GOVERNMENT OF
NEWFOUNDLAND AND LABRADOR
Department of Mines and Energy
Geological Survey

INDUSTRIAL MINERAL POTENTIAL OF THE LOWER PALEOZOIC CARBONATE ROCKS OF WESTERN NEWFOUNDLAND

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Open File NFLD/2853

St. John's, Newfoundland
February 2004

NOTE

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Recommended citation:
A.F. Howse
2004: Industrial mineral potential of the Lower Paleozoic carbonate rocks of western Newfoundland. Newfoundland and Labrador Department of Mines and Energy, Geological Survey, Open File NFLD/2853, 61 pages.

Cover photo: High-purity limestone of the Table Point Formation underlies much of the coast and inland area around Cooks Harbour.

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ABSTRACT

The province of Newfoundland and Labrador hosts abundant limestone, dolostone and their crystalline equivalents. Limestone and limestone products have been steadily produced for almost a century and commercial production of dolomite has been added in recent years from both Newfoundland and Labrador sources.

The largest and most commercially attractive deposits of industrial carbonates are found in the western part of the island including the Great Northern Peninsula. These resources are mainly confined to Cambro-Ordovician platformal rocks of the St. George and Table Head groups. They supply raw material for industries producing a variety of commodities, agricultural limestone, limestone aggregate, and chemical-grade limestone and dolomite products. Extensive undeveloped white, high-calcium marble deposits occur in the Roddickton region. Significant, but relatively unexplored high-purity dolostone prospects, most of which are located on tidewater, are found on the Port au Port Peninsula, at Goose Arm in the Bay of Islands, and at several localities on the Great Northern Peninsula. Important marble prospects for use as dimension stone have been documented in areas south of the city of Corner Brook and west of Deer Lake.

The purpose of this report is to summarize information on these carbonate deposits including data resulting from work carried out by the Newfoundland and Labrador Department of Mines and Energy. This includes data pertaining to potential uses in more recently developed industrial applications such as pollution control systems and industrial fillers.

INTRODUCTION

The province of Newfoundland and Labrador is generously endowed with resources of limestone and dolostone and their marble equivalents, and the island has produced limestone and limestone products for almost a century. The resource, ranging in age from Precambrian to Carboniferous, is widely distributed, but the west coast of Newfoundland hosts the largest and purest deposits, and is the main focus of this report. In recent years, considerable new information has been built up on the province's limestone, dolostone and marble resources, resulting from studies and assessments by government and industry. Work on limestone, dolostone and marble have provided much new information on the chemical and physical quality of various undeveloped prospects. In addition, new studies and assessments have been carried out by government and industry into the dimension-stone potential of the carbonate rocks mostly to the south of Corner Brook and west of Deer Lake. The purpose of this report is to provide interested parties with data on undeveloped carbonate resources, to stimulate those who may be interested in investigating and developing such resources, and to consider this province as a potential primary source of carbonate raw material.

Global trends affecting the production and trade of industrial minerals are likely to have a direct impact on the further development of Newfoundland and Labrador's abundant carbonate rock resources. Such trends include: public pressure and resulting government legislation concerning the control of environmental pollution; new developing technology including more elaborate processing techniques and new applications; a trend favouring natural stone in construction and renovations; and an increasing international trade in industrial minerals.

Environmental laws and regulations aimed at reducing sulphur emissions and acid rain should have a positive impact on market demand for limestone and lime (and possibly dolostone), which are used to scrub gasses from smoke stacks and to treat liquid wastes and industrial effluent. On January 1, 2000, Phase II of the United States Clean Air Act Amendments of 1990 went into effect and is expected to benefit the flue-gas desulphurization market for lime and limestone. Phase II generally limits sulphur dioxide emissions to the same level as for post-1978 power plant level, *viz.*, 1.2 lbs of sulphur dioxide per million BTU (Miller, 2000).

The evolving technology of industrial minerals and resulting new end-uses are likely to benefit this province. In the field of filler and extender minerals, ground calcium carbonate (GCC) (marble) is replacing more expensive titanium dioxide in paint, and the use of ultra-fine ground white marble for filling and coating paper is growing. Another example of the link between research and development and carbonate rocks can be seen in Labrador, where the Iron Ore Company of Canada produces self-fluxing iron-ore pellets at its Labrador City iron-ore facility using a local source of dolomite and limestone from Newfoundland.

Advances in cutting-machine technology and lower production costs, has enhanced the traditional popularity of marble as a dimension stone, particularly for interior decoration and trim. Thus, the multicoloured and diversely textured marbles on the west coast of Newfoundland are likely to attract more commercial attention in the future.

DEFINITION OF TERMS

The terminology and definition of terms used in literature on limestone and dolostone are not always uniform and consistent. Table 1 defines some of the main terms as used in this report.

Table 1. Definitions of limestone and dolostone as used in the report

Limestone	A sedimentary rock containing more than 50 percent by weight of the mineral calcite ($CaCO_3$).
Dolostone	A sedimentary rock similar to limestone in which the mineral dolomite, $CaMg(CO_3)_2$, predominates.
High-calcium limestone	Contains at least 95 percent calcite ($CaCO_3$).
High-purity dolomite	Contains 87 to 94 percent dolomite, $CaMg(CO_3)_2$, or 40 to 43 percent $MgCO_3$.
Marble	A metamorphic, highly crystalline carbonate rock, which may be highly calcitic or dolomitic.
Burnt lime	A general term referring to burned or calcined limestone and its secondary products including slaked and hydrated lime.
Cement stone	An impure limestone composed of the required balance of calcium carbonate, silica, and aluminum, needed for manufacturing Portland cement.

USES AND INDUSTRIAL SPECIFICATIONS

LIMESTONE / DOLOSTONE

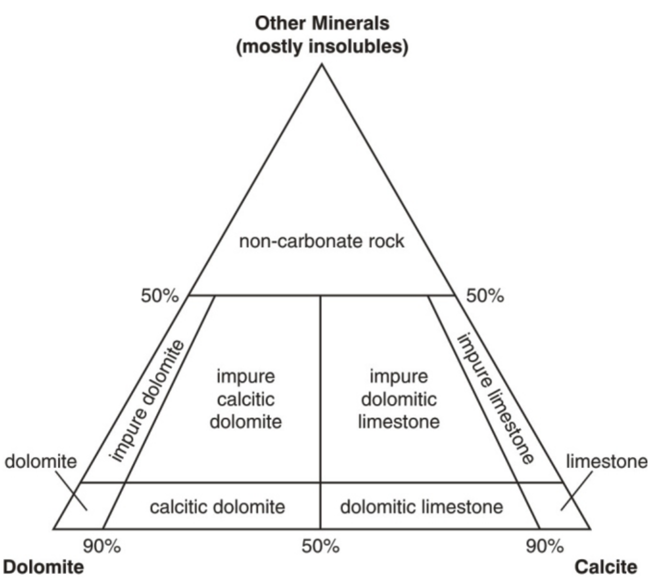
Limestone is probably the most useful of all the industrial rocks and minerals with over a hundred industrial applications. The main use is in the construction industry where it is used in cement, aggregate, and as building stone. Other important uses for limestone and its derived products include fluxes, glass raw material, pollution control, paper manufacture, dolomitic refractories, fillers, abrasives, soil conditioners and numerous chemical processes. Figures 1 and 2 show carbonate rock classifications by end-use and mineralogy.

Limestone for Cement

Limestone is used to form a calcium aluminosilicate clinker (by fusion of calcium oxide with clay) in the manufacture of cement. The critical criteria in determining if limestone is cement grade is its MgO content, which should not exceed 4 percent. Considerable variation in other elements, particularly silica, aluminum and iron, can be accommodated because quartzite and shale are commonly added to raw clinker in a cement plant. Among the trace elements, the alkali content (K_2O + Na_2O) can be very deleterious if it exceeds 0.5 percent.

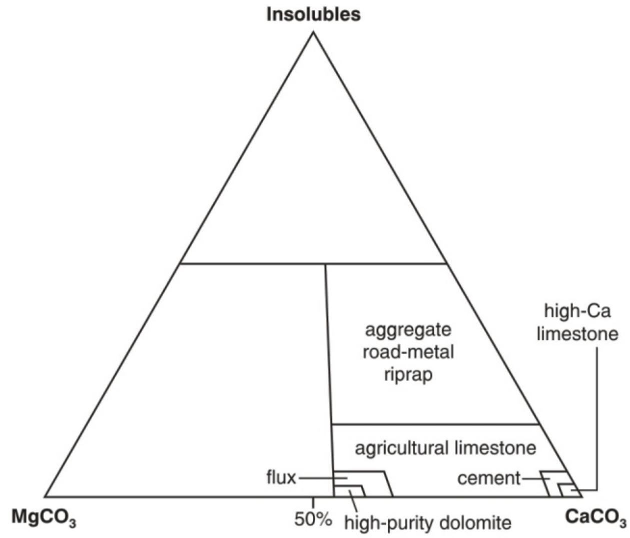
Flue Gas Desulphurization

Public pressure and resulting government legislation concerning the control of air pollution have hastened the



Source: Lefond (Ed.) 1983. Industrial Minerals and Rocks

Figure 1. *Mineralogical classification of carbonate rocks.*



Source: Hershey & Mahar 1985. Limestone & dolomite resources of Tennessee

Figure 2. *Carbonate rock classification by end use and mineralogy.*

development of scrubbing devices to reduce emissions from the burning of high-sulphur coal, oil and lignite. Several methods have been developed including the use of Flue Gas Desulphurization (FGD) units or scrubbers. The scrubbing options include wet scrubbing with limestone or lime, dry scrubbing with lime, dry injection using sodium reagents, trona, or nacholite, dry injection using limestone integrated with calcium oxide activation, and dry injection of hydrated lime. Wet scrubbing processes using limestone or lime appear to be gaining favour but the ultimate choice depends on many factors including resource availability, solid waste disposal programs, flue-gas characteristics, and the type of fuel consumed by the power station (Andrews and Vagt, 1993).

The physical and chemical characteristics of limestone have been the subject of extensive research to determine the factors that make it most reactive in the traditional wet and newer dry injection processes (Miller *et al*., 1993). The stone has to be subjected to pilot-plant assessment to evaluate its behavior. Generally, the use of limestone in scrubbers requires a chemical purity of 85 to 95 percent $CaCO_3$, <5 percent acid insolubles, and in most cases <5 percent MgO. Iron content could be beneficial as a catalyst in the process, but not if it occurs as pyrite, which reduces reactivity. Other factors such as grain size, porosity, and pore-size distribution significantly affect reactivity (Power, 1985; Hamer, 1986).

The environmental importance of lime is emphasized by its increasing use in such applications as the treatment of liquid wastes and industrial affluents, and the neutralization of lakes that have been acidified by precipitation containing sulphur dioxide and nitrogen dioxide emissions. The treatment of such acid bodies of water has utilized limestone and limestone products such as quicklime and hydrated lime in addition to powdered calcite and dolomite. Research carried out in Ontario has shown that high-purity limestone (or calcite) is the most cost-effective material (Andrews and Vaght, 1993).

Agricultural Use

Limestone is used in agriculture to neutralize excess soil acidity. A useful figure used to compare the theoretical acid-neutralizing capacities of various limestone and dolostone products is their calcium carbonate equivalent (CCE). This number expresses the acid-neutralizing capacity of a carbonate rock relative to the capacity of pure calcium carbonate (calcite), which has a CCE of 100 percent. It is calculated using the formula CCE=(1.785 x wt.% CaO + 2.483 wt.% MgO). Other factors such as particle size and distribution, and the type of impurities present also have to be considered in evaluating the quality of agricultural limestone (Goodwin, 1979).

Fillers, Extenders and Whiteners

Finely ground and pulverized calcium carbonate is used as a filler in various products (Table 2). Generally its source is limestone, chalk, marble and less commonly vein calcite. In industrialized countries, calcium carbonate used as filler may outrank calcium carbonate used as dimension stone by as much as 40 times by tonnage, and twice by value (Harben and Bates, 1990). Deposits of white marble, though scarce, are the most common sources of carbonate mineral fillers.

The original purpose of a filler was to replace a more expensive material such as titanium dioxide in paint or polymer in plastics or rubber. Now the role of fillers has evolved into more functional aspects such as adding colour, stiffness, opacity or other desirable attributes to a product. The expanded role of fillers has escalated their price so that they are no longer considered inexpensive. In this field, calcium

Table 2. Primary uses for carbonate fillers

Application	Function	General Specifications
Paint	Extender of prime pigments	High whiteness, 44 to 8 microns top size, acid insoluble 0.2% max.
Plastics	As a resin extender in a wide range of polymer systems	High whiteness, controlled particle size 30 to 5 microns top size, acid insoluble 1.0, 5 max.
Paper	Filler for paper coatings, partial replacement for kaolin	High whiteness, controlled particle size, low abrasion, particle size 10 to 4 microns, acid insoluble 1.0% max.
Putty, Caulking, Sealing	Filler and sealant	White, medium to fine 90-99 percent 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
Carpet Backing	To provide body and weight	White to grey colour, 90-99 percent passing 325 mesh
Asphaltic Products	Filler in roofing materials and asphalt sealers	Off colour, buff to grey, coarse ranging from 80 percent passing 325 to 80 percent passing 200 mesh
Rubber	Filler pigment in footwear, car goods non-reinforced rubber, wire and cable coatings	White to off-color, fine to medium fine products
Construction	Filler in jointing compounds for gypsum board	Lower grade white products; 90-95 percent passing 325 mesh
Other	Synthetic marble	White coarse products; 80-85 percent finer than 200 mesh, and granular grades
Coal mines	Coal dusting	White to buff, coarse filler used in coal mining

carbonate competes with numerous other industrial minerals.

The most significant attributes of carbonate fillers that determine their usefulness in industrial applications are particle size, brightness (whiteness) and mineralogical and chemical purity. Products such as paper, paint and plastics require very bright fillers. Depending on the method used to measure light reflectance, minimum brightness specifications may range from 94 to 96 percent. Other products such as asphalt roofing and sealers, carpet backing, jointing compounds and some plastics, are less demanding and permit the use of off-white to grey calcium carbonate, provided other specifications are met.

With regard to mineralogical and chemical purity, the main requirement is to have the maximum calcium carbonate possible. It is desirable to have a minimum of acid insoluble minerals such as quartz or any hard, abrasive minerals. The presence of dark minerals adversely affects the colour of the filler thus limiting its commercial value. It is possible to remove such contaminants by magnetic separation, electronic colour sorting, froth flotation, and manual sorting of the crude rock. Table 2 lists the primary uses and general specifications for carbonate fillers.

Limestone Aggregate in Concrete

A significant market for limestone is its use as aggregate in concrete where a hard, dense material having low porosity is required to resist frost attack. The limestone must be free of any clay, mica, shale or other platy or laminated particles, and be free of any soluble minerals, sulphides or organic matter.

Limestone in Iron Smelting

Limestone is used as a flux in the reduction of iron ores and as a sulphur remover. The specifications for this application are strict, requiring high-calcium carbonate and no sulphur or phosphorous, and <1 percent silica.

Limestone in Glass Production

Limestone plays an important role in glass making because its fluxing action on silica sand forms a chemically fused calcium silicate glass. The CaO content of limestone improves the chemical and physical characteristics of the glass by increasing the insolubility factor of the finished material. Limestone also enhances the quality of finished glass by improving its strength, reducing brittleness, and providing a more enduring luster. Table 3 gives the British Standard BS 3108 specifications for chemical purity of limestone in the manufacture of colourless glass are typical for the industry.

Table 3. Specifications for chemical purity of limestone for the manufacture of glass

CaO	min.	55.2%
$CaCO_3$ equivalent	min.	98.5%
Fe_2O_3 and FeO	max.	0.035%
Acid insoluble content	max.	1.0%
Organic matter	max.	1.0%
Moisture content	max.	2.0%
MnO, PbO, P_2O_5, SO_2 (each)		<0.1%

Source: Andrews and Vagt (1993)

Dimension Stone

Marble and limestone can be highly valued commodities in the construction industry, particularly for interior building applications such as columns/facings, floors and trim. For these and other purposes producers are expected to supply large, thin, polishable, slabs with no physical flaws. In a review of procedures and standards for dimension-stone assessment, Harben and Purdy (1991) emphasized that the manner in which test blocks are excavated is as critical in dimension-stone evaluation as in any other mining project. Blocks should be sawn rather than blasted, and maximum use made of natural attributes of cleavage and bedding. In practical terms the specimen block for technical testing should measure at least 56 x 61 x 76 cm (22 x 24 x 30 inches). Blocks extracted for slabbing, to assess the aesthetic qualities of the marble, should be as large as possible, or at least 1 x 1 x 1.5 to 2.0 m. The standard ASTM tests (Table 4) are considered critical in the dimension-stone industry for estimating product potential.

The presence of esthetically pleasing colours and textures are potential advantages that cannot be overated in a competitive market. For the potential producer this means that once such a rock unit has been identified, physical tests have to be carried out and significant tonnages of uniform colour and texture have to be proved.

Table 4. Standard ASTM tests for dimension stone

Water absorption / Bulk specific gravity	ASTM C 97
Modulus of rupture	ASTM C 99
Compression strength	ASTM C 170
Abrasion resistance	ASTM C 241
Flexural strength	ASTM C 880

GEOLOGICAL SETTING OF LIMESTONE AND DOLOSTONE AND THEIR MARBLE EQUIVALENTS

Insular Newfoundland represents a cross-section of the Appalachian–Caledonian orogen, a mountain belt that extends from the southeastern United States along the Atlantic seaboard and through the Atlantic Provinces of Canada. Beyond Newfoundland, the belt has been fragmented by opening of the Atlantic Ocean but is recognized in Ireland, Britain, Scandinavia, Greenland and western Europe. Williams (1979) divided Newfoundland geology into four zones (Humber, Dunnage, Gander and Avalon) based on the contrasting development of pre-Middle Ordovician rocks. Rocks of the Humber Zone record the evolution and destruction of the continental margin of ancient eastern North America (Figure 3). The Dunnage Zone contains ophiolite suites and volcanic complexes that collectively represent remnants of an early Paleozoic ocean, whereas the Gander Zone comprises the eastern margin of that terrane. Rocks of the Avalon Zone represent elements of an easterly late Precambrian–Cambrian continental terrane.

Limestone deposits ranging in age from Precambrian through Carboniferous comprise part of the sedimentary and metasedimentary sequences in all four tectonographic zones. However, the Humber Zone is by far the most generously endowed division, containing extensive areas underlain by thick sequences of limestone and dolostone, some parts of which are metamorphosed into marble. Thin carbonate units occur in the two major Carboniferous sedimentary basins (Bay St. George and Deer Lake basins) occur within the Humber Zone, adjacent to and west of the Cabot Fault system (Figure 4).

