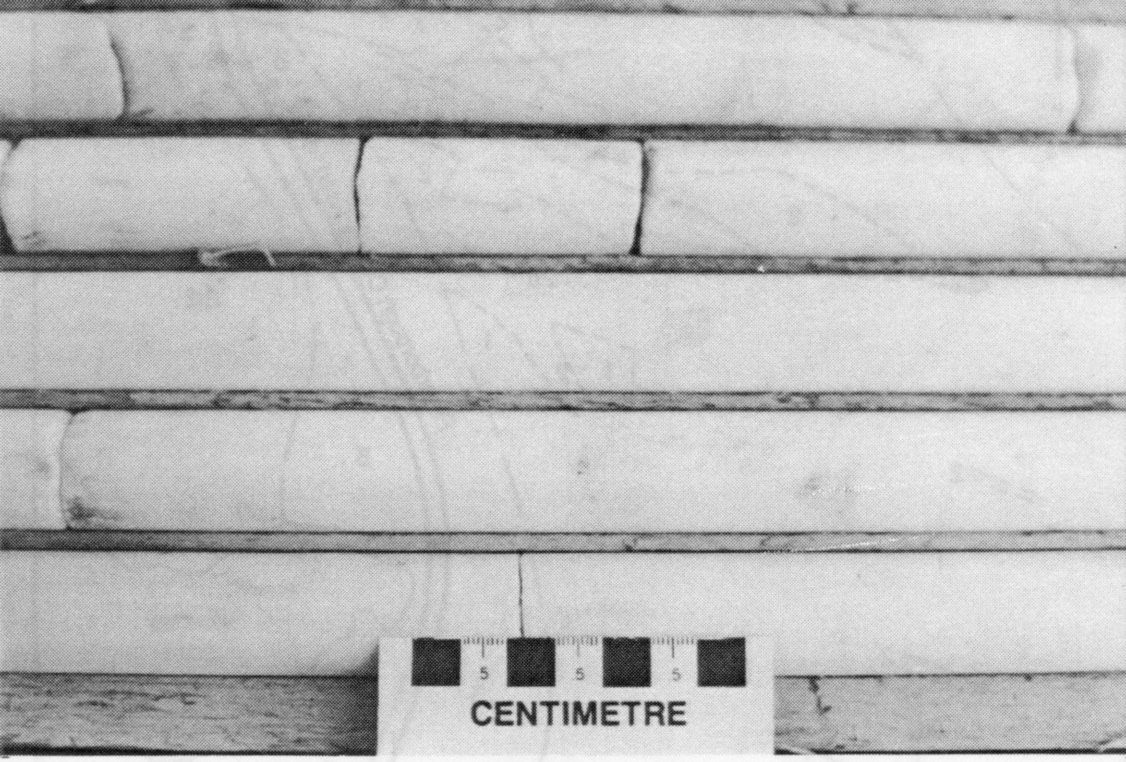
Appendix 1

Southeastern Ontario Dolomitic Marbles - Partial Analyses

Property Name	Sample No.	Na2O %	K2O %	TiO2 %	P2O5 %	MnO %
BAT-01	1915	0.0	0.12	0.02	0.08	0.04
	89 BAT-01	0.1	0.27	0.05	0.04	0.04
BEL-02	89 BEL-02	0.1	0.04	0.02	0.02	0.06
CLA-01	604	0.0	0.00	0.00	0.00	0.04
	89 CLA-01	0.1	0.04	0.02	0.02	0.03
	89 CLA-01a	0.1	0.03	0.01	0.02	0.07
ELZ-01	89 ELZ-01	0.1	0.02	0.02	0.01	0.03
	89 ELZ-01a	0.1	0.02	0.01	0.03	0.00
GRI-01	E-2	<0.1	0.03	0.02	0.02	0.04
GRI-02	G-1	0.1	0.02	0.01	0.03	0.03
HUN-01	89 HUN-01	0.1	0.06	0.02	0.02	0.05
LAN-01	1656	0.0	0.00	0.00	0.08	0.04
	1658	0.0	0.00	0.00	0.08	0.04
	89 LAN-01	0.1	0.06	0.02	0.03	0.05
	89 LAN-01a	0.1	0.06	0.03	0.03	0.05
LAN-02	1553	0.0	0.01	0.01	0.09	0.05
	89 LAN-03	<0.1	0.06	0.01	0.03	0.03
MAD-01	42a	0.0	0.00	0.00	0.00	0.01
	42b	0.0	0.07	0.00	0.00	0.01
	44	0.0	0.00	0.00	0.00	0.03
	89 MAD-01	0.1	0.12	0.02	0.02	0.01
MAD-02	2	0.0	0.00	0.00	0.00	0.05
	3	0.0	0.00	0.00	0.00	0.01
MAY-01	M-1	<0.1	0.31	0.02	0.03	0.07
	M-2	<0.1	0.46	0.05	0.03	0.08
OLD-01	455	0.0	0.00	0.00	0.00	0.09
	460	0.0	0.00	0.01	0.00	0.07
PAL-01	709	0.0	0.00	0.00	0.00	0.06
RAM-01	1745	0.0	0.01	0.02	0.09	0.04
	1758	0.0	0.03	0.01	0.10	0.03
	89 RAM-01	0.1	0.07	0.02	0.03	0.02
	89 RAM-01a	0.2	0.10	0.03	0.03	0.04