The Humber Zone consists mainly of Precambrian basement rocks overlain by platformal sequence of clastics and carbonate rocks (Figure 4) and allochthonous sedimentary and ophiolitic rocks. The platform rocks are mainly limestones and dolomite and lesser siliciclastic rocks that range in age from Early Cambrian to Middle Ordovician. They

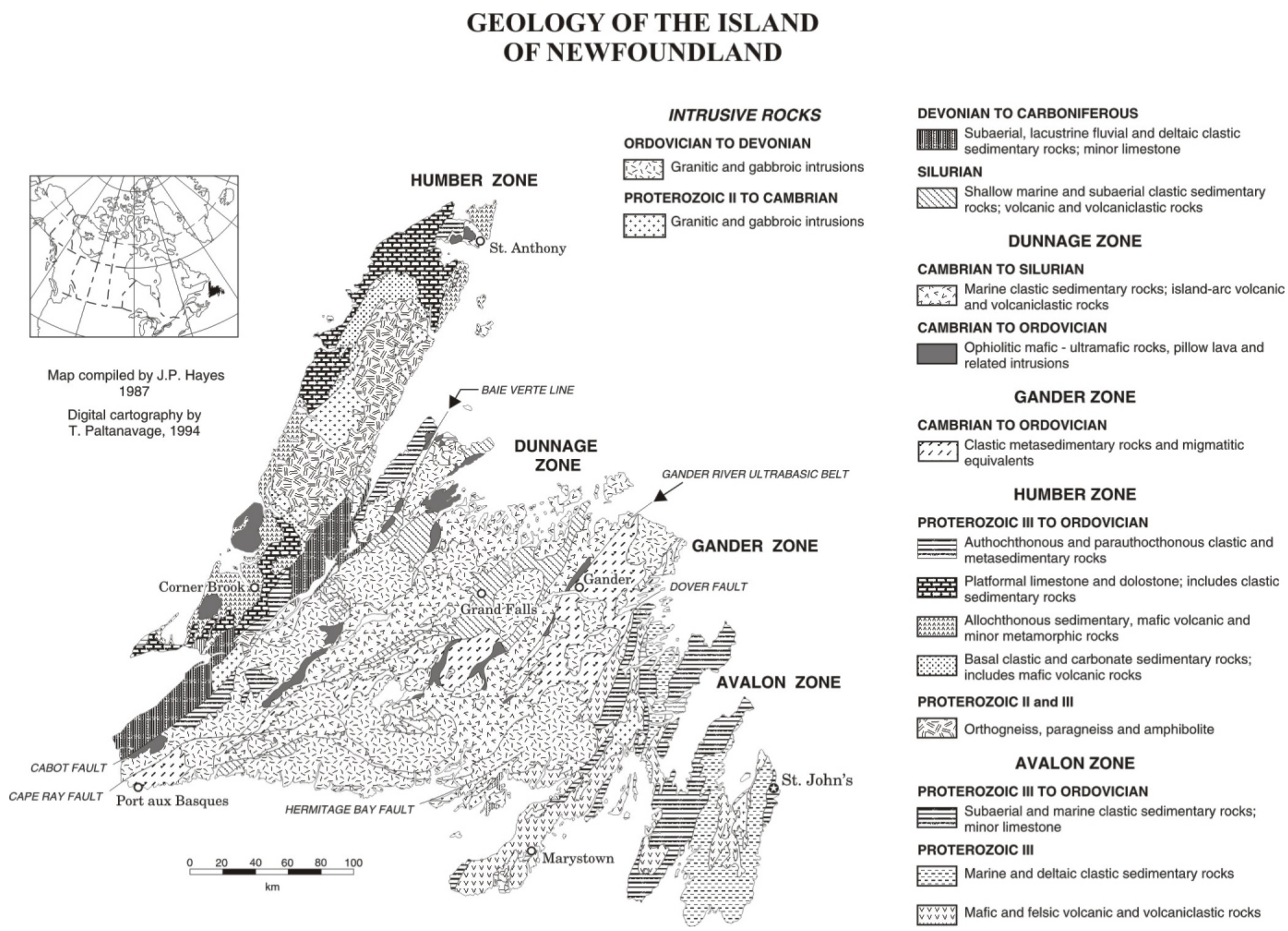


Figure 3. *Geological map of Newfoundland showing tectonostratigraphic zones.*

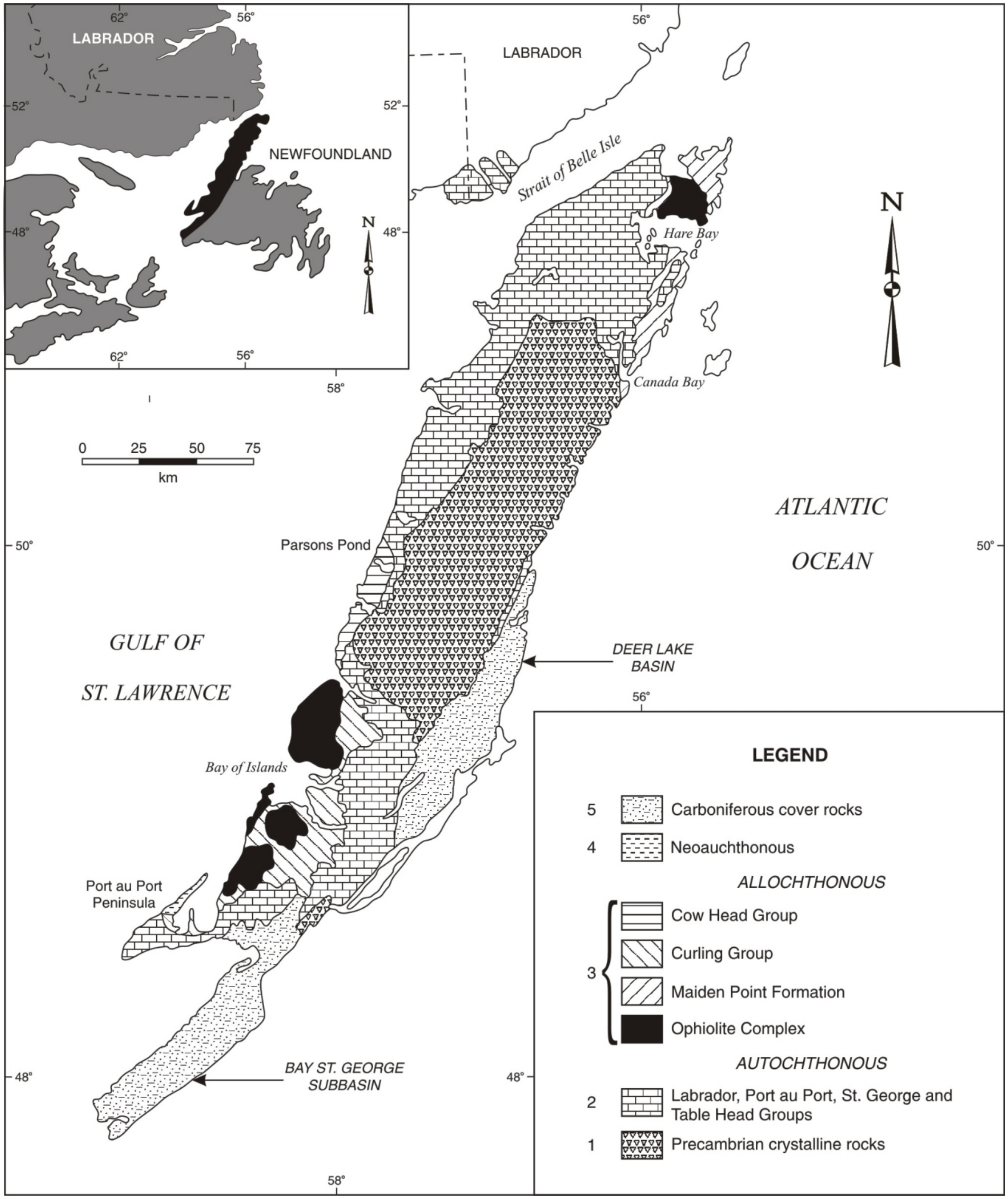


Figure 4. *Geology of the Humber Zone in western Newfoundland.*

record the development of a passive continental margin and the early phases of the Taconic Orogeny (Knight *et al.*, 1995). In Newfoundland, the sequence is divided into the Labrador, Port au Port, St. George and Table Head groups. They underlie a 400 km strike length from the Port au Port Peninsula in the south to Cape Norman at the northern tip of the Northern Peninsula (Figure 4). The St. George and Table Head groups are particularly important because they host economic deposits of limestone and dolomite, and significant deposits of their marble equivalents (Figure 5). Current production is confined to the southern end of the belt where operations consist of a high-volume limestone and dolostone quarry on the Port au Port Peninsula (Atlantic Minerals Limited), and an aglime and aggregate quarry at Cormack (C-Mack Construction Limited). A limestone quarry at Aguathuna on the northeast shore of the Port au Port Peninsula, was a source of flux for the Dominion Steel and Coal Corporation (DOSCO) of Nova Scotia for over 50 years and cement was manufactured until recently at Corner Brook (Northstar Cement Limited). Marbles having industrial potential are found in the Roddickton area (industrial filler and whitener) and the Corner Brook and Deer Lake regions (dimension stone).

Other significant marble deposits have been documented in the Long Range Precambrian inlier and in the Eocambrian to Cambrian Coney Arm Group, a belt of clastic–carbonate rocks that unconformably overlies the southeast edge of the inlier.

The industrial potential for limestone and dolostone appears to be low in the Dunnage and Gander zones. Known occurrences are associated with apparent Eocambrian and Ordovician metamorphosed rocks and, to a limited extent, with Ordovician and Silurian volcanic rocks.

Limestone deposits in the Avalon Zone occur almost entirely within the Cambrian section, which is partially preserved in numerous, widely distributed localities throughout the subdivision.

REVIEW OF ASSESSMENT AND DEVELOPMENT

The carbonate rock resources of western Newfoundland range in their degree of assessment. Many prospects have had only cursory evaluations involving mapping and surface sampling, while some advanced prospects have had more intense programs involving core drilling for reserve and grade calculations, test quarry development, and bulk sampling for metallurgical and processing studies. Generally, drilling programs are required to estimate the grades and tonnages of most potential deposits. Only deposits at the southern end of the carbonate belt have been developed. However, deposits of similar size, and in some cases superior quality on the Northern Peninsula have yet to become producers. The vastly improved infrastructure and transportation on the peninsula make these deposits amenable to development.

LIMESTONE

Limestone production in Newfoundland dates back to the early nineteenth century when quarrying on a small scale was carried out in several areas to supply raw material for lime production. Kilns located in St. John's were supplied with stone from thin Cambrian sequences on the Avalon Peninsula and with higher grade limestone from the higher grade Ordovician deposits at Cobbs Arm in central Newfoundland. The busy copper mines at Tilt Cove, Betts Cove and Little Bay also used Notre Dame Bay limestone to provide a neutralizing agent for treating their ores (Harris, 1962).

In 1913, the limestone industry acquired a more important status in the Newfoundland economy when DOSCO established a quarry and loading facility at Aguathuna, on the Port au Port Peninsula. The Aguathuna operation operated for fifty years and had produced about 10 million tonnes by the time it closed in 1965. The Aguathuna quarries marked the first significant limestone production from the west coast carbonate sequences. Most of the production came from the Middle Ordovician Table Point Formation although in later years some production came from the carbonates of the Lower Ordovician St. George Group. The limestone was shipped to Sydney, Nova Scotia, where it was used as a fluxing agent in the DOSCO steel mills.

The start of the pulp and paper industry in Grand Falls, Newfoundland in 1909 introduced a new but rather modest market for limestone. This demand was met by the existing quarries at Aguathuna, Cobbs Arm and the Dormston quarry at Corner Brook. Between 1943 and 1956, Bowaters Pulp and Paper Limited at Corner Brook quarried 15 000 to 20 000 tonnes annually from the Dormston quarry for the manufacture of sulphite pulp.

In 1949, a cement plant was established in Corner Brook and was operated by Northstar Cement Limited. The plant used nearby deposits of limestone and shale, and a small amount of gypsum from Flat Bay, to manufacture Portland cement. About 80 000 tonnes of cement per year were produced for the Newfoundland construction industry. The limestone graded from 53 to 55 percent CaO and 1 to 2 percent MgO. Strict quarrying control was necessary to avoid high magnesium sections. Shale was obtained from a nearby quarry which was located in older, overlying strata.

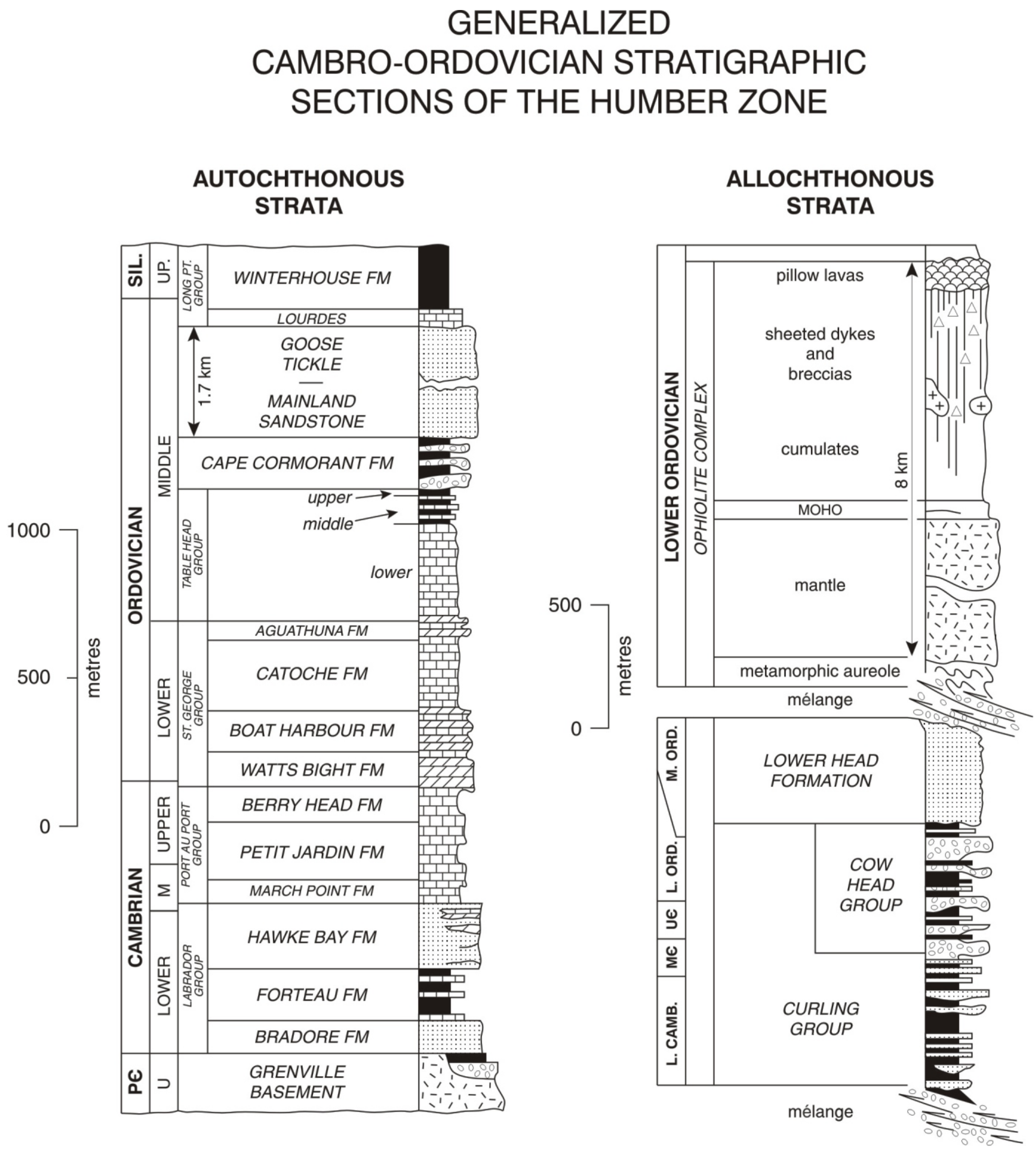


Figure 5. *Generalized Cambro-Ordovician stratigraphic sections of the Humber Zone.*

On May 17, 2000, Northstar Cement Limited announced the closure of its cement manufacturing plant at Corner Brook including its storage and distribution terminal at Humbermouth less than a kilometre away. Among the reasons for closure, the company cited high fuel costs, inability to tender for large projects because of changes in cement specifications that they were unable to meet, and the need to further upgrade the aging plant that would have required a prohibitive level of capital investment.

Beginning in the 1950s, there was an increased recognition of the province's industrial mineral potential. This was reflected on the west coast by a series of limestone and gypsum studies, including reconnaissance limestone surveys by Lee (1956) and Harris (1962), followed by more detailed studies around Corner Brook by McKillop (1961, 1963), and on the Port au Port Peninsula (Besaw, 1973). The data from these surveys, as well as information from numerous other sources, were incorporated into a comprehensive report on insular Newfoundland's limestone resources by DeGrace (1974). The report concluded that large commercially attractive deposits of limestone occur on Newfoundland's west coast and the Northern Peninsula and made special note of the large resource of high-purity limestone exposed on the Port au Port Peninsula.

The development of an integrated limestone aggregate quarrying and shipping facility at Lower Cove on the Port au Port Peninsula by Explaura Holdings Limited in 1985 refocused interest on the Port au Port Peninsula and its extensive carbonate rock resources. This operation went bankrupt and the property was acquired by Atlantic Minerals Limited in 1990. The new production of chemical and metallurgical-grade limestone and dolomite, was an important milestone in the development of the province's industrial carbonate resources. In Labrador, the Iron Ore Company of Canada produces dolostone from a dolomitic marble deposit near Labrador City. It is used in the production of self-fluxing "dolomitic type" pellets at its Labrador City iron-ore facility.

MARBLE

Newfoundland's marble deposits initially attracted interest because of their potential use as building stone. Early attempts to quarry ornamental building stone from white marble deposits at Clay Cove in White Bay and Canada Harbor on the Great Northern Peninsula were unsuccessful (Edgar, 1928; Bain, 1937). Initial work by Muir (1935) and Howse (1936) on marbles in the White Bay and Canada Bay areas led to a more detailed study by Bain (1937) into the potential use of marble for dimension stone. Goudge (1965) explored the possibilities of producing terrazo chips for use in floor tiles from marble deposits near Corner Brook and Sops Arm. Further evaluation of Newfoundland marble deposits was carried out during larger surveys of the island's limestone resources, e.g., Lee (1956), McKillop (1963), Besaw (1973) and DeGrace (1974). These studies were primarily concerned with identifying carbonate suitable for industrial applications such as cement and quicklime manufacturing, together with metallurgical use.

In 1985, the Newfoundland Department of Mines and Energy began an evaluation of the province's marble resources (Howse, 1986). The study was sparked by the increasing industrial demand for ground calcium carbonate for use as mineral filler in a variety of industrial products including paint, paper, and plastic. The 1985 survey involved extensive chip sampling of white, high-purity marble prospects on Newfoundland's west coast and Northern Peninsula. Chemical and physical analyses of the samples identified several white marble showings that warranted follow-up work. A diamond drilling program near Roddickton delineated two deposits of high-calcium white marble (Penny's Pond and Coles Pond), both of which were awarded to private industry for further assessment and development (Howse, 1987).

DOLOSTONE

Carbonate rocks of the Lower Ordovician St. George Group of Newfoundland's west coast have been studied extensively in recent years (Knight, 1977, 1985, 1986, 1987; Knight and Boyce, 1984; Knight *et al*., 1983). Haywick and James (1984) studied the stratigraphic and geographic distribution of dolomite in the St. George Group and also documented its various textures. However, except for the early studies of Fong (1968), Besaw (1974) and DeGrace (1974), little was done to determine the economic potential of the dolostone. Fong's (1968) survey included the Port au Port Peninsula, Goose Arm, Deer Cove and Port au Choix areas. Besaw (1974) studied the dolostone potential of the Port au Port Peninsula and identified a unit of dolostone that he called the Pine Tree Unit, as possibly hosting metallurgical-grade stone. This unit is stratigraphically equivalent to the dolostones of the Lower Ordovician Catoche Formation of Knight and James (1987). More recently, Norsk Hydro carried out reconnaissance exploration for metallurgical-grade dolostone on the west coast of Newfoundland. The objective was to identify dolostone of sufficient quality for the production of magnesium oxide and magnesium metal. Norsk Hydro, through mapping and diamond drilling, delineated a significant resource of high-purity dolostone south of Piccadilly on the Port au Port Peninsula but no further development took place.

A project was initiated in 1987 by the Newfoundland Department of Mines and Energy aimed at locating and assessing the potential for metallurgical-grade dolostone deposits in the carbonate sequences of western Newfoundland (Delaney and Howse, 1988). The objective was to locate a deposit (minimum 10 million tonnes having 21 percent MgO, less than 1.5 percent SiO_2, total Al_2O_3 + Fe_2O_3 less than 1 percent, less than 200 ppm Mn, less than 10 to 15 ppm B, and low Cr. Suitability for quarrying and proximity to tidewater were also important considerations in the assessment program, which consisted mainly of detailed mapping and sampling. Five areas with good potential were outlined, most of which occur in the Catoche Formation. Sites worthy of followup were found on the Port au Port Peninsula, Goose Arm, Deer Cove, Port au Choix, and Cape Norman.

To date the only development of dolostone in western Newfoundland is located at Lower Cove on the Port au Port Peninsula, where Atlantic Minerals Ltd. quarries and exports high-purity limestone and dolostone products to national and international markets.

THE PORT AU PORT PENINSULA – LIMESTONE AND DOLOSTONE RESOURCES AND DEVELOPMENT

GEOLOGY

The Port au Port Peninsula is underlain by sedimentary rocks that are mainly part of the Cambro-Ordovician platformal sequence of western Newfoundland. The geology is dominated by shelf carbonate limestone and dolomite (Figure 6). Although these rocks host both active and dormant limestone and dolostone quarries they, also comprise a huge undeveloped resource located in an area of the province that has excellent infrastructure and tidewater access.

The Humber Arm Supergroup structurally overlies the Table Head Group. The rocks of the Humber Arm Supergroup consist of red, green and black shales and carbonate breccia deposited in deeper water conditions than the carbonates of the St. George and Table Head, but during the same time span. During the Middle Ordovician Taconic Orogeny the Humber Arm Supergroup was overthrust from the east as a klippe.

The platformal carbonate rocks are characterized by gentle northerly dips ranging from 5 to 20°. The transported Humber Arm Supergroup rocks are typically highly fractured, brecciated and folded. There are two prominent fault trends. In the Aguathuna area the faults trend north, whereas southwest and west of Piccadilly Bay the trend is northeast.

The neoautochthonous depositional sequence of the Western Platform is represented on the Port au Port Peninsula by the Upper Ordovician to Lower Silurian Long Point Group, which underlies Long Point and a coastal strip extending southwest of the point. The Long Point Group consists of interbedded limestones, sandstones and shales, with a thick bedded, grey limestone in the lower part. The lower limestone unit is approximately 60 m thick having beds dipping from 30° to vertical to overturned.

High-purity limestone and dolostone units in the upper part of the Catoche Formation of the St. George Group are the source of chemical-grade carbonate products being produced at Lower Cove. Limestone and dolomitic limestone from stratigraphically lower in the St. George Group are quarried for aggregate at the same operation. Limestone of the overlying Table Head Group was also quarried for many years at Aguathuna as a source of flux for Sydney steel mills.

The youngest rocks on the Port au Port Peninsula belong to the Upper Mississippian Codroy Group and are preserved in numerous small erosion or fault-controlled valleys in the Lower Paleozoic carbonate rocks.

LOWER COVE

Atlantic Minerals Limited (AML), a subsidiary of Newfoundland Cement Co. Limited, has an operation located at Lower Cove, on the Port au Port Peninsula, consisting of three quarries, a processing plant and ship-loading facilities (Plate 1). Atlantic Minerals acquired the facilities, which previously had mainly produced aggregates. The company has now expanded into the production of high-purity limestone and dolostone. The limestone aggregate quarry is located near the coast, adjacent to the production and shipping facilities. The high-calcium limestone and high-purity dolostone quarries are located 3.5 km north of the aggregate

Plate 1. *Aerial view of the Atlantic Minerals limestone and dolomite operation at Lower Cove on the Port au Port Peninsula.*

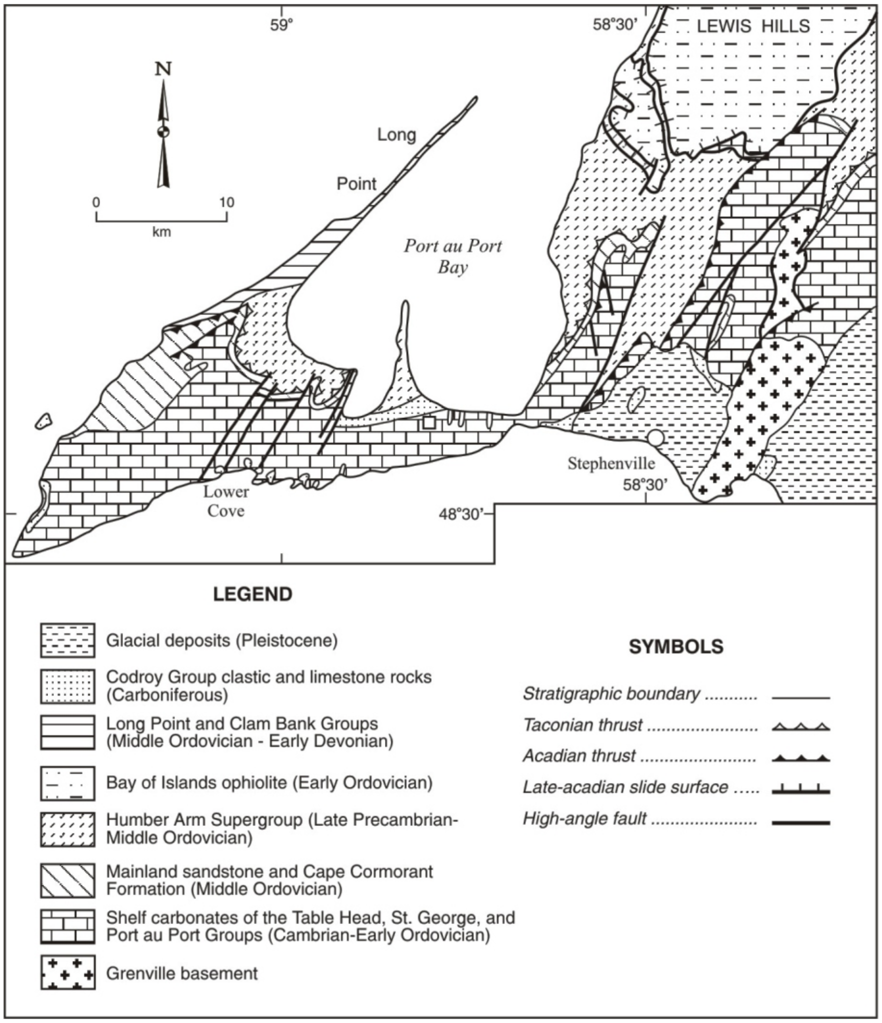


Figure 6. *General geology of the Port au Port Peninsula.*

quarry. Limestone is exported to the iron ore companies in Labrador and Quebec, and the dolomite is exported for use in the steel industry. In 1997, Atlantic Minerals shipped 960 000 tonnes, double the 1996 level, and shipments were forecast to increase to over 1 million tonnes in 1998. Reserves are approximately 86 million tonnes of limestone aggregate, 100 million tonnes of high-calcium limestone and 52 million tonnes of dolostone.

Production focuses mainly on Catoche Formation high-purity limestone and dolostone of the Lower Ordovician St. George Group although limestone from other underlying beds of the St. George Group have also supplied aggregate material. The dolostone is typically a buff or light brown unit, medium grained, and about 60 m thick. Chert is the main impurity and occurs as nodules and irregular masses and lenses often in discontinuous layers. Generally it is more abundant in the lower 15 m of the unit. Bedding in the dolostone is indistinct because of the dolomitization process. The overlying limestone is a pale grey to ivory, thick bedded, fine-grained unit whose main impurities consists of minor chlorite and hematite (limonite) in partings, on fractures and lining stylolites.

Products

The limestone and dolostone produced by AML is sound and dense, fine grained, relatively non-porous, with very low absorption. Thus the material can dry and heat readily, remain intact, and resist deprecation at all levels of handling and processing. The high-calcium deposit is exceptionally pure and consistent. As illustrated in Table 5, the chemistry makes it ideal for use as flux in the iron-ore industry, desulphurization processes, lime production in vertical shaft and rotary kilns, and other chemical/industrial uses. The dolostone is successfully used in iron-ore pelletization, the sintering process of iron production, electric-furnace steelmaking, and dolomitic lime manufacturing.

AGUATHUNA LIMESTONE AND DOLOMITE

The dormant Aguathuna Quarry is located on Route 461, 2 km west of the isthmus on the north side of the Port au Port Peninsula (Figure 7). Commercial production of limestone began in 1913 and with the exception of the years 1915, 1925 and 1932, continued until the quarry closed in 1964. A total of some 12 million tonnes of limestone was shipped from the site.

The market for the Aguathuna limestone was the steel industry in Sydney, Nova Scotia, where it was used as a flux in the smelting of iron ore. Dominion Limestone Limited, a subsidiary of DOSCO Ltd., and its predecessor companies, conducted the large Aguathuna open-pit operation on a seasonal basis. Three quarries were developed consisting of the adjacent East and West Quarries, and the Brook Quarry located approximately 750 m to the south. Average annual production was around 250 000 tonnes. Development of an alternative limestone source in Cape Breton, not far from the steel plant, eliminated demand for Aguathuna stone after more than a half century of production.

In the Aguathuna operation, the limestone was reduced in stages to minus 10 cm size, screened to remove minus 2

Table 5. *Chemical and physical specifications of carbonate products from Lower Cove*

Chemical Content	% **High Calcium Limestone**	% **Dolomite**	% **Construction Aggregates**
$CaCO_3$	97.80	56.30	0.00
CaO	54.80	31.50	43.50
$MgCO_3$	0.33	41.10	0.00
MgO	0.16	19.70	4.40
SiO_2	0.66	1.65	6.50
Fe_2O_3	0.15	0.23	0.40
Al_2O_3	0.22	0.21	1.40
S	0.01	0.01	0.00
Na_2O	0.01	0.03	0.10
Mn_20_3	0.01	0.04	0.01
TiO_2	0.02	0.01	0.06
K_2O	0.11	0.04	1.50
P_2O_5	0.00	0.00	0.02
Loss on Ignition (LOI)	43.30	45.50	40.00
Physical Properties			
S.G., Bulk, ASTM C127	2.71	2.773	2.692
Absorption, ASTM C127	0.25	0.50	0.60
L.A. Abrasion, ASTM C131	27.60	20.20	23.60
Soundness, ASTM C88	1.04	0.34	1.39
Crushed Particles	100.0	100.0	100.0
Elongated Particles	0.00	0.00	0.00
Grindability (WBI # 325 Mesh)	10.90	0.00	0.00

Source:http://www.atlanticminerals.com/

Chemical analyses in weight percent.

cm fines and conveyed to a 22 000 tonne storage area. From there it was loaded into ships for the voyage to Sydney, Nova Scotia.

Exposed in the quarry are carbonate rocks of Early Ordovician, Middle Ordovician and Carboniferous age, all separated by unconformities. The Middle Ordovician Table Head limestone supplied most of the quarry's production. Toward the end of the life of the operation, the Brook Quarry was established in high-purity limestone of the Lower Ordovician St. George Group.

Mississippian-age limestones of the Codroy Group were originally deposited in a sinkhole in the Ordovician limestone, but now form a small isolated island in the quarry. This section was not quarried because impurities such as pyrite, galena, barite, and celestite made the stone unsuitable for use in the Sydney mills. The limestone is highly fossiliferous containing, for example, brachiopods, mollusks, conularids and worm burrows (Dix and James, 1987).

UNDEVELOPED CARBONATE ROCK RESOURCES OF THE PORT AU PORT PENINSULA

Limestone

In addition to the existing limestone and dolomite deposits at Lower Cove and Aguathuna, there are other extensive undeveloped deposits on the Port au Port Peninsula that could become future producers given the appropriate marketing, technological, and economic factors. The total limestone resource on the peninsula is extremely large, and there are many sites that have yet to be tested by diamond drilling. These sites, should be considered, as geological resource estimates only, and are based on geological mapping and surface assessments involving chip sampling and trenching.

In the west central part of the peninsula, about 5 km northwest of Sheaves Cove, diamond drilling has outlined 74 million tonnes of limestone grading over 97 percent cal-

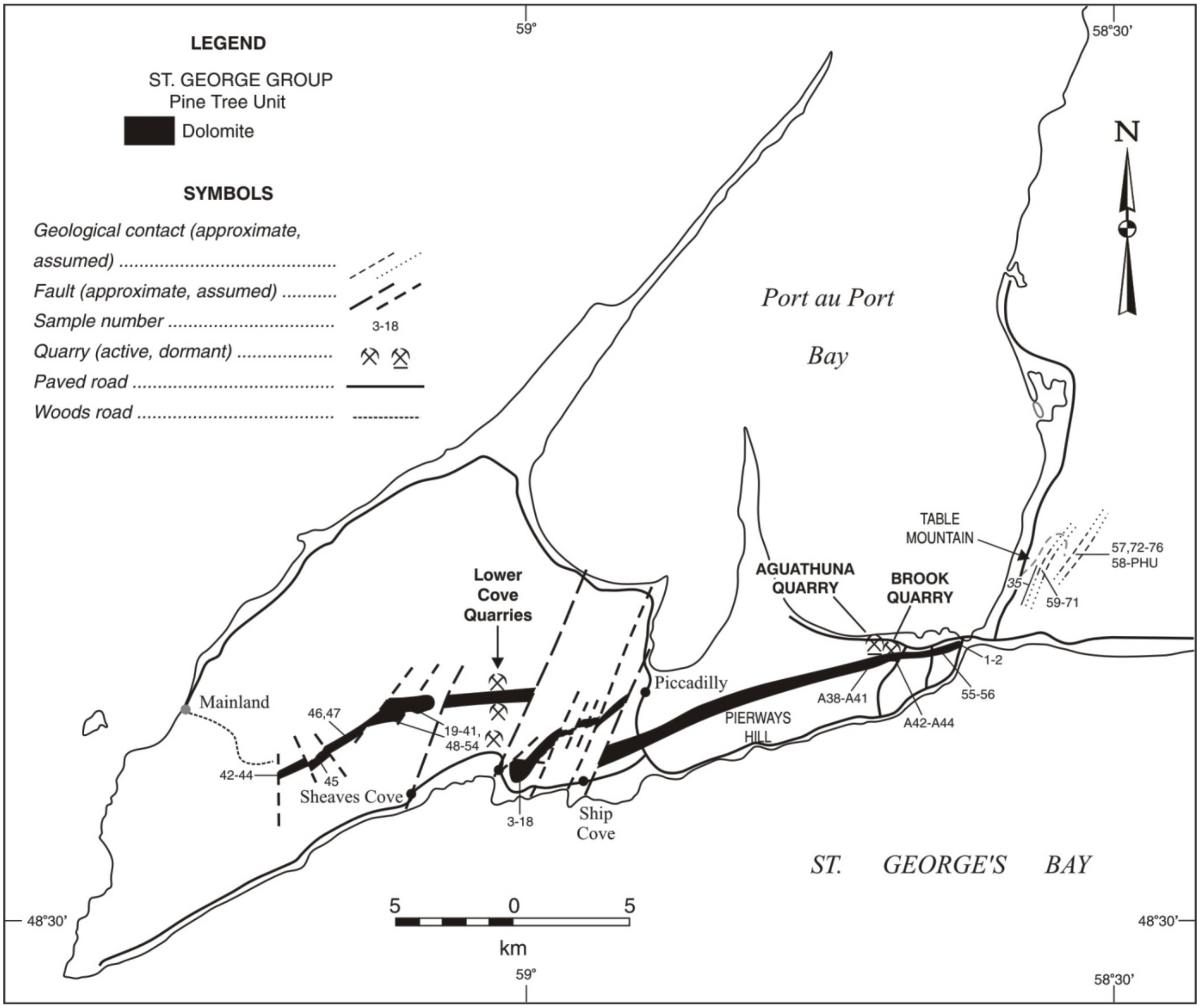


Figure 7. *Distribution of dolostone (Pine Tree Unit) on the Port au Port Peninsula.*

cium carbonate (Limestone #7, Table 6, Figure 8). Known as the White Hills deposit (Plate 2) it is accessible by road from the community of Mainland. A further inferred resource of 200 million tonnes of similar grade is indicated by wider spaced drilling along the strike from the deposit. The limestone is suitable for a wide range of industrial applications.

West of the community of Piccadilly, limestone of the Table Head Group forms cliffs up to 30 m high (Limestone #4, Table 6, Figure 8). The limestone beds have relatively shallow dips (10° north) but faulting, as reflected topographically by the cliffs, has created a number of high-angle structural blocks that could complicate limestone excavation. Nevertheless, it has been estimated that up to 400 million tonnes of limestone could be removed from this area based on an average quarrying depth of 45 m (DeGrace, 1974). Geochemical analyses of chip and representative grab samples showed the limestone compares favorably with that of other Table Head Group limestone in the area but drilling is required to confirm this.

On the east side of the Port au Port Bay, adjacent to the peninsula, shelf carbonate rocks of the St. George Group and Table Head Formation are exposed over a wide area (Limestone#1, Table 6, Figure 8). Information is lacking on the size and quality of the resource but geological observations and a limited amount of assessment work indicate large tonnages of both high-calcium limestone and high-purity dolomite may be available (DeGrace, 1974; Delaney and Howse, 1988).

Table 6. *Resource estimates for Port au Port limestone and dolostone*

#	Location	Resource 10^6 tonnes	CaO	MgO	SiO_2	R_2O_2	S	$CaCO_3$	Al_2O_3	Fe_2O_3	K	Na_2O_3	P_2O_5	BaO	Author
Limestone															
1	North of Port	200	50	1	2	04	-	-							DeGrace, 1974
	au Port														
2	Aquathuna	1	51.9	2.2	1.6	1.1	-	-							DeGrace, 1974
	East & West Quarries														
3	Aquathuna	9	53.9	1.2	0.8	-	0.3	-							Zeraldo Minerals,
	Jack of Clubs Brook														1990
4	Piccadilly	400	53.8	0.8	0.7	0.4	-	-							DeGrace, 1974
5	Lower Cove NE	100	-	-	-	-	-	-							Atlantic Minerals
															Feb 2002 webpage
6	Lower Cove	700	49.0	3.0	2.4	0.6	-	-							DeGrace, 1974
		90													Atlantic Minerals
															Feb 2002 webpage
7	Sheaves Cove	300	55.0	0.20	0.21	0.10	-	-							DeGrace, 1974
8	North de Grau	200	52.8	0.6	2.0	0.4									DeGrace, 1974
		74	-	-	-	-	-	97+							Saunders, 1990
Dolostone															
9	Aguathuna	38	33.0	18.0	1.5	-	0.4	-							Besaw, 1972
	Dolomite	15.2	34.16	17.33	1.38	-	-	-							Midatlantic Min.,
															1998
10	Piccadilly South	20	-	19.0	-	-	-	-							Besaw, 1972
11	Norsk Hydro	54.5	30.75	19.14	2.44	-	-	-	0.49	0.23	0.09	0.05	0.15	0.01	Saunders, 1993
	(North Block)														
12	Norsk Hydro	32.0	31.09	18.89	2.41	-	-	-	0.61	0.31	0.22	0.08	0.15	0.01	Saunders, 1993
	(South Block)														
13	Lower Cove	52.0													Atlantic Minerals
	NE Dolomite														Feb 2002 webpage

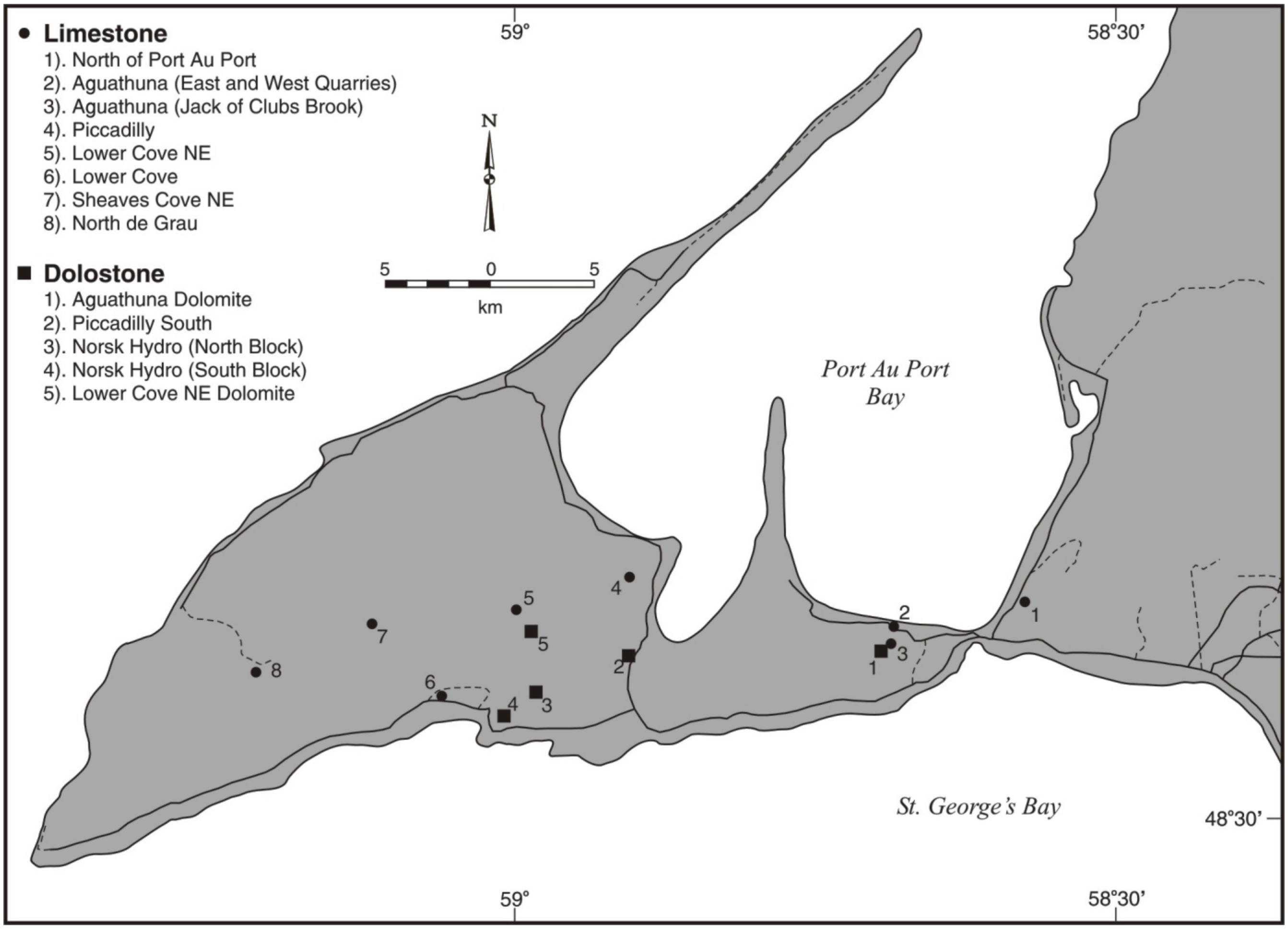


Figure 8. *Locations of limestone and dolostone deposits on the Port au Port Peninsula.*

Plate 2. *Surface expression of the White Hills limestone deposit, Port au Port Peninsula.*

Dolomite

A unit of dolostone in the St. George Group (informally known as the Pine Tree unit) is the main focus of interest as a source of metallurgical grade dolomite on the Port au Port Peninsula (Figure 7). Metallurgical specifications require high-purity dolostone containing less than 1.5 percent SiO_2 and total Al_2O_3 + Fe_2O_3 less than 1 percent. Silica is the most serious impurity in the Pine Tree unit but because it is usually concentrated in zones, commonly near the bottom of the unit, it can be controlled by selective mining. The Pine Tree unit forms an east-trending belt across the peninsula. Northeast- and east-trending faults commonly displace the dolomite particularly in the area between Lower Cove and Piccadilly, and the western region north of Sheaves Cove.

Deposits of dolostone have been delineated by detailed geological mapping and diamond drilling in an area northeast of Lower Cove (Dolomite #13; Table 6, Figure 8) and south of Piccadilly (Dolomite #11; Table 6, Figure 8). A drilling program carried out by Norsk Hydro on the South Block (Saunders, 1993; Dolomite #4; Table 6, Figure 8) outlined approximately 32 million tonnes grading 18.89 percent MgO and 2.41 percent SiO_2, and a recent drilling program of Midatlantic Minerals on the Aguathuna property delineated 15 million tonnes grading 17.33 percent MgO and 1.38 percent SiO_2 (Dolostone #9, Table 6, Figure 8).

Besaw (1972) estimated that the area south of Picadilly (Dolostone #10; Table 6, Figure 8)) contained some 20 million tonnes of high-purity dolostone following geological mapping and surface bedrock sampling.

There has been no drilling assessment of the Pine Tree unit north and northwest of Sheaves Cove in the western part of the peninsula. A 1988 survey aimed at identifying metallurgical-grade dolomite collected a total of 26 chip and representative samples along a 6-km strike length of the Pine Tree unit. The samples averaged 19.32 percent MgO and 2.20 percent SiO_2 (Delaney and Howse, 1988).