Property Name	Sample No.	Na2O %	K2O %	TiO2 %	P2O5 %	MnO %
RAM-02	1804	0.0	0.02	0.02	0.08	0.04
	89 RAM-02	0.2	0.11	0.02	0.02	0.04
ROSS-01	T-2	<0.1	0.02	0.01	0.02	0.02
ROSS-02	89 ROSS-02	<0.1	0.02	0.01	0.01	0.01
ROSS-03	89 ROSS-03	<0.1	0.04	0.02	0.04	0.05
ROSS-04	89 ROSS-04	<0.1	0.03	0.02	0.04	0.07





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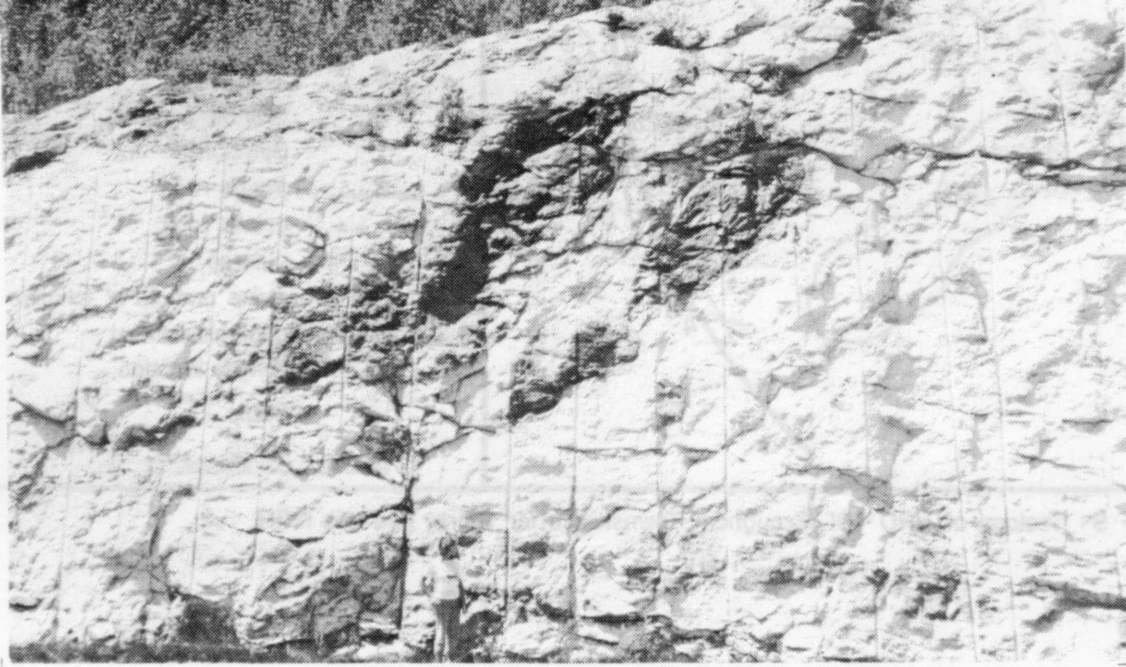

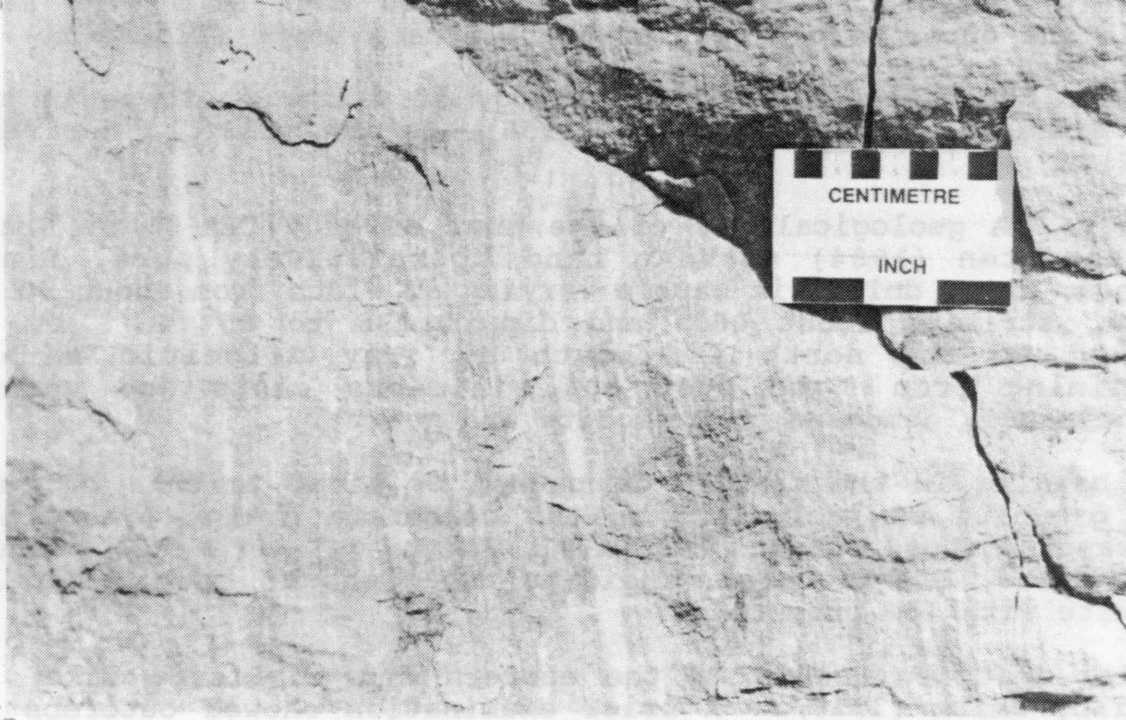
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