Pine Tree unit dolomite exposed just east of the Port au Port Peninsula was the object of a 1987 assessment (Delaney and Howse, 1988). Analyses of 17 samples from the showing averaged approximately 18 percent MgO and 3.36 percent SiO_2. Further assessment including drilling is required before more meaningful estimates of tonnages and grade can be made.

CORNER BROOK

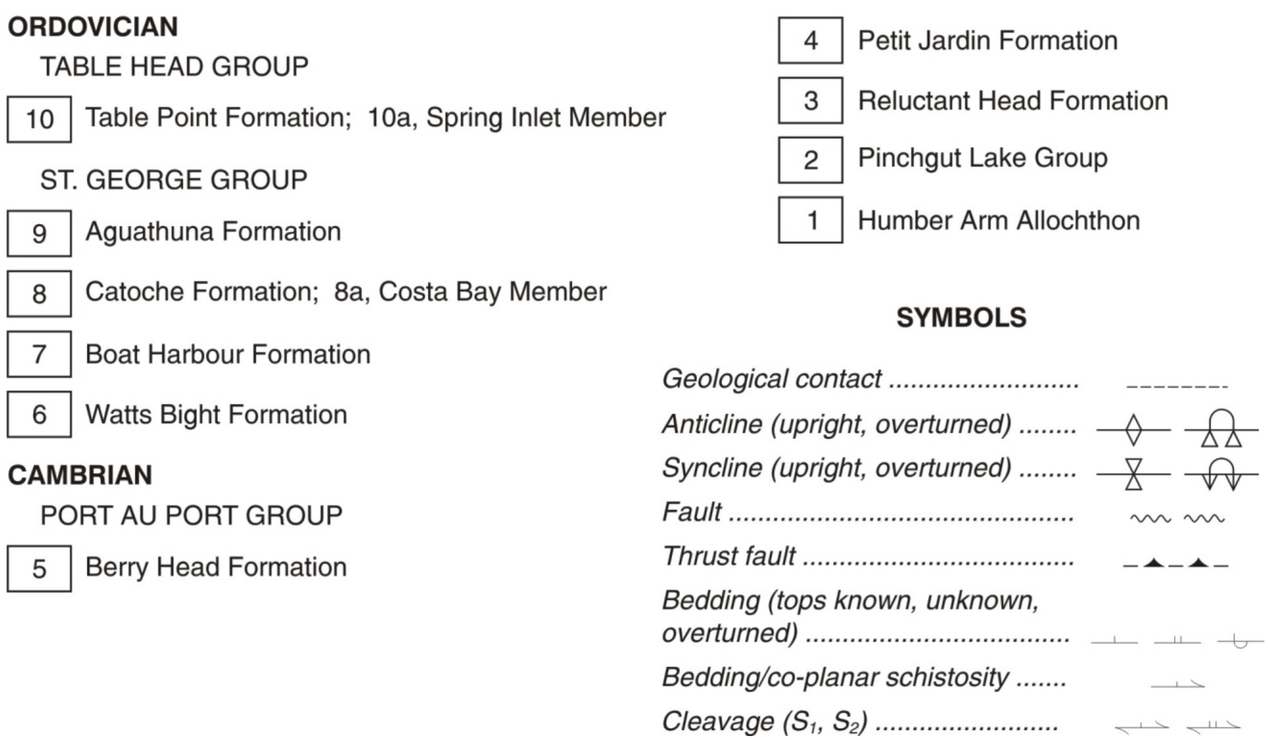
Variously deformed and metamorphosed, Cambro-Ordovician platformal rocks underlie much of the region around Corner Brook (Figure 9). Limestone of the Catoche Formation was used in making cement products. Numerous marble prospects containing multicoloured and textured stone have been identified in carbonate rocks south and southwest of Corner Brook (Figure 9) and in the Goose Arm region west of Deer Lake. These marbles have attracted commercial interest because of their potential dimensional and ornamental applications.

The following account of the geology of the carbonate rocks in and around Corner Brook is condensed from Knight (1995). Low-grade metamorphosed Cambrian to Ordovician carbonate rocks form a wedge-shaped belt from the Humber River gorge to just north of Corner Brook Lake (Figure 9). The carbonates are bounded to the east by the Corner Brook Lake Thrust and to the west by the Humber Arm Allochton.

Cambrian carbonates mainly of the Port au Port Group, occur along the eastern edge of the carbonate wedge. The lowest unit consists of ribbon limestone and phyllite of the Reluctant Head Formation. This unit is overlain by a sequence of dolostone and interbedded limestone marble of the Berry Head Formation. This upper sequence contains varicoloured breccias, pink, white and grey limestone marble, and white to purple dolostone marble.

The western half of the carbonate terrane is formed by Ordovician carbonates of the St. George Group and the overlying Table Head Group. The St. George Group comprises

LEGEND (for Figure 9)



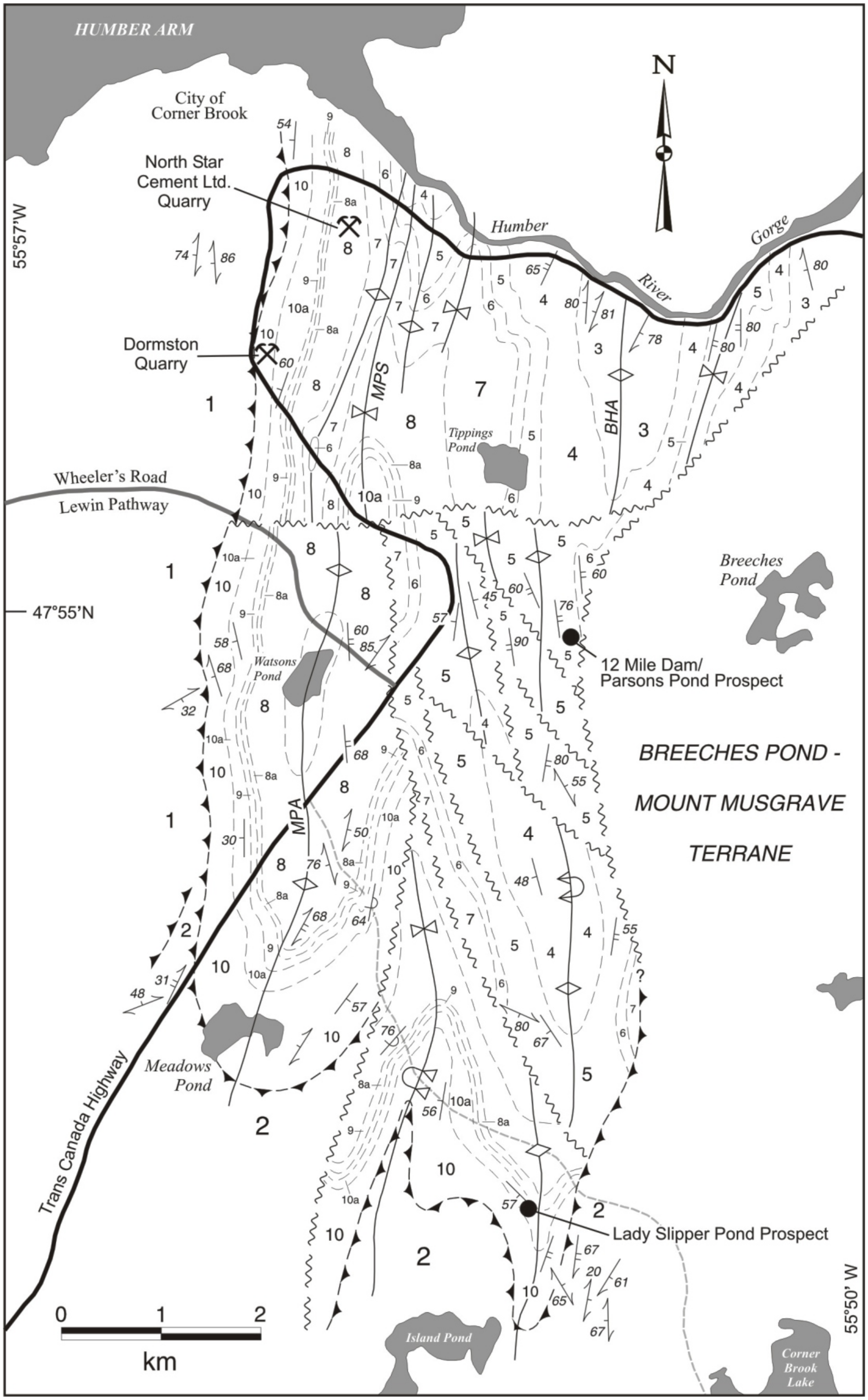


Figure 9. *Geology of the Cambrian–Ordovician terrane in and south of Corner Brook showing location of dimension-stone prospects. Legend on previous page.*

mounded dark grey limestone of the Watts Bight Formation, grey to white limestone and dolostone of the Boat Harbour Formation, and white to pink limestone (Costa Bay Member) of the Catoche Formation. Table Point Formation rocks are well-bedded, dark grey to grey limestones.

Carbonate units of economic interest include the Catoche Formation, which supplied limestone to the Northstar cement plant at Corner Brook; the Berry Head Formation and Costa Bay Member are also of particular interest as dimension-stone targets because of associated attractive marbles of pink, red, purple and off-white colours. Red and purple colours are characteristic of the Berry Head Formation, which hosts Lower Paleozoic collapse breccias. Both dolostone and collapse breccia are commonly associated with abundant white calcite veining of possible Carboniferous age (Knight, 1994).

LADY SLIPPER POND MARBLE PROSPECT

The Lady Slipper Pond dimension-stone prospect is located southeast of Corner Brook on the Lady Slipper Pond logging road, 4.2 km east of the Trans-Canada Highway (Figure 9). The marble unit of interest is 10 m thick and dips 30° to the southwest. It is a multicoloured stone with pink, and salmon to orange-coloured zones, and also red-banded (styolitic), cream and grey varieties. In some places, minor chloritic streaks adds to the texture of the marble. It should be noted that this site was stripped by a backhoe but not blasted. Knight (1994) mapped the prospect as part of Costa Bay Member of the Ordovician Catoche Formation.

PINCHGUT LAKE MARBLE PROSPECTS

Deformed and metamorphosed Cambro-Ordovician carbonate shelf rocks in the Pinchgut Lake area, southwest of Corner Brook (Figure 10), host numerous marble occurrences that display a variety of colours and textures (Knight, 1996). A network of woods-roads branching south from Pinchgut Lake on the Trans-Canada Highway provides good access to the area. A reconnaissence survey by Howse (1988) identified narrow bands of white marble and wider, more extensive zones of pink, red and yellow dolomitic marble in the area east of Big Gull Pond and the potential of the

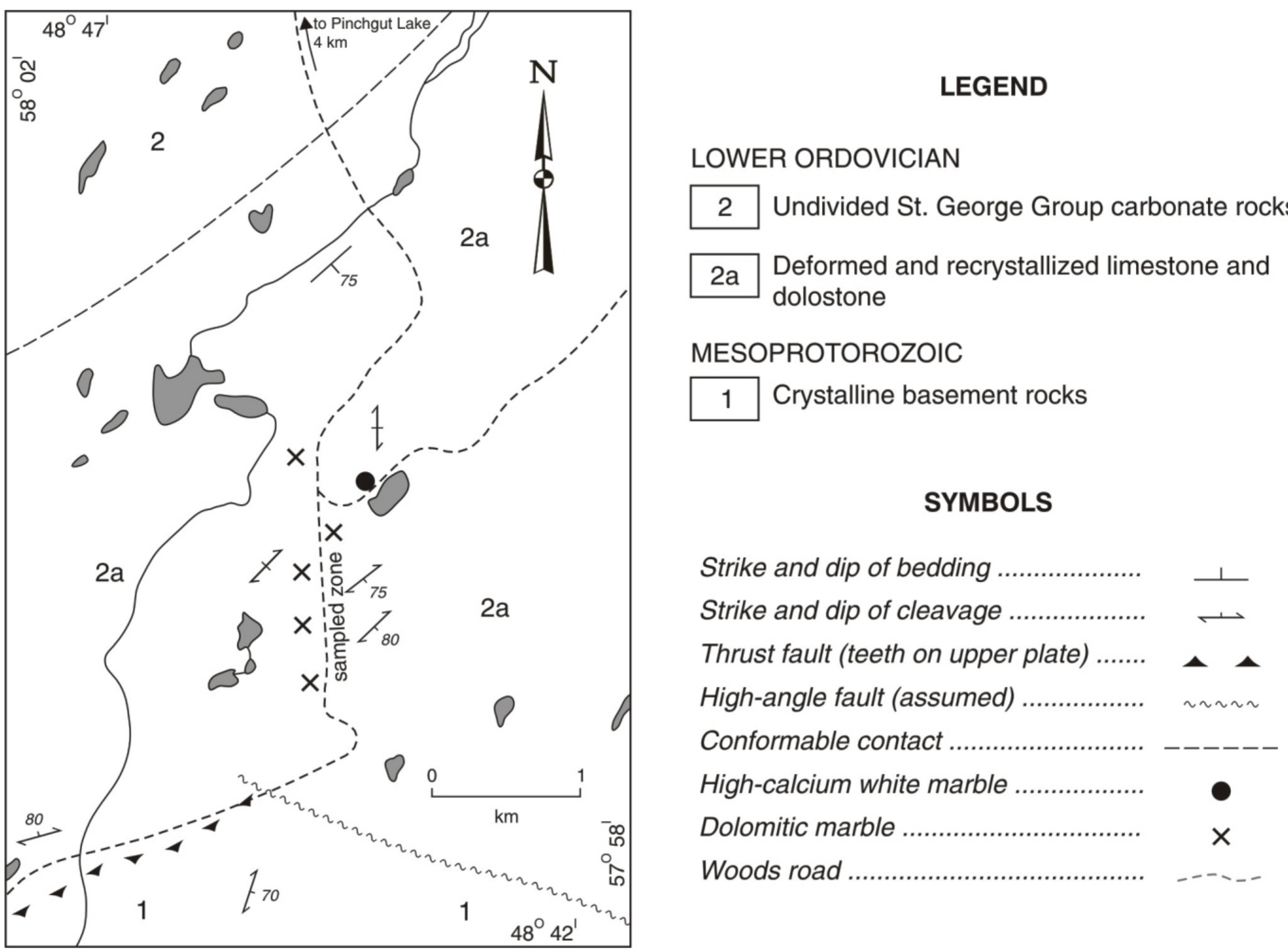


Figure 10. *Location of sampled dolomitic marble zone south of Pinchgut Lake.*

stone both for dimension stone and industrial filler was reported (Plate 3, Figure 10). A growing interest in dimension stone and an increasing awareness of potential local sources led to the discovery, assessment, and promotion of several potential quarry sites by local entrepreneurs.

OTHER OCCURRENCES

An extensive zone of recrystallized dolomitic marble located approximately 3 km east–southeast of Big Gull Pond, 20 km south of Corner Brook and accessible via the Pinchgut Lake road system, was examined and sampled to determine its metallurgical potential (Howse,1988; Figure 10). In places, the rock has an attractive red and pink colour suggesting a potential use as building or decorative stone. However the rock is extensively jointed and fractured and shatters easily. Impurities are mainly small nodules of chert and pervasive hematite along fractures. Bands of recrystallized beige dolostone and mottled, blue-grey dolostone are also present in the sequence. Results of chemical analyses of representative chip samples from the dolostone zone are given in Table 7. The samples represent outcrops of dolomite discontinuously exposed along 1500 m north–south section of woods-road about 3 km east–southeast of Big Gull Pond. The results indicate the presence of several bands of poten-

Plate 3. *Dolomitic marble near Big Gull Pond, Pinchgut Lake Road.*

Table 7. Chemical analyses in weight percent of representative chip samples from a dolostone zone near Big Gull Pond in the Pinch Gut Lake region

Sample No.	SiO_2	Al_2O_3	MgO	Fe_2O_3	CaO	K_2O	MnO	P_2O_5	LOI
5948016	0.95	0.29	21.13	0.26	29.59	0.19	0.02	0.01	46.68
5948017	16.07	2.16	17.09	0.77	24.32	1.37	0.02	0.04	37.74
5948018	3.11	0.25	20.85	0.18	29.09	0.15	0.02	<0.01	45.74
5948019	2.65	0.26	20.87	0.18	29.38	0.13	<0.01	<0.01	45.84
5948021	3.65	0.47	19.03	0.22	30.49	0.21	0.01	<0.01	45.12
5948022	3.04	0.56	19.29	0.26	30.44	0.31	0.01	<0.01	45.22
5948023	2.00	0.76	19.37	0.29	31.00	0.30	0.02	0.01	45.63
5948024	3.95	0.64	19.03	0.24	30.09	0.36	0.02	<0.01	44.78
5948025	1.97	0.28	20.39	0.20	30.57	0.12	0.02	<0.01	46.13
5948026	1.19	0.22	21.14	0.18	29.54	0.09	0.02	<0.01	46.70
5948027	2.32	0.23	20.98	0.18	29.36	0.09	0.01	<0.01	46.17
5948029	5.89	0.68	19.82	0.28	28.03	0.29	0.02	<0.01	43.93
5948030	2.07	0.76	19.21	0.28	30.84	0.30	0.02	<0.01	45.67
5948031	1.26	0.31	21.3	0.22	29.66	0.13	0.02	0.01	46.59
5948032	2.45	0.61	20.66	0.33	29.26	0.30	0.01	<0.01	45.77
5948033	1.35	0.16	6.15	0.09	47.56	0.07	0.01	<0.01	44.15
5948034	3.17	0.39	20.58	0.24	29.00	0.13	0.02	<0.01	45.58
5948035	2.98	0.30	20.77	0.17	29.06	0.11	0.02	<0.01	45.73
5948036	3.27	0.60	20.71	0.31	29.04	0.25	0.02	<0.01	45.37
5948037	2.08	0.49	20.95	0.27	29.01	0.21	0.03	<0.01	46.06
Average	3.27	0.51	19.47	0.26	30.26	0.21	0.03	<0.01	45.23

LOI = Loss on ignition

tial metallurgical-grade dolostone with MgO content close to or better than 21 percent. The width of this zone, along with the promising chemical analyses suggest a highly prospective area of deposits high-purity dolomite. Silica is the main impurity.

GOOSE ARM REGION

A 1987 dolomite assessment project aimed at locating and assessing new potential metallurgical-grade dolomite deposits in the carbonate sequences of western Newfoundland, identified several sites of interest in the Goose Arm region of the Bay of Islands (Figure 11; Delaney and Howse, 1988). There are at least five high-tonnage prospects on tide-water along Goose Arm and Penguin Arm, namely: 1) Penguin Cove; 2) Goose Arm South; 3) Narrows; 4) Penguin Hills and 5) Penguin Arm deposits. A sixth site, the Goose Arm Road deposit (not to be confused with Pye's Ridge marble), can be accessed by road from Deer Lake. Relief is excellent in all areas. In some of the deposits, large amounts of silica in the form of quartz veins may be detrimental to development.

The Hughes Brook Formation composed of dolostones and shaly dolostones (Lilly, 1963) is the unit of interest in the Goose Arm area. The Hughes Brook Formation is a correlative of the Berry Head Formation of the Port au Port Group (Chow and James, 1987) and the Watts Bight and Boat Harbour formations of the St. George Group (I. Knight, personal communication, 2001).

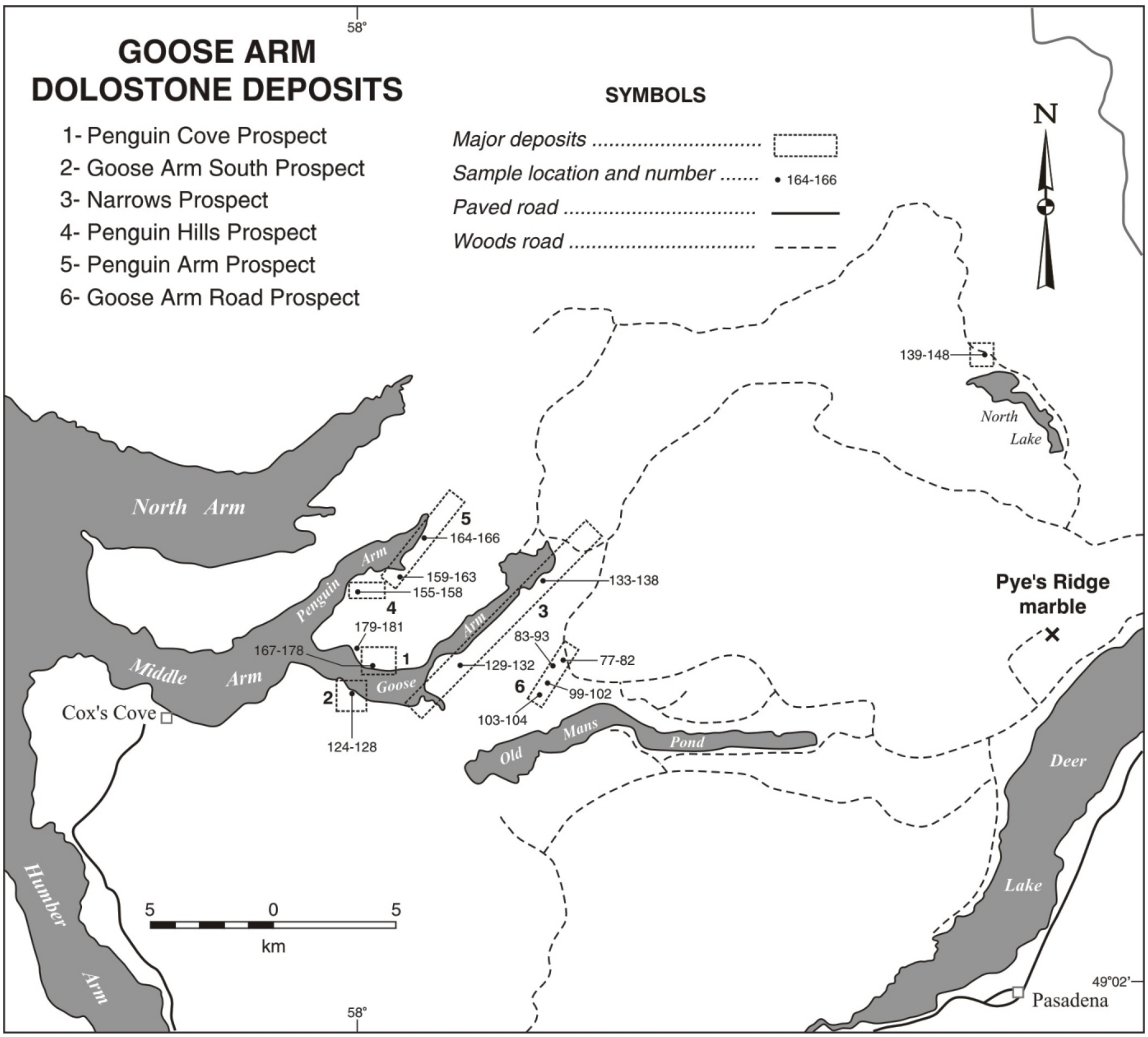


Figure 11. *Location of Goose Arm dolostone deposits.*

The dolostone is typically very hard, massive, light grey, very fine grained and medium to thick bedded. Chert, calcite and quartz are rare in the dolostone but in three of the deposits (Numbers 3, 5 and 6 in Figure 11) the dolostone has been cut by numerous quartz veins up to 1 cm thick. Generally, they are spaced less than 20 cm apart and may follow one main trend or several trends. Interbedded shale was seen on the woods road north of the head of Goose Arm.

The following are brief descriptions of sampled Goose Arm dolostone deposits. Chemical analyses of the samples collected from each site are given in tables keyed to Figure 11.

PENGUIN COVE PROSPECT

A significant dolostone prospect occurs east of Penguin Cove where beds of dolostone about 1 m thick and dipping 20° east, are exposed in a 150-m-high vertical cliff (Plate 4). Approximately 75 m of bedding are exposed along the shore and 11 samples were taken perpendicular to bedding, each representing a thickness of 5 m. This section of the Hughes Brook Formation varies from dark grey, generally massive dolomite (but with some beds heavily cleaved in the lower 25 m of the section) to a light grey, stylolitic dolostone in the upper part. Impurities were noted in only one sample that contained trace amounts of fine-grained pyrite and possibly chlorite. Lilly (1963) also reported flecks of galena and sphalerite in the cliff face and noted silty laminations that may represent stylolites. Galena and pyrite also occur in dolostone to the west in Penguin Cove.

The contact between the Hughes Brook Formation and sandstones and shales of the Penguin Cove Formation, which was considered by Lilly (1963) to be conformable within an anticline, is here considered to be a high-angle fault contact, possibly with an anticline structure. To the east, the Hughes Brook Formation is conformably overlain by fine-grained, burrowed limestones of the Corner Brook Formation (equivalent to the Catoche Formation of Knight and James, 1987).

Chemical analyses of samples from the Penguin Cove prospect are shown in Table 8. Average MgO content is very close to metallurgical grade; however the level of SiO_2 at 2.79 percent is high as is the combined Al_2O_3 and Fe_2O_3 at 1.18 percent. It is likely that selective quarrying could significantly lower the level of impurities in this prospect.

GOOSE ARM SOUTH PROSPECT

An approximately 85-m-thick section of Hughes Brook dolostone is exposed across Goose Arm from the Penguin Cove prospect. The dolostone beds dip 42° east and have a

Plate 4. *Thick-bedded dolostone exposed in an approximately 150-m-high cliff east of Penguin Cove, Goose Arm.*

conformable eastern contact with a fine-grained burrowed limestone, and a high-angle fault contact with steeply west-dipping (65 to 70°) black shale and limestone on the west. The dolostone is similar to the Penguin Cove prospect but the vertical stratigraphic change in rock type and cleaved beds observed at the Penguin Cove prospect were not observed in this section. The dolostone near the fault contact is iron stained and contains clasts of grey dolostone set in a creamy, coarse-grained vuggy dolomite matrix. The land surface rises rapidly away from the shore indicating that significant tonnage may be present at this site.

Five representative chip samples from the Goose Arm South prospect indicate the presence of metallurgical grade dolostone (Table 9). Impurities such as silica, iron oxides, and alumina are well within specifications.

THE NARROWS DOLOSTONE PROSPECT

The Narrows dolostone prospect outcrops in northeast-trending cliffs up to 230-m high that parallel the strike of Goose Arm (Plate 4). The dolomite is predominantly massive but fine laminae and an oolitic bed are also present in the section. Extensive quartz veins are less than 1 cm thick, and dip 35° northeast. Calcite locally coats fractures. An approximately 60-m-thick section of horizontally bedded dolostone is located near the head of Goose Arm. A probable fault separates it from the main cliff section. The horizontal beds contain no quartz veins. Bedding in the rest of the deposit is vertical and trends 050°, roughly the same strike as the cliffs. The stratigraphic thickness of the cliff section is

Table 8. *Chemical analyses in weight percent of chip samples from the Penguin Cove dolostone prospect*

Sample No.	SiO_2	Al_2O_3	Fe total*	MgO	CaO	K_2O	MnO	LOI
9167	0.48	0.13	0.54	21.0	30.5	0.10	0.10	47.3
9168	0.99	0.24	1.08	20.5	30.1	0.13	0.12	46.7
9169	2.45	0.40	1.27	20.1	29.4	0.26	0.13	45.6
9171	3.71	0.68	0.43	20.2	29.3	0.44	0.01	45.1
9172	2.92	0.57	0.30	20.7	29.5	0.33	0.01	45.6
9173	1.56	0.39	0.29	21.0	30.2	0.25	0.01	46.3
9174	5.17	1.21	0.65	19.6	28.4	0.69	0.01	43.6
9176	2.37	0.45	0.31	20.9	30.1	0.25	0.01	45.9
9177	2.81	0.69	0.43	20.7	29.8	0.40	0.01	45.3
9178	5.47	1.15	0.57	19.7	28.9	0.60	0.01	43.7
Average	2.79	0.59	0.59	20.5	29.6	0.34	0.04	45.5

*Total iron as Fe_2O_3; LOI = Loss on ignition

Table 9. *Chemical analyses in weight percent of representative chip samples from the Goose Arm South dolostone prospect*

Sample No.	SiO_2	Al_2O_3	Fe total*	MgO	CaO	K_2O	MnO	LOI
9124	1.51	0.30	0.27	21.1	29.8	0.21	0.02	46.7
9125	0.67	0.22	0.20	21.1	30.5	0.13	0.01	46.9
9126	0.62	0.15	0.44	20.6	30.5	0.10	0.01	47.4
9127	0.70	0.21	0.74	21.0	30.2	0.14	0.01	47.0
9128	1.05	0.41	0.54	20.9	29.5	0.19	0.01	47.0
Average	0.91	0.26	0.44	20.9	30.1	0.15	0.01	47.0

*Total iron as Fe_2O_3; LOI = Loss on ignition

Table 10. *Chemical analyses in weight percent of representative chip samples from the Narrows dolostone*

Sample No.	SiO_2	Al_2O_3	Fe total+	MgO	CaO	K_2O	MnO	LOI
9129	17.95	2.75	1.01	15.1	24.5	1.48	0.02	36.1
9131	3.26	0.98	0.47	19.8	29.2	0.65	0.02	45.1
9132	2.68	0.85	0.38	20.3	29.5	0.53	0.01	45.4
9133	1.69	0.24	0.22	21.1	30.3	0.15	0.01	46.5
9134	5.39	0.47	0.27	19.9	29.1	0.26	0.02	44.4
9135	7.79	0.67	0.36	19.3	27.8	0.39	0.02	43.1
9136	7.38	1.58	0.71	19.1	27.7	0.91	0.02	42.4
9137	5.13	0.78	0.45	19.9	29.1	0.36	0.02	44.3
9138	6.71	1.27	0.58	19.3	27.8	0.67	0.02	43.1
Average 1	6.44	1.07	0.49	19.3	28.3	0.60	0.02	43.4
Average 2*	5.00	0.86	0.43	19.8	28.8	0.49	0.02	44.3

*excludes sample 9129; +Total iron as Fe_2O_3; LOI = Loss on ignition

hard to define, but Lilly (1963) estimates the thickness of the Hughes Brook Formation in the Goose Arm area at more than 400 m. Thick wedges of dolostone talus at the base of the cliffs could also be extracted. Reserves of over 100 million tonnes are estimated from the entire 6-km-long cliff exposure (Delaney and Howse, 1987).

Chemical analyses of chip samples from the Narrows dolostone prospect are shown in Table 10. The biggest concern is the uniformly high level of SiO_2 (>5 percent) which, would appear to preclude premium industrial applications.

PENGUIN HILLS DOLOSTONE PROSPECT

The Penguin Hills dolostone prospect consists of heavily cleaved, laminated dolostone with cobble-sized pieces of dolostone in the talus slope. Rare 1-mm-diameter quartz grains and 1- to 2-cm-diameter clumps of grey or brown clay are present in the dolostone. The beds dip 20° north. More than 10 million tonnes of dolostone are estimated for this prospect (Delaney and Howse, 1987).

The results of the chemical analyses of four representative chip samples from the Penguin Hills prospect are shown in Table 11. These indicate the presence of potentially metallurgical grade dolostone.

PENGUIN ARM DOLOSTONE PROSPECT

Hughes Brook Formation dolostone outcrops in cliffs on the north and south side of Penguin Arm. The unit is also continuously exposed in cliffs along the east side of Penguin Arm for another 2 to 3 km. South of Penguin Arm, the cliff exposes at least 30 m of dolostone dipping 65° northwest. At this locality, the dolostone contains solitary blocky crystals of pink dolomite and zones containing clasts of fine-grained dolostone set in a coarse-grained dolostone matrix. No visible impurities were noted in outcrop but chert was observed in the talus slope at the base of

Table 11. *Chemical analyses in weight percent of representative chip samples from the Penguin Hills dolostone prospect*

Sample No.	SiO_2	Al_2O_3	Fe total*	MgO	CaO	MnO	LOI
9155	2.33	0.16	0.13	20.8	29.9	0.01	46.0
9156	1.94	0.20	0.14	20.9	29.9	0.01	46.3
9157	1.76	0.46	0.22	20.8	39.7	0.01	46.2
9158	0.88	0.19	0.14	21.3	30.3	0.01	46.8
Average	1.73	0.25	0.16	21.0	30.0	0.01	46.3

*Total iron as Fe_2O_3; LOI = Loss on ignition

the cliff. Near the head of Penguin Arm, the dolostone is extensively veined by quartz and calcite trending in several different directions.

The results of the chemical analyses of chip samples from the Penguin Arm dolostone prospect are given in Table 12. The SiO_2 content averaged >4 percent and this would preclude potential metallurgical use.

GOOSE ARM ROAD DOLOSTONE PROSPECT

Dolostone was identified and sampled along a woods road about 5 km east of Goose Arm. A rock cut exposes a minimum stratigraphic thickness of 60 m of medium-bedded stone dipping 42° northeast. It is cut by up to 1-cm-thick dolostone veins and local quartz veins. This block of dolostone is separated from a larger block to the west by a northeast-trending fault. The northwest and south sides of this larger block (40 000 m^2 in plain view) consist of 30 m cliffs (Plate 5) that encompass an area of approximately 400 by 100 m. The dolostone beds are vertically dipping and contain extensive quartz veins with widths up to 1 cm. A 1- to 2-m-thick bed containing up to a few percent rounded quartz grains is also present (Delaney and Howse, 1987).

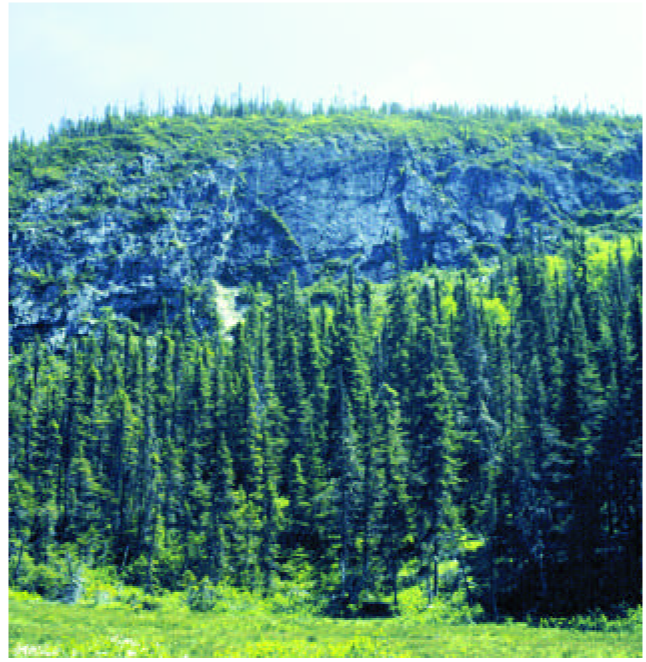


Plate 5. *Thirty metre high cliffs along the south side of the larger block of dolostone, Goose Arm Road.*

Results of the chemical analyses of 20 chip samples from the Goose Arm road dolostone are shown in Table 13. They indicate the section contains highly siliceous bands that greatly detract from the industrial potential of this site.

Table 12. *Chemical analyses in weight percent of chip samples from the Penguin Arm dolostone prospect*

Sample No.	SiO_2	Al_2O_3	Fe total+	MgO	CaO	K_2O	MnO	LOI
9159	4.20	0.55	0.24	20.0	29.0	0.03	0.01	45.0
9161	1.38	0.17	0.14	20.4	30.5	0.10	0.01	46.8
9162	1.18	0.24	0.20	20.1	30.6	0.13	0.01	47.1
9163	2.73	0.52	0.21	20.5	29.8	0.10	0.01	45.6
9164	6.33	1.52	0.57	19.0	28.2	0.01	0.01	46.2
9165	5.76	1.38	0.56	19.6	28.3	1.01	0.01	43.4
9166	6.90	1.38	0.49	17.2	30.2	0.89	0.01	42.5
Average 1	4.07	0.82	0.34	19.5	29.5	0.53	0.01	44.8

*Total iron as Fe_2O_3; LOI = Loss on ignition

DEER LAKE

PYE'S RIDGE MARBLE

The Pye's Ridge marble prospect (Figure 11) is located in rugged tree-covered terrain near the northwest shore of Deer Lake about 15 km from the town of Deer Lake. A network of woods-roads and skidder trails provide good access to the property which essentially comprises a mountain ridge, 5 by 2.5 km in area, having a maximum elevation of 285 m.

The ridge encompasses a rectangular area of predominantly recrystallized limestone and dolomite of the Early to Middle Ordovician St. George and Table Head groups. The property is bounded to the east by sedimentary rocks of the Carboniferous Deer Lake Basin, and to the south and west by Hadrynian to Ordovician? rocks of the

Table 13. *Chemical analyses in weight percent of chip samples from the Goose Arm Road dolostone prospect*

Sample No.	SiO_2	Al_2O_3	Fe total*	MgO	CaO	K_2O	MnO	LOI
9077	4.10	0.88	0.37	18.8	30.4	0.50	0.01	44.5
9078	3.10	0.71	0.29	20.7	29.4	0.48	0.01	45.2
9079	2.83	0.65	0.26	20.8	29.4	0.45	0.01	45.5
9081	6.45	0.38	0.23	19.9	28.3	0.19	0.01	44.0
9082	2.76	0.65	0.24	20.0	30.2	0.40	0.01	45.4
9083	1.09	0.35	0.21	20.0	31.1	0.23	0.01	46.7
9084	1.00	0.30	0.20	19.2	32.5	0.20	0.01	46.6
9085	77.60	0.92	0.22	4.2	6.5	0.40	0.01	9.6
9086	90.90	0.48	0.28	1.5	2.7	0.17	0.01	3.9
9087	87.60	0.13	0.04	2.3	3.8	0.00	0.01	5.5
9088	3.64	0.64	0.35	18.8	30.9	0.34	0.01	45.0
9089	0.84	0.28	0.19	20.7	30.4	0.17	0.01	47.1
9091	0.68	0.19	0.10	20.0	31.8	0.10	0.01	47.1
9092	3.90	0.47	0.23	19.1	30.4	0.23	0.01	45.3
9093	4.44	0.81	0.35	18.4	31.0	0.50	0.01	44.2
9099	2.91	0.28	0.16	20.7	29.8	0.17	0.01	45.9
9101	4.20	0.42	0.20	20.4	29.0	0.22	0.01	45.1
9102	20.50	1.08	0.20	16.6	23.9	0.29	0.01	36.8
9103	6.11	1.15	0.45	17.9	29.9	0.73	0.01	43.5
9104	4.71	0.78	0.33	18.9	29.8	0.33	0.01	44.5
Average[1]	16.46	0.58	0.25	16.9	26.1	0.31	0.01	39.1
Average[2]	3.28	0.56	0.26	19.6	30.3	0.33	0.01	45.4

[1] Average includes all samples; [2] Average excludes samples 9085-9087 and 9102
*Total iron as Fe_2O_3; LOI = Loss on ignition

Old Mans Pond Allochthonon (Knight, 1994). First staked in 1991 by logger prospector Len Pye of Cormack, the marbles of Pye's Ridge were mapped in detail by Knight (1992) who meticulously described the textures and colours of the different marbles units. More recently, the deposit has been the object of a number of assessments involving trenching, diamond drilling, block removal and testing, and preliminary feasibility and marketing studies. Marble is present in a wide range of colours and textures although in terms of consistency and abundance, the off-white and styolitic grey varities may have the best dimension-stone potential. Areas of white calcitic marble could have potential as premium-quality industrial filler.

CORMACK AGLIME AND AGGREGATE QUARRY

C-Mack Construction Limited of Deer Lake operates a limestone quarry (Plate 6) located about 8 km north of Deer Lake on the west side of Route 430 near the Cormack road intersection. The quarry contains fine-grained Cambro-Ordovician limestone and produces finely ground stone for agricultural limestone in addition to crushed aggregate for road beds and other general construction uses. The stone is quarried by blasting and fed into a grinding mill located at the site. It is delivered by truck to local markets mainly in east Newfoundland.

Plate 6. *Cormack agricultural limestone and aggregate quarry on Route 430, about 8 km north of Deer Lake.*

The quarry walls contain cavities and fractures up to a metre in length containing Carboniferous sandstone and conglomerate. This is evidence that sometime during the Paleozoic, a karstic landscape developed on the Cambro-Ordovician carbonate rocks. The karst deposits are correlated with the Carboniferous North Brook Formation by Hyde (1988). The Carboniferous Rocky Brook Formation unconformably overlies the Cambro-Ordovician strata at this locality and it is has been suggested that the quarry is situated on an exhumed headland that was at the margin of the Carboniferous lake.

RODDICKTON AREA MARBLE PROSPECTS

Lower Paleozoic platformal rocks flank the Long Range Precambrian inlier core of the Northern Peninsula. The sequence dominates the western coastal geology northward to Cape Norman and extends across the peninsula and southwards from

Hare Bay to Canada Harbour forming a triangular wedge between Precambrian basement to the west and the Taconic Hare Bay Allochthon to the east (Figures 4 and 12). The Precambrian crystalline basement, carbonate platform, and Hare Bay Allochthon represent the Lower Paleozoic continental margin of North America. The margin was telescoped during the Middle Ordovician Taconic Orogeny, interpreted as an arc-continent collision, and further deformed during the Devonian Acadian Orogeny.

RODDICKTON MARBLE BELT

White marble on the northeast side of the Northern Peninsula occurs within a continuous belt from Canada Harbour in the south to about 10 km south of Hare Bay in the north, a distance of more than 50 km. It occurs along deformed and metamorphosed zones of Lower Paleozoic carbonate rocks that underlie the Hare Bay Allochthon. In the Roddickton area, the marble is associated with a series of easterly dipping thrust sheets that are progressively more deformed closer to the Hare Bay Allochthon (Reusch, 1987; *see* Figure 16)

In 1985, white marble occurrences near Roddickton were investigated by the Newfoundland Department of Mines and Energy to determine their suitability for industrial fillers. Results from the Roddickton area were excellent and warranted a follow-up drilling program (Plate 7). Significant reserves (approximately 3 million tonnes) of high-purity white marble (96 percent dry brightness index) were outlined at Penny's Pond and Coles Pond (Howse, 1986; Howse and Delaney, 1987; Figures 13 and 14).

Plate 7. *Drilling the first hole on Coles Pond marble deposit, 1986.*

After a call for development proposals from industry, the Penny's Pond and Coles Pond deposits were awarded to ECC International and Aurion Minerals Limited, respectively. Subsequent programmes carried out by these companies included mapping, trenching, diamond drilling, overburden sampling, and bulk sampling. Work carried out on the Coles Pond prospect also included overburden stripping, and quarry development (Plates 8 and 9a, b). This work increased the reserve estimate for marble resources in the Roddickton region to approximately 10 million tonnnes (Reusch, 1987). Although commercial production has not been achieved to date, extensive marble assessment has been carried out at Coles Pond, Penny's Pond, Marble Brook and Mud Pond and significant reserves of high-purity marble with excellent dry brightness have been delineated (Table 14). Other marble showings have been identified along the marble belt including relatively unexplored zones south of Upper Marble Pond, a ridge north of Mud Pond and a prospect south of Coles Pond (Reusch, 1987).

Marble of potential commercial interest as filler and dimension stone also occurs along a 20-km-long belt of deformed carbonate rocks known as the White Arm Pond Window located in the region between the Croque access road and Hare Bay (Figure 12). Platformal carbonates, exposed by erosion of the overlying Hare Bay Allochthon consist of recrystallized limestone and dolostone altered to white and grey marble. A highly prospective prospect known as the Bonus deposit and several other showings have been identified in this region.

In 1996, Industrial Fillers Limited, a wholly owned subsidiary of Pluss-Staufer A.G. (parent company of Pluess-Staufer Industries Limited) acquired the Coles Pond

Plate 8. *Coles Pond marble deposit showing quarry development face and stripped surface area.*

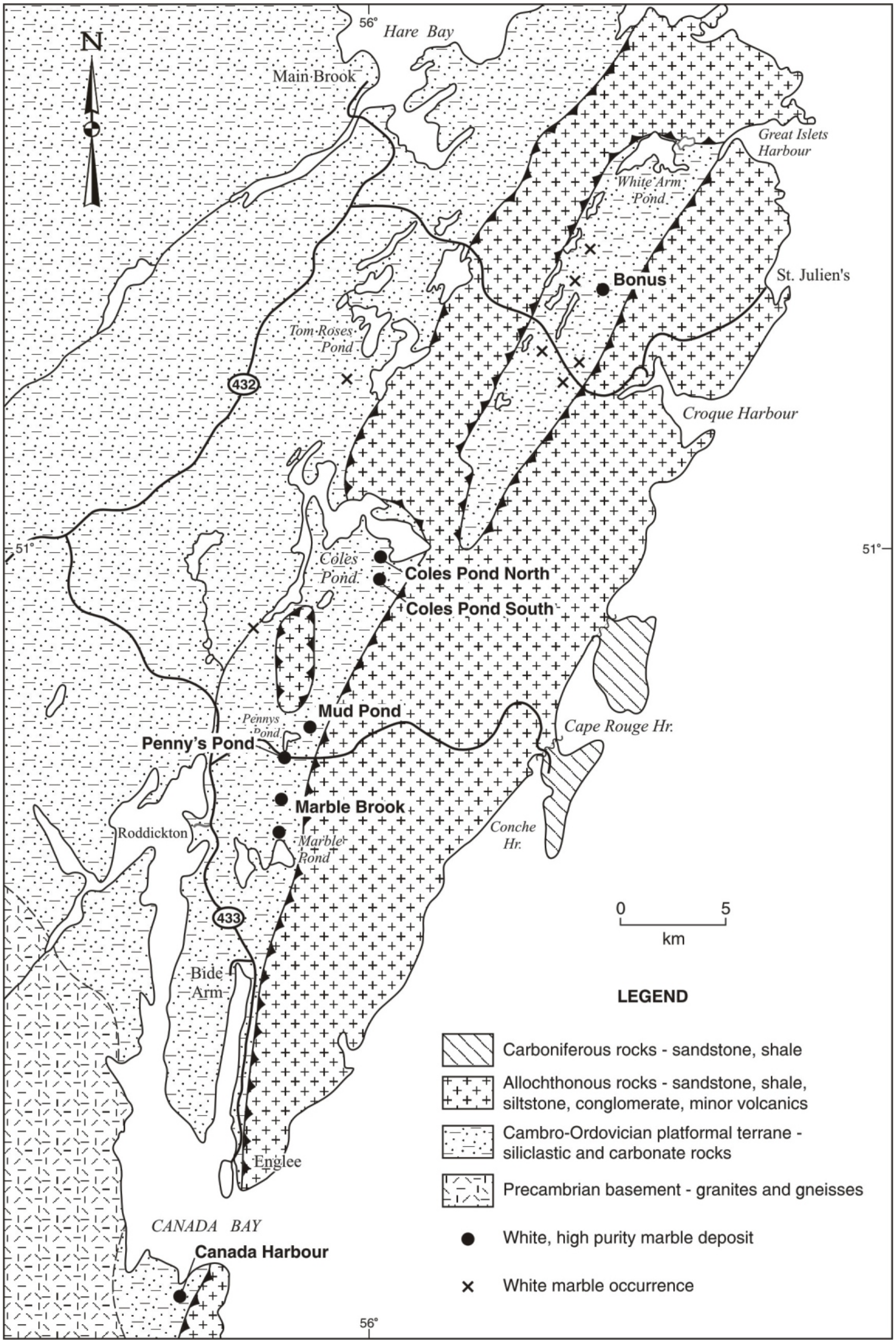


Figure 12. *Generalized map of the Canada Bay–Hare Bay region showing main geological elements and location of marble deposits.*

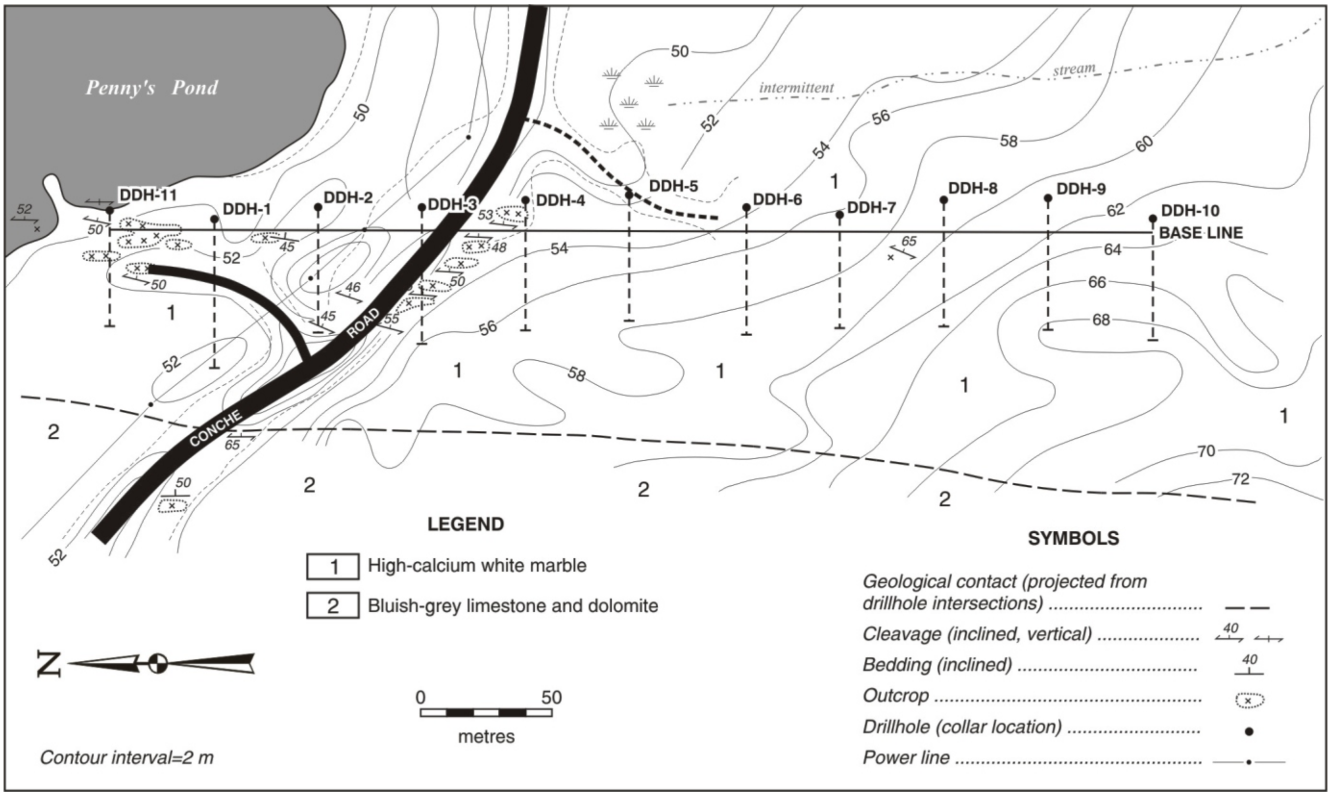


Figure 13. *Geology and drilling plan for the Penny's Pond marble deposit.*

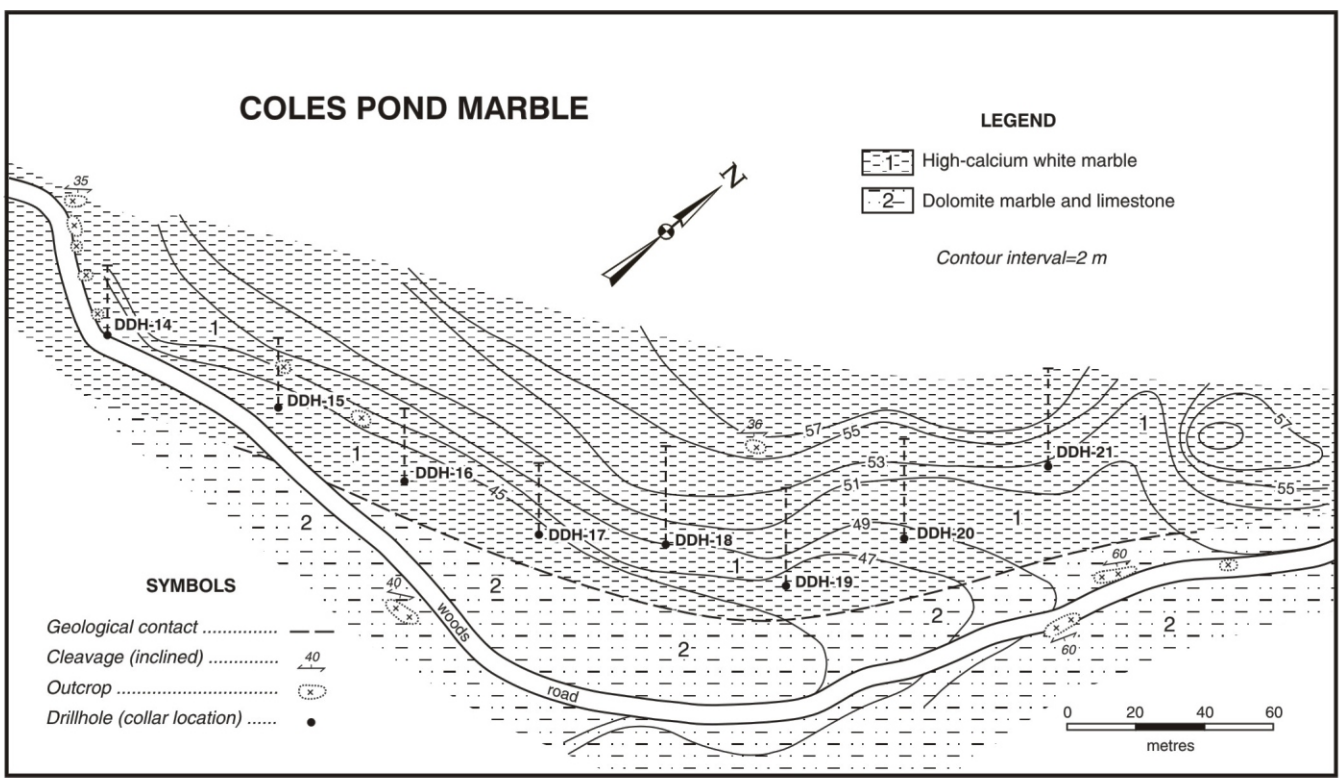


Figure 14. *Geology and drilling plan for the Coles Pond marble deposit.*

Plate 9a. *Jacob Lushman standing on stripped area of the Coles Pond marble deposit.*

Table 14. *Tonnage estimates - Roddickton marble belt (*modified from *Royce, 1987)*

	width (m)	length (m)	depth (m)	tonnes
Coles Pond	80	1000	15	3 100 000
Penny's Pond	100	500	10	1 300 000
Marble Brook	75	1500	12.5	3 700 000
Mud Pond	50	500	10	700 000

prospect from Aurion Minerals Limited and a trial marble ore bulk sample (5586 tonnes) was quarried and crushed on site. The bulk sample was shipped from Roddickton to Hustadmamour A/S in Elnesvagen, Norway, in September, 1997, for an evaluation of its potential use in the production of white, high-calcium filler products.

Industrial Fillers Limited, staked five license groups in 1995 to 1996 in the Roddickton marble belt aimed at further exploration and assessment of marble prospects including ground adjacent to the Coles Pond and Penny's Pond prospects. Seven holes were drilled totaling 585 m. The visual core results (no core analyses were reported) indicated suitable quality to warrant later testing (Blumenthal, 1997).

The following account includes brief descriptions of the most significant marble prospects in the Roddickton region.

Penny's Pond Marble

The Penny's Pond marble prospect is exposed north and south of the Conche Highway (Route 433), about 3.5 km east of the intersection with Route 432 (Figure 12). The marble has a fairly strong north-trending, moderately east-dipping cleavage in outcrop. In drill core the cleavage is not as apparent, and massive, unfractured sections are common. The stone is fine-grained and breaks conchoidally. Colour varies from brilliant pure white to ivory and bluish grey. The main contaminant is chlorite, which occurs as thin films along fractures and in bands of carbonate schist several centimetres thick. Other impurities include very minor sericite along fractures and quartz associated with chlorite schist bands. There are also sections of pure white marble in excess of 5 m thick containing little or no contaminating minerals and no visible fractures.

Plate 9b. *Marble surface at Coles Pond after overburden removal and high-pressure water hosing.*

The width of the marble zone, as defined by the drilling, averages at least 58 m (Table 15). The footwall is a mottled bluish-grey limestone unit intersected in all but the two southernmost holes. All holes were collared in white marble and the average width should be considered a minimum thickness.

The drilling program traced the marble zone southward for over 450 m from the south shore of Penny's Pond. However the marble zone extends far beyond the limit of the 1986 drilling. Subsequent exploration and drilling carried out by English China Clay (Reusch, 1987) showed that the belt of white marble belt that includes the Penny's Pond deposit continues southward for at least another 4.5 km and includes zones named by Reusch (1987), as the Marble Brook and Marble Pond deposits.

The white marble at Marble Brook and Marble Pond is very similar to that at Penny's Pond although fine-grained pyrite was noted in the Marble Brook core. The marble zones range up to 100 m in width and the purest stone is 100 percent white calcite. The marble is fine grained and contains a cleavage that is noticeable in outcrop but not in drill core. As at Penny's Pond, the marble grades into a mottled

Table 15. Penny's Pond marble tonnage and grades from the 1986 drill program

DDH#	Interval (m)	SiO_2	Al_2O_3	Fe_2O_3+	$MgCO_3$	$CaCO_3$	DB*	tonnes
1	2.14-51.85	1.49	0.38	0.14	1.08	93.99	95.66	276 000
2	3.05-51.85	1.62	0.39	0.13	0.65	96.36	96.01	229 500
3	32.02-57.95	1.88	0.36	0.13	0.98	96.34	96.02	248 800
4	3.05-59.48	1.49	0.35	0.15	0.65	96.61	95.82	183 000
5	1.52-69.54	1.48	0.35	0.12	0.86	97.01	96.08	171 000
11	2.75-10.68	1.09	0.27	0.09	0.56	96.95	96.00	138 862
Average		1.58	0.36	0.13	0.84	96.58	95.83	
Total tonnes								1 247 162

*Dry brightness (% light reflectance) using the tri-stimulus method as described in A.S.T.M. test method e-97
+Total iron as Fe_2O_3

grey limestone with the mottled effect caused by wisps and thin bands of grey calcite.

Coles Pond

Deposits of high-purity white marble were discovered northeast of Penny's Pond in 1986. They are exposed along woods roads just south of Coles Pond about 8 km north of the Conche Highway. The white marble overlies dolomitic marble and limestone in a northeast-trending asymmetric syncline, which has a steeply dipping east limb and a more gently dipping west limb. The structure is cut by a fault that parallels the fold axis. Coarsely crystalline white calcite occurs along the southern part of the fold.

Initial drilling of the Coles Pond marble in 1986 by the Department of Mines and Energy tested three areas (Figure 15). Eight holes, totaling 354 m, were drilled on the western limb of the structure (Figure 14). One hole tested a section of the east limb, and a 47 m hole tested a calcite showing. In the following descriptions, these marble prospects are referred to as the Coles Pond North and Coles Pond South deposits, and the calcite prospect.

Coles Pond North Prospect

The Coles Pond marble, which occurs along a northeast-trending ridge, dips gently to the southeast, is cleaved, and has colours of brilliant white, ivory, and blue. It is extremely fine grained and fractures easily producing a white powder. In the initial drilling program, eight holes of 45 m average depth and inclined at 60° were spaced at 40 m intervals along the base of the ridge (Plate 7) and drilled in a northwesterly direction normal to the trend of the marble zone (Figure 14). The results (Table 16) confirmed the predominantly white marble composition of the ridge but drill core showed significant zones of interbanded, mottled, and cloudy, greyish-blue marble. In the two holes drilled at the northeast end of the ridge, the greyish-blue marble is predominant.

Like the Penny's Pond deposit, the Coles Pond North deposit contains thin bands of chlorite along cleavage planes. Trace amounts of quartz in a calcite matrix was also noted in core. The presence of chlorite imparts a cloudy or mottled appearance to some sections of the marble.

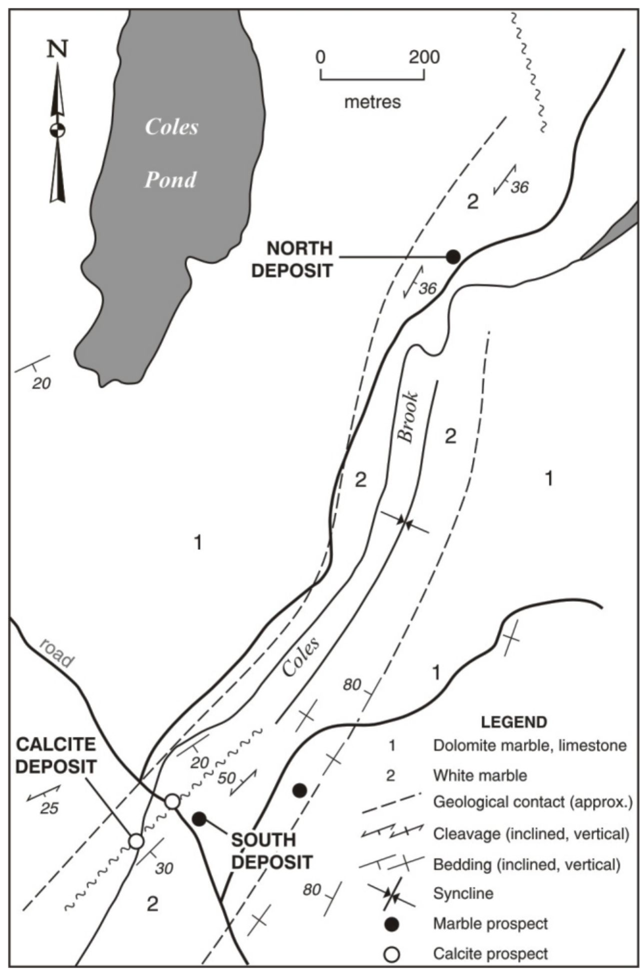


Figure 15. *Sketch map showing location of marble and calcite assessed by the 1986 diamond drilling program at Coles Pond.*

Table 16. Coles Pond marble analyses in weight percent and tonnage from the 1986 drill program

DDH#	Interval (m)	SiO_2	Al_2O_3	Fe_2O_3+	$MgCO_3$	$CaCO_3$	DB*(%)	tonnes
14	1.52-27.45	1.70	0.44	0.15	0.65	95.94	96.00	276 000
15	2.14-38.13	1.70	0.45	0.14	0.67	96.36	95.63	229 500
16	2.14-38.13	1.46	0.34	0.12	0.63	96.72	96.14	248 800
17	2.44-32.02	1.57	0.35	0.11	0.63	96.26	96.38	183 000
18	3.66-35.68	1.46	0.47	0.12	0.63	97.01	95.88	171 000
19	2.74-34.46	1.06	0.23	0.11	0.56	97.93	95.61	138 862
Average		1.52	0.39	0.13	0.63	96.6	95.95	
Total tonnes								1 247 162

*Dry brightness; +Total iron as Fe_2O_3

Coles Pond South Deposit

The Coles Pond South marble is exposed on the east side of Coles Brook in an area that was stripped of overburden by road construction. Bedding features are not evident in the marble, but the presence of thin dolomite beds indicate a near vertical dip. The marble is a continuation of the belt that includes the Coles Pond North prospect and was assessed by Reusch (1987) who estimated the length of the north-south belt to be about 2 km.

The marble was tested by a single drillhole, DDH #12, which was inclined a 45° and drilled in a southeast direction. It intersected high-purity white marble interbanded with chlorite–carbonate bands. The bands range up to 2 m wide and are widely separated. Also present are impure sections of white marble that contain thin bands of chlorite up to 1 cm wide. The cumulative section of pure white marble is 17 m.

Approximately 300 m to the southwest of the drillhole location, the apparent extension of this zone of white marble is exposed on both sides of a woods road. It also outcrops 150 m north of the hole thus indicating a strike length of at least 450 m.

Calcite Prospect

An occurrence of coarsely crystalline calcite is exposed in Coles Brook (Figure 15) and also in outcrops about 100 m along strike to the north, along a woods road. The showing consists of crystalline calcite aggregates that form cliffs along the southeast bank of the stream. Calcite crystals up to 7 cm wide form rhombohedral profiles on the surface of the outcrop. Calcite also occurs in narrow vein-like structures in the bed of the brook. The road showing consist of small flat outcrops of coarsely crystalline calcite on both sides of the road.

The calcite was tested by a drillhole (DDH #13) collared on the southwest side of the road and inclined at 70° westward. Core recovery was poor particularly in the upper sections. The top 54 m of core consists of coarse calcite; from 5.4 to 8.4 m the core was ground up and lost. The recovered upper 5.4 m section consists of aggregates of calcite crystals. These are generally white, but are locally stained light green and blue. High-calcium marble containing several impure zones of multi-coloured chlorite–carbonate schist was intersected from 8.4 to 16.9 m. White marble having a bluish-grey tint which increases downward, was encountered from 16.9 to 28.2 m. The hole ended at 41 m in interbanded bluish-grey limestone and marble and light grey marble.

Other Marble Occurrences

White marble has been identified in a number of localities such as Marble Pond, Upper Marble Pond, Coles Pond South, and Northeast Brook (Figure 16). These are poorly exposed, relatively unexplored areas, and little is known about the extent of the marble.

The Upper Marble Pond showing consists of a belt of white marble exposed in a cliff located about 100 m south of the pond and along a trail near Middle Marble Pond. Overlying sandstone of the Hare Bay Allochthon appears to have preserved the marble from erosion. A grab sample, collected by Reusch, from the weathered cliff outcrop yielded a relatively low brightness (89 percent ISO) which may not be indicative of its true brightness and more exploration was recommended (Reusch, 1987).

Marble exposed both north and south of Marble Pond is a continuation of the belt that includes the Penny's Pond and Marble Brook prospects. At the north end of the pond, flat-lying white marble outcrops in the brook and apparently extends southward beneath the pond (Plate 10). It can also be traced continuously northward along the brook for 50 m, and a farther several hundred metres through sporadic outcrops along the brook. The stone has a slightly grey cast, finely crystalline texture, and tends to break into thin slabs not more than 2 cm in thickness. Widely spaced vertical joints trend 340 to 250° (Howse, 1986). A sample of this marble taken from the stream bed at the entrance to Marble Pond yielded a surprisingly high dry brightness of 97 per-

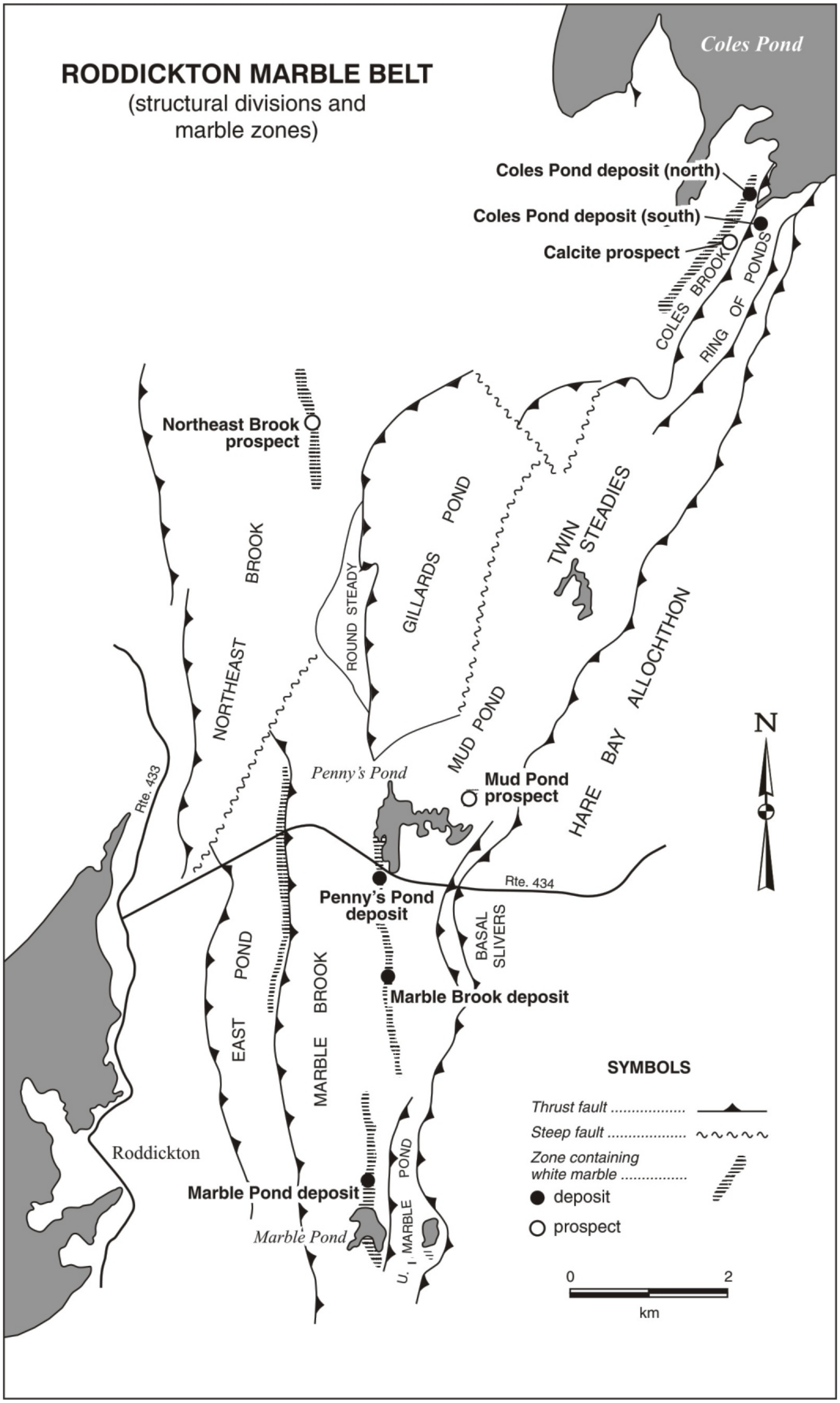


Figure 16. *Roddickton marble belt showing zones of white marble prospects.*

Plate 10. *White marble exposed along the shore of Marble Brook.*

cent. Here, the high water table would preclude quarry development; similarly the marble shown on the map by Knight (1987) at the south end of the pond is similarly restricted because of its upstream location from the Roddickton water supply.

Reusch (1987) reported outcrops of white marble on both sides of Northeast Brook. The marble dips gently east and is underlain by dolostone of the Upper Cambrian Petit Jardin Formation. A grab sample yielded a brightness of 93.6 percent ISO.

MARBLE IN THE WHITE ARM POND WINDOW

The Hare Bay Allocation has been eroded from White Arm Pond southward exposing an approximately 20-km-long belt of carbonate rocks known as the White Arm Pond Window (Smyth, 1971; Figure 17). Stouge (1983a) divided the carbonate rocks within the window into the Brent Island and Southern Arm formations of the Lower Ordovician St. George Group. Interbedded grey to black limestone and grey dolostone of the Middle Ordovician Table Head Group underlie the northern part of the window.

Northeast-trending faults cut the sequence and the carbonate rocks display a strong northeast-trending regional cleavage. The limestones and dolostones on the eastern and western margins of the White Arm Pond Window have been recrystallized into fine- to medium-grained aggregates. Locally, the limestones have been sheared and metamorphosed into white and grey marble. Several such showings were investigated in by the Department of Mines and Energy in 1987. For convenience the more significant occurrences are informally referred to as the Powerline, Skidder Trail and Sawmill prospects (Figure 17) and are described below.

Powerline Marble Prospect

Bands of white, grey, and bluish-grey marble are exposed north and south of the Croque road near the eastern margin of the White Arm Pond Window (Figure 17). The Croque powerline crosses the deposit.

The marble occurs within interbedded limestones and dolostones of the Brent Island Formation and is part of the northeast-trending, tightly folded sequence of limestones and dolostones exposed on the north and south sides of the Croque road. The purest white marble is found just a few metres south of the road in a 23-m-wide band exposed by construction of the road and powerline. The marble has a light-brown weathered surface and is strongly cleaved (050°/40°SE). On fresh surfaces, the marble is white to buff and is fine grained. Bands of mica-rich impurities, 30 to 40 cm wide, were noted in some large loose blocks. Because of overburden, the marble cannot be traced along strike beyond a few metres. Thin-bedded recrystallized dolostone occurs above and below the white marble, striking to the northeast, and dipping 45° to the southeast. The dolostone is bleached light- grey and contains numerous cm-scale veins of white quartz and grey chert nodules.

North of the road, beginning at a point approximately 50 m northwest of the showing described above, a section of northeast-trending, interlayered dolostone, limestone, and marble is sporadically exposed over a distance of 145 m. Within the steeply eastward-dipping sequence, at least 7 bands of white marble are present, ranging in width from 1 to 13 m. The marble is fairly white and pure, and is intimately associated with cherty, quartz-veined dolostone. Repetitive bands of bluish limestone containing dolomitized burrows, mixed dolostone and marble are also present in the sequence.

The results of chemical analyses and dry brightness tests carried out on representative chip samples from the south zone are shown in Table 17. Although brightness ranges from good to excellent, the presence of dolomitic bands is reflected in the high magnesium content and elevated level of silica.

Skidder Trail Marble

White marble is exposed at several locations along the western margin of the White Arm Window within the

Southern Arm Formation. One of these showings, the Skidder Trail prospect, is intermittently exposed along a low ridge about 500 m southwest of the Croque Road (Figure 17). The deposit consists mainly of interlayered white, high-purity marble and lesser amounts of beige-weathered, light-grey dolostone. Bands of marble, ranging in width up to 8 m, were observed along a northeast-trending belt traceable for more than 600 m. It is fine-grained and somewhat chalky in places. Silty laminae are present in some of the bands that are aligned along a strong cleavage that trends northeast and dips steeply (70 to 80°) to the southeast.

It appears likely that significantly wider bands of marble than those observed may lie underneath overburden. In one partly exposed section, chip samples were collected across a 100 m width and only two minor bands of dolostone (2 and 4 m) were observed. Trenching and (or) drilling is necessary to properly assess the area.

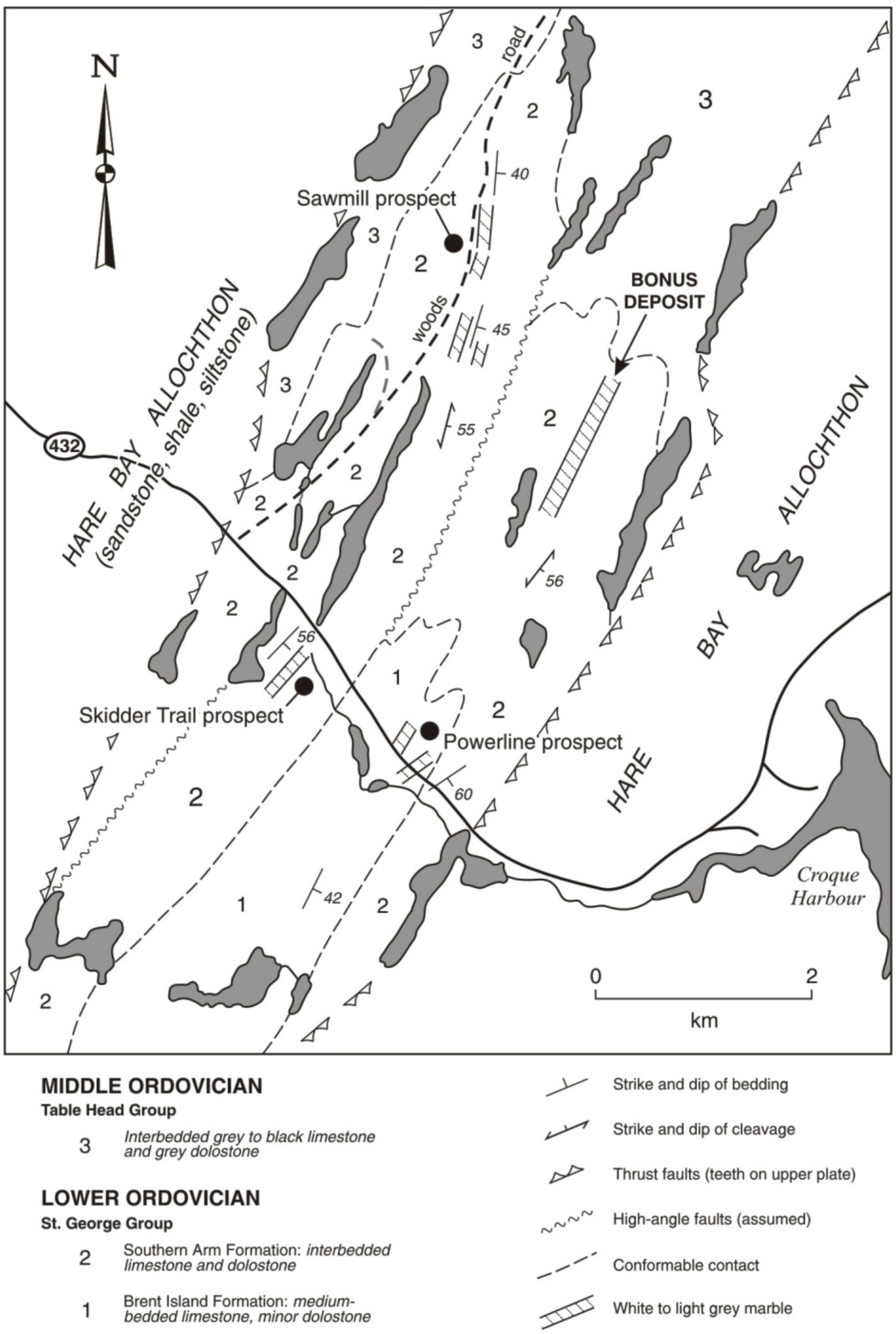


Figure 17. *White marble showings in the White Arm Pond Window*

Sawmill Marble

White marble is present in two northeast-trending zones located approximately 3 and 4 km north of the Croque road (Figure 17). Both lie within the Southern Arm Formation and outcrop along the flanks and crests of a series of northeast-trending hills and ridges. A woods road to an abandoned sawmill, located north of the Croque road, provides access to the showing.

The southern zone consists of fine-grained, white to grey bands of marble interlayered with dolostone. The marble is strongly cleaved (020°/65°SE) and breaks easily into slabs. Lack of outcrop makes it impossible to determine the maximum width of dolostone-free marble. However, separate, discontinuous outcrops, 3 to 4 m wide, were sampled over a width of approximately 50 m. Impurities in the zone consist of sericite and iron staining along some fractures, a 1-m thick chlorite-carbonate layer, and a few cm-scale shaly bands.

The northern zone of marble showings consists of at least two bands of white marble, 15 and 20 m wide, located about 1 km north of the southern zone. The marble outcrops along a low ridge. It is ivory white, fine to medium grained and strongly cleaved (020°/50-55°SE).

These marble occurrences indicate excellent potential for finding significant resources of white marble in the White Arm window and, in particular, the area underlain by the

Table 17. Chemical analyses in weight percent and dry brightness for chip samples from the Powerline marble occurrences

Sample No.	$CaCO_3$	Al_2O_3	$MgCO_3$	SiO_2	Fe_2O_3+	DB*
South showing						
8119	96.96	0.29	0.75	1.84	0.07	94.33
8121	98.68	0.15	0.48	0.42	0.06	96.54
8122	52.26	0.98	33.69	11.03	0.49	93.03
Average	82.63	0.47	11.64	4.43	0.20	94.63

Sample No.	$CaCO_3$	Al_2O_3	$MgCO_3$	SiO_2	Fe_2O_3+	DB*
North showing						
8155	97.81	0.09	0.69	0.21	0.05	91.98
8156	98.11	0.11	0.4	0.23	0.05	92.36
8157	98.2	0.1	0.42	0.26	0.05	94.98
8158	97.31	0.2	0.73	0.45	0.08	95.41
8159	98.27	0.08	0.36	0.16	0.05	92.85
8161	98.11	0.12	0.42	0.41	0.09	95.62
Average	97.97	0.12	0.5	0.29	0.06	93.57

*Dry brightness; +Total iron as Fe_2O_3

Southern Arm Formation is a highly prospective. Because bedrock exposure constitutes only about 5 percent of the area, trenching and or drilling is necessary in order to assess the marble potential of the region. Representative chip samples from the marble zone indicate only 2 percent impurities including very low silica content and good brightness (Table 18).

Table 18. Chemical analyses in weight percent and dry brightness tests for the Sawmill Road marble showing

Sample No	SiO_2	Al_2O_3	Fe_2O_3+	$MgCO_3$	$CaCO_3$	DB*
5948155	0.21	0.09	0.05	0.68	97.81	91.98
5948156	0.23	0.11	0.05	0.40	97.92	92.36
5948157	0.26	0.10	0.05	0.42	98.20	94.98
5948158	0.45	0.20	0.08	0.73	97.31	95.41
5948159	0.16	0.08	0.05	0.35	98.27	92.85
5948161	0.41	0.12	0.09	0.42	98.11	95.62
Average	0.29	0.12	0.06	0.50	97.97	93.87

*Dry brightness; +Total iron as Fe_2O_3

Tom Roses Pond Marble

White marble is present in a parauthochthonous slice of St. George Group limestone and dolomite located immediately south of Tom Roses Pond, approximately 4 km east of Route 432 (Figure12). Stouge (1983b) assigned these rocks to the Brent Island Formation and attributed the marble to shearing and secondary bleaching of the unit.

The marble outcrops along a low ridge and also on a woods road joining Route 432 to the northwest corner of Coles Pond. It is fine to medium grained, strongly cleaved (025°/20°E) and contains black and brown stains along fracture planes. In places, the marble has completely disintegrated into a white clay. The zone strikes northeast and is intermittently exposed for about 300 m. The thickness of this relatively flat-lying marble is unknown. Seven representative samples were collected for analyses and the results are shown in Table 19. The results show that a low level of silica is present (average 0.81 percent) and has a good dry brightness (average 92.9 percent) indicating potential for good to excellent quality filler.

Bonus/Hanging Wall Marble Deposits

In the fall of 1987, after several white marble showings were identified that summer (Howse, 1988), Aurion Minerals Limited, a Halifax-based junior mining company, staked a large portion of the White Arm Pond Window area. Exploratory work within their claims found several showings, the most promising of which is called the Bonus deposit (Figure 17). This showing became the object of extensive follow-up work including detailed mapping, diamond drilling, preliminary quarry development and bulk testing (Reusch, 1988; Aurion Minerals Limited, 1989; Plate 11). The company planned to develop the deposit as a source of calcium carbonate to be used in paper production,

Table 19. Chemical analyses in weight percent and dry brightness tests for the Tom Roses Pond marble showing

Sample No	SiO_2	Al_2O_3	Fe_2O_3+	$MgCO_3$	$CaCO_3$	DB*
5948148	0.30	0.12	0.08	0.46	97.54	91.58
5948149	1.56	0.26	0.10	1.42	95.23	95.00
5948151	1.91	0.74	0.26	0.84	94.54	92.24
5948152	0.60	0.10	0.06	10.2	88.12	92.88
5948153	0.27	0.12	0.05	0.48	97.67	92.21
5948154	0.22	0.12	0.06	0.48	98.17	93.50
Average	0.81	0.24	0.1	2.32	95.21	92.90

*Dry brightness; +Total iron as Fe_2O_3

Plate 11. *Bonus marble deposit located 5 km northwest of Croque.*

paint manufacturing, and sealants and caulkings. However, Aurion decided to focus on the Coles Pond prospect after their development proposal for that resource was accepted by the Newfoundland and Labrador Department of Mines and Energy.

The Bonus/Hanging Wall prospects comprise two white marble zones located approximately 1.5 km northeast along strike from the Powerline occurrences. The largest (Bonus) occupies a valley and is composed of white marble containing minor chlorite. Several 1- to 2-m-wide bands of grey to white dolostone are found in this zone of marble. The prospect is within the Upper Cambrian Petit Jardin Formation of the Port au Port Group.

The second prospect (Hanging Wall) is smaller than the Bonus Prospect and consists of mainly white fine-grained calcitic marble with very minor dolostone. The presence of grey wisps and streaks in the marble and the absence of significant dolostone and associated silica suggest this is a different unit than the Bonus deposit marble, stratigraphically higher (base of the St. George Group), and resembling marble to the south at Coles Pond and Penny's Pond.

The ubiquitous presence of quartz-veined dolomite in the Bonus deposit marble is a concern if one contemplates its use as premium quality filler. Additional processing after fine grinding would be required to reduce silica content to an acceptable level.

The Bonus deposit has 5.5 million tonnes of proven reserves, and a further indicated and inferred resource of 1.6 million tonnes. There are no estimates of tonnages available for the Hanging Wall prospect. Table 20 contains analyses from 4 representative diamond-drill holes from the Bonus and Hanging Wall deposits. The marble from both deposits has good brightness but contains a relatively high level of silica. It is possible that both brightness and the amount of impurities present could be significantly improved by beneficiation.

Table 20. Average analyses in weight percent and dry brightness for drill core from four representative diamond drillholes from the Bonus and Hanging wall marble deposits

DDH	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3+	LOI	Total	DB
7 (B)	48.70	3.28	4.21	0.87	0.32	41.65	99.03	94.46
19 (B)	47.68	3.58	5.12	1.00	0.28	41.42	99.08	94.35
27 (B)	49.76	2.60	3.23	0.72	0.22	42.06	98.59	94.77
12 (HB)	49.27	3.23	3.27	0.57	0.18	42.84	99.36	na

*Dry brightness; +Total iron as Fe_2O_3

Canada Harbour Marble Prospect

The first determined effort to exploit marble in Newfoundland took place at Canada Harbour in the early 1900s. During the period 1912-15, William Edgar, a native of Scotland, tried to quarry white marble for dimension stone, but after a considerable investment of men and equipment the enterprise failed. The inflationary freight rates and shipping hazards of World War I are believed to be significant factors that contributed to its failure (Martin, 1983).

The commercial potential of using Canada Harbour marble for building stone, ornamental stone and in memorials continued to attract interest after the First World War. Initial work by Muir (1935) and Howse (1936) on marbles in the White Bay and Canada Bay areas led to a more comprehensive study by Bain (1937) on its potential for use as dimension stone. In 1967, British Newfoundland Exploration Limited investigated the Canada Harbour prospect in a program that included detailed geological mapping and bulk sampling (Barron, 1967), but nothing further developed. A survey of Newfoundland's limestone resources by DeGrace (1974) included an evaluation of the Canada Harbour prospect. This study was primarily concerned with identifying limestone and marble having the chemical specifications for such industrial applications as cement and quicklime manufacturing. The Canada Harbour marble prospect was further assessed by Howse (1986, 1987) mainly to determine its potential use as industrial filler.

Location and Access

Canada Harbour, once the site of a fishing community, now a summer settlement, is located at the entrance to Canada Bay on the eastern side of the Great Northern Peninsula (Figures 12 and 18). There are no road connections to Canada Harbour. Englee, a major fish-processing

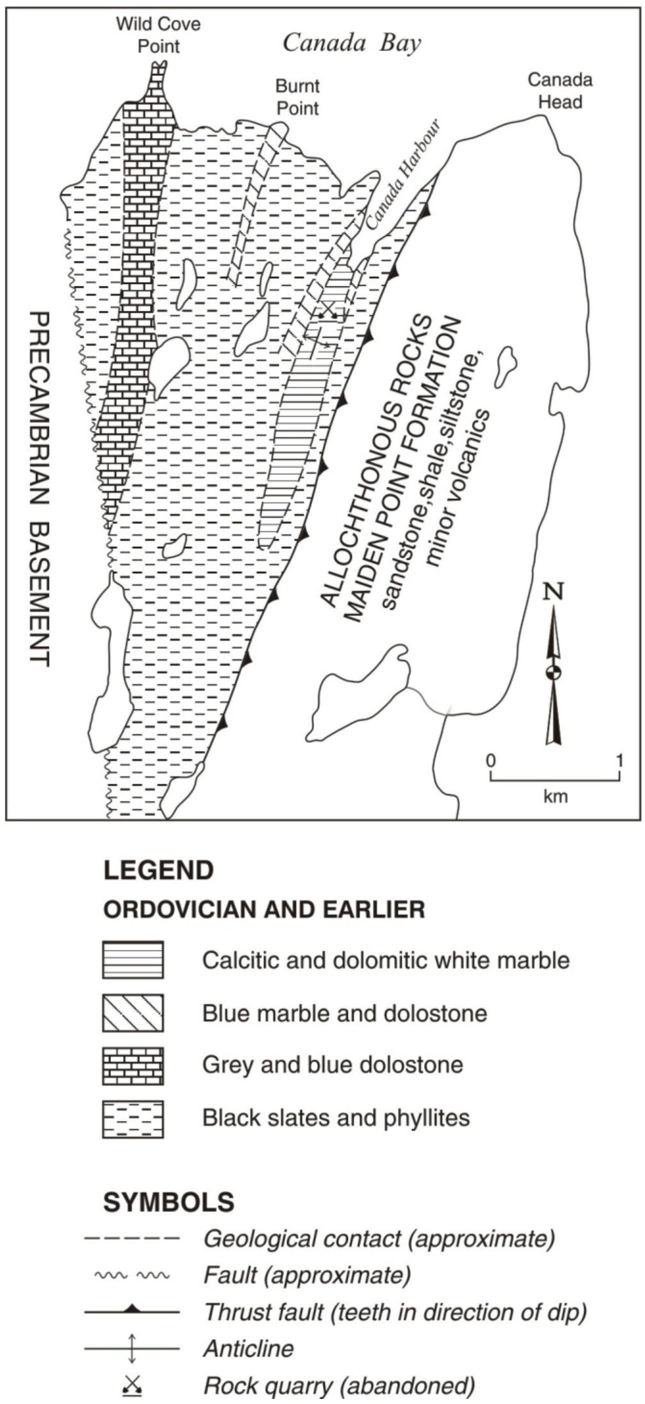


Figure 18. *Canada Harbour marble deposit.*

centre for the region, is located 5 km north across the bay and is linked by paved road to the province's highway system. Canada Harbour is a sheltered inlet with deep water suitable for large ships. However, except for one or two small fishing wharves used by local fishermen there are no docking facilities available.

Regional Geological Setting

In the Canada Harbour region, Cambo-Ordovician platformal rocks are wedged between Precambrian crystalline basement on the west and the structurally overlying allochthonous rocks to the east (Figure 18). The white marble zone closely parallels the western margin of the allochthon. The precise stratigraphic position of the Canada Harbour marble is uncertain. I. Knight (personal communication, 1988) stressed the need for further stratigraphic studies in that area of Canada Bay, and tentatively correlated the marbles with the Watts Bight Formation of the Lower Ordovician St. George Group.

Description of the Prospect

Calcitic and dolomitic white marble is exposed on Marble Hill (Plate 12) in the main quarry, an open cut about 42 by 24 m (Figure 19). A much smaller open cut (Quarry No. 2), which is located near the crest of the ridge, was examined but not sampled by Howse (1987). In the main quarry, the white marble is overlain by blue-grey marble and dolomite. The deposit is structurally complex and bedding features are not apparent. Bain (1937) showed the white marble as occupying the core of an upright anticline, with the blue-grey marble on its flanks. The exact thickness of the white marble unit is unknown but in the main quarry, a zone approximately 35 m wide, was measured and sampled. This measurement allows for the irregular layout (in plan) of the quarry face (Figure 19).

The marble is generally white but is also ivory or cream and, in places, has a distinctive pink hue. It is extremely fine grained and breaks with a conchoidal fracture. Some of the whiter stone has a porcelaineous texture and breaks much more irregularly. This feature seems to be more pronounced in the small quarry.

Plate 12. *Marble Hill, a prominent topographic feature of the abandoned community of Canada Harbour. The hill is composed mainly of high-calcium white marble.*

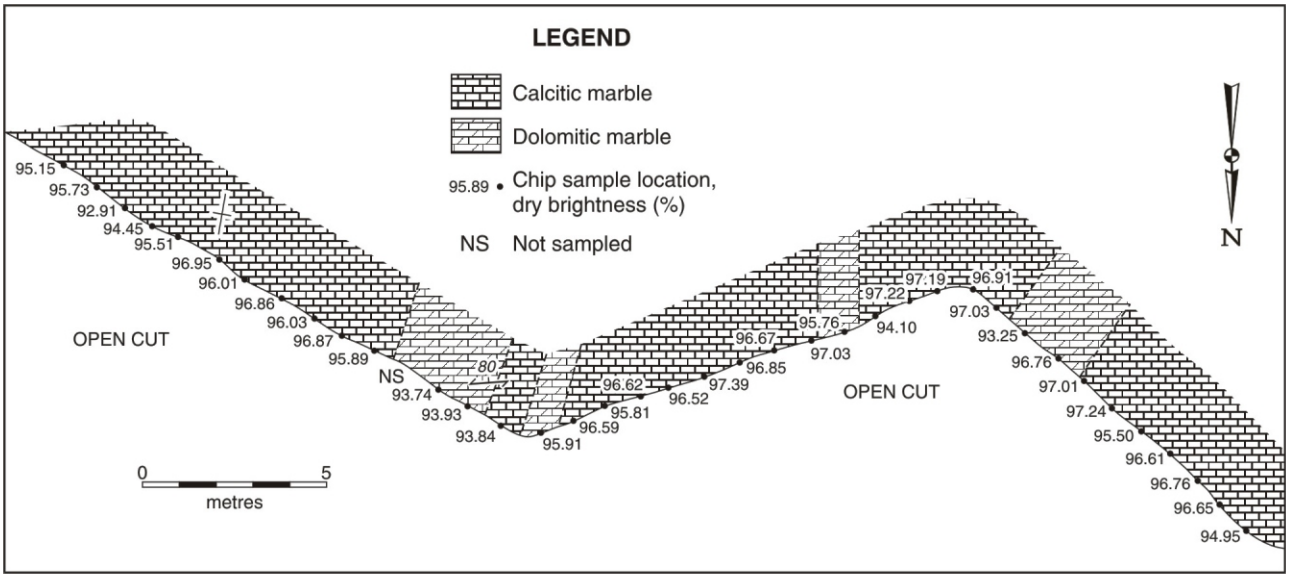


Figure 19. *Plan view of the main open cut at the Canada Harbour marble deposit showing geology and dry brightness.*

Impurities in the marble include chlorite and sericite, which occur as thin coatings along joints and bedding planes. Quartz is present in only small amounts. However, where bands of dolomitic marble occur, the silica content is high. At least four such bands ranging up to 4 m in width are found in the face of the main quarry.

Two diabase dykes were uncovered in earlier exploration trenches that were dug across the white marble zone on Marble Ridge (Barron, 1967). The dykes have irregular widths ranging up to 4.5 m, are steeply dipping and cut the marble zone at 10 to 30°. They have porphyritic chilled margins but the surrounding marble is relatively unaltered (Barron, 1967). The trenches are now refilled, overgrown and inaccessible. However, a basic dyke outcrops on the shore of Canada Harbour about 300 m northeast of the main quarry. The dyke is up to 4 m in width, and cuts blue marble on the east flank of the white marble zone. Its 030° strike indicates it could intersect the white marble in the Marble Ridge area. The presence of diabase dykes within the marble zone of Canada Harbour is a feature not found in other marble prospects in the region.

Reserve Potential

The Canada Harbour marble is exposed on the shore at Canada Harbour (Plate 13), in the open cuts on Marble Ridge and in a few scattered outcrops south of the ridge for a total length of approximately 2.5 km. The area is covered with a thin but pervasive blanket of till so it is not presently known if the zone is continuous along its strike. For practical purposes only, Marble Ridge and the area south can be considered as having reserve potential. Therefore if one assumes the white marble zone is continuous south of the main quarry for 2 km, and further assumes a width of 35 m, and a quarryable depth of 30 m, a tonnage of about 4.6 million tonnes is indicated using a specific gravity of 2.75. The actual mining depth that might be realized by a potential developer is a major uncertainty, and greatly influences reserve calculations. The possible presence of diabase dykes in the deposit is also a major concern.

Chemistry and Dry Brightness

The chemical analyses show that approximately 20 percent of the white marble unit in the main quarry is dolomitic (Table 21). The dolomitic beds are high in impurities, especially quartz, and are intimately interbanded with the calcitic marble. The calcitic marble is fairly pure with silica, the main contaminant, averaging less than 1.2 percent, and Al_2O_3 and Fe_2O_3 totaling well below 1 percent. The average grade, making no distinction between the dolomite and calcite is in the order of 89 percent $CaCO_3$ with 2.5 percent silica, and

Plate 13. *White marble exposed on the shore of Canada Harbour.*

Table 21. Chemical analyses in weight percent and dry brightness tests for chip samples from the Canada Harbour white marble deposit. Chips represent one metre intervals on the main quarry face going from east to west. Analyses in weight percent

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	$MgCO_3$	$CaCO_3$	DB*	Rock type
5945898	0.62	0.14	0.07	0.54	96.12	95.15	calcitic marble
5945899	0.68	0.15	0.08	0.48	97.19	95.73	calcitic marble
5945901	4.67	0.83	0.22	1.00	91.08	92.91	calcitic marble
5945902	0.67	0.07	0.05	0.54	98.08	94.45	calcitic marble
5945903	0.60	0.12	0.05	0.50	98.61	95.51	calcitic marble
5945904	3.28	0.54	0.12	0.65	93.70	96.95	calcitic marble
5945905	1.31	0.41	0.14	0.71	97.35	96.01	calcitic marble
5945906	0.39	0.06	0.06	0.46	98.15	96.86	calcitic marble
5945907	0.82	0.19	0.09	0.69	96.69	96.03	calcitic marble
5945908	0.72	0.10	0.05	0.54	98.18	96.87	calcitic marble
5945909	5.49	0.48	0.25	32.52	60.45	95.89	dolomitic marble
5945911	31.35	4.84	1.40	24.07	35.12	N.A.**	dolomitic marble
5945912	2.99	0.41	0.27	39.96	56.67	93.74	dolomitic marble
5945913	4.38	0.34	0.28	40.56	54.22	93.93	dolomitic marble
5945914	0.73	0.16	0.06	0.79	97.13	93.84	calcitic marble
5945915	4.39	0.67	0.29	23.68	70.17	95.91	dolomitic marble
5945916	0.52	0.07	0.03	1.10	96.80	96.59	calcitic marble
5945917	0.38	0.05	0.03	0.52	97.37	95.81	calcitic marble
5945918	0.32	0.04	0.03	0.54	97.03	96.62	calcitic marble
5945919	0.50	0.10	0.05	4.26	93.29	96.52	calcitic marble
5945921	0.38	0.06	0.04	0.48	98.13	97.39	calcitic marble
5945922	0.53	0.10	0.04	0.73	97.33	96.85	calcitic marble
5945923	1.88	0.31	0.14	4.14	91.69	96.67	calcitic marble
5945924	0.40	0.07	0.04	0.52	97.10	97.03	calcitic marble
5945925	7.81	1.41	0.64	23.78	63.85	95.76	dolomitic marble
5945926	2.99	0.89	0.30	8.57	86.77	94.10	calcitic marble
5945927	0.64	0.11	0.06	0.73	97.53	97.22	calcitic marble
5945928	0.48	0.07	0.05	0.58	99.48	97.19	calcitic marble
5945929	0.67	0.14	0.09	0.81	97.44	96.91	calcitic marble
5945931	0.64	0.12	0.07	0.77	97.77	97.03	calcitic marble
5945932	5.14	0.17	0.16	10.74	72.46	93.25	dolomitic marble
5945933	4.03	1.00	0.38	13.17	79.16	96.76	dolomitic marble
5945934	0.49	0.12	0.06	0.48	97.49	97.01	calcitic marble
5945935	0.45	0.08	0.04	0.42	96.56	97.24	calcitic marble
5945936	1.53	0.24	0.12	0.63	95.55	95.50	calcitic marble
5945937	0.91	0.32	0.10	0.61	96.07	96.61	calcitic marble
5945938	0.78	0.25	0.10	0.65	96.05	96.76	calcitic marble
5945939	2.14	0.45	0.19	0.75	94.43	96.65	calcitic marble
5945941	0.83	0.24	0.11	1.02	96.23	94.95	calcitic marble
Average	2.50	0.40	0.16	6.24	89.08	95.96	
Average	1.12	0.25	0.10	1.30	96.21	96.16	calcitic marble
Average	8.29	1.16	0.45	26.06	61.51	94.75	dolomitic marble

Note: Tests for brightness by I.M.D. Laboratories Limited (1986)
* Dry brightness (% light reflectance) using the tri-stimulus method as described in A.S.T.M. test method E-97)
** Not analyzed; Fe_2O_3+

$MgCO_3$ over 6 percent. Alumina and iron total less than 0.5 percent.

The dry brightness of the marble, a critical factor in determining the marble's suitability as an industrial filler, averages 95.96 percent. Excluding the dolomitic beds, which averaged a surprisingly high 94.75 percent, the samples show an average brightness of 96.16 percent. Seven of the samples (18 percent of the total) had values in excess of 97 percent, all within the calcitic marble. This shows that although there is a significant brightness difference between the dolomite and calcite, dilution in brightness due to the dolomite, does not seriously affect the overall brightness of the marble.

Summary

The Canada Harbour white marble prospect is the southernmost deposit in a belt that has been documented to extend from Canada Bay to Croque, a distance of more than 50 km. The marble occurs along deformed zones of carbonate rocks that structurally underlie the Hare Bay Allochthon.

Chemical analyses of chip samples from the face of the main open cut at Canada Harbour, show that about 20 percent of the marble is dolomitic. This distinguishes the deposit from the calcitic marble at Penny's Pond and Coles Pond. Silica is significantly higher in the Canada Harbour marble reflecting the higher level of impurities associated with the dolomitic units. Total iron as Fe_2O_3 and Al_2O_3 average less than 0.5 percent.

NORTHERN PENINSULA DOLOSTONE PROSPECTS

DEER COVE PROSPECT

The Deer Cove dolostone prospect is located approximately 5 km north of Bellburns on the Great Northern Peninsula between the Viking Trail (Route 430) and the sea (Figure 20). The dolostone comprises a section of the Catoche Formation of the Lower Ordovician St. George Group. The flat-lying to gently west-dipping beds are up to 2 m thick. The dolomite is fine to medium grained, has a crystalline texture and varies in colour from light- to dark-grey-brown. A maximum thickness of 20 m is exposed along the coast. The deposit can be traced for at least 3 km along a northerly strike but for only about 200 m inland. This represents a deposit of nearly 35 million tonnes. The Deer Cove dolostone was chip sampled by Slivitzky (1987) and the average results for two sampled areas are given in Table 22.

Work carried out to date, indicates a high degree of variation in the silica content of the dolostone along its strike. In order to determine an accurate grade for this deposit, a follow-up assessment including drilling would be required.

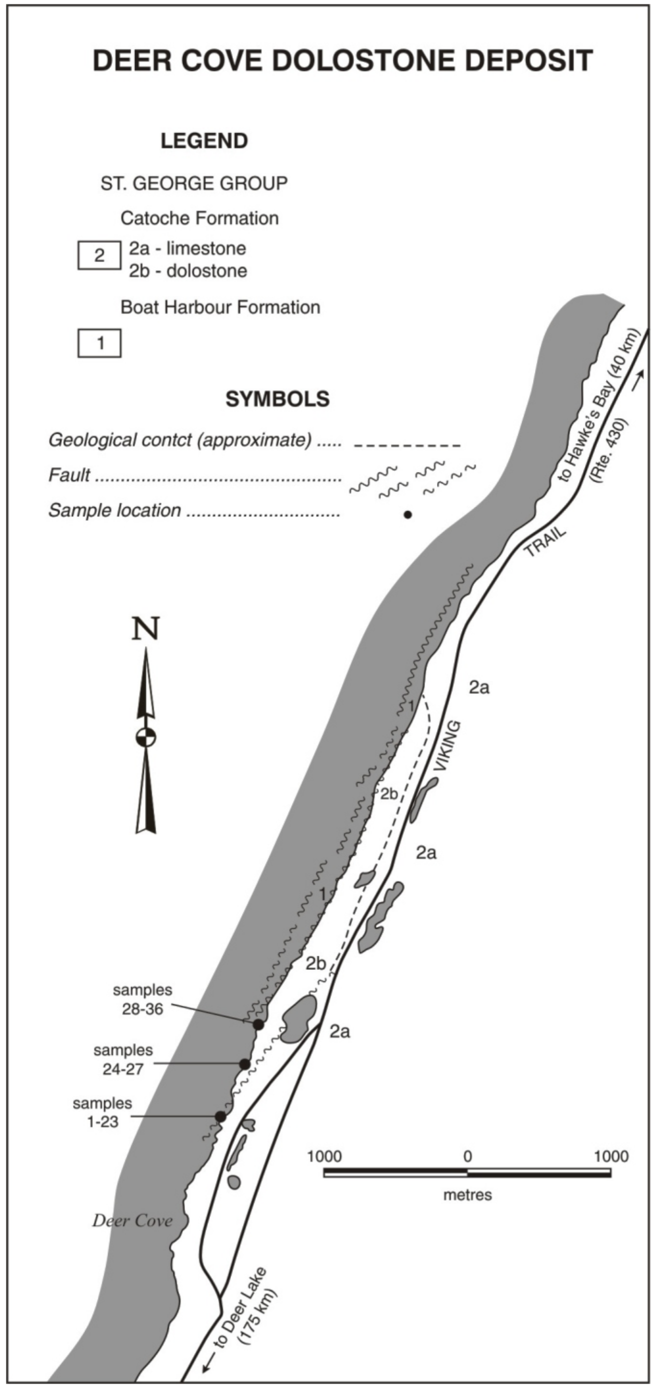


Figure 20. *The Deer Cove dolostone prospect.*

BACK ARM DOLOSTONE PROSPECT

The Back Arm dolostone prospect is located on the east side of Back Arm near the town of Port au Choix (Figure 21; Plate 14). It consists of a gently (5 to 10°) southwest-dipping, 16-m-thick section of Catoche Formation dolo-

Table 22. Chemical analyses in weight percent of the Deer Cove dolostone prospect

	MgO	SiO_2	Fe_2O_3+	Al_2O_3	MnO	B
Samples 1-23	19.8	2.52	0.45	0.72	0.034	<20 ppm
Samples 24-36	20.0	0.98	0.26	0.32	0.020	

+Total iron as Fe_2O_3; *dark brownish-grey dolostone (southern part of section); **light brownish-grey dolostone (northern part of section)

stone. The dolostone is buff to medium brown and is variably mottled and vuggy. It is medium to thick bedded and is fine to medium grained. Vugs constitute less than 1 percent of the rock but in some beds or locally within a bed, comprise approximately 25 percent of the rock. The more intensely vuggy zones are characterized by 1- to 2-cm-diameter vugs and a texture that may relate to burrowing (Plate 15). The medium-grained portions have abundant intergranular space which, along with the vugs, are partly filled with black organic material. Vugs in the more massive rock are lined with either quartz or dolomite in equal proportions and rarely contain calcite crystals. Chert, up to 1 percent by volume, also occurs as nodules, 1- to 4-cm, that are most abundant in the upper portions of the section. The unit underlies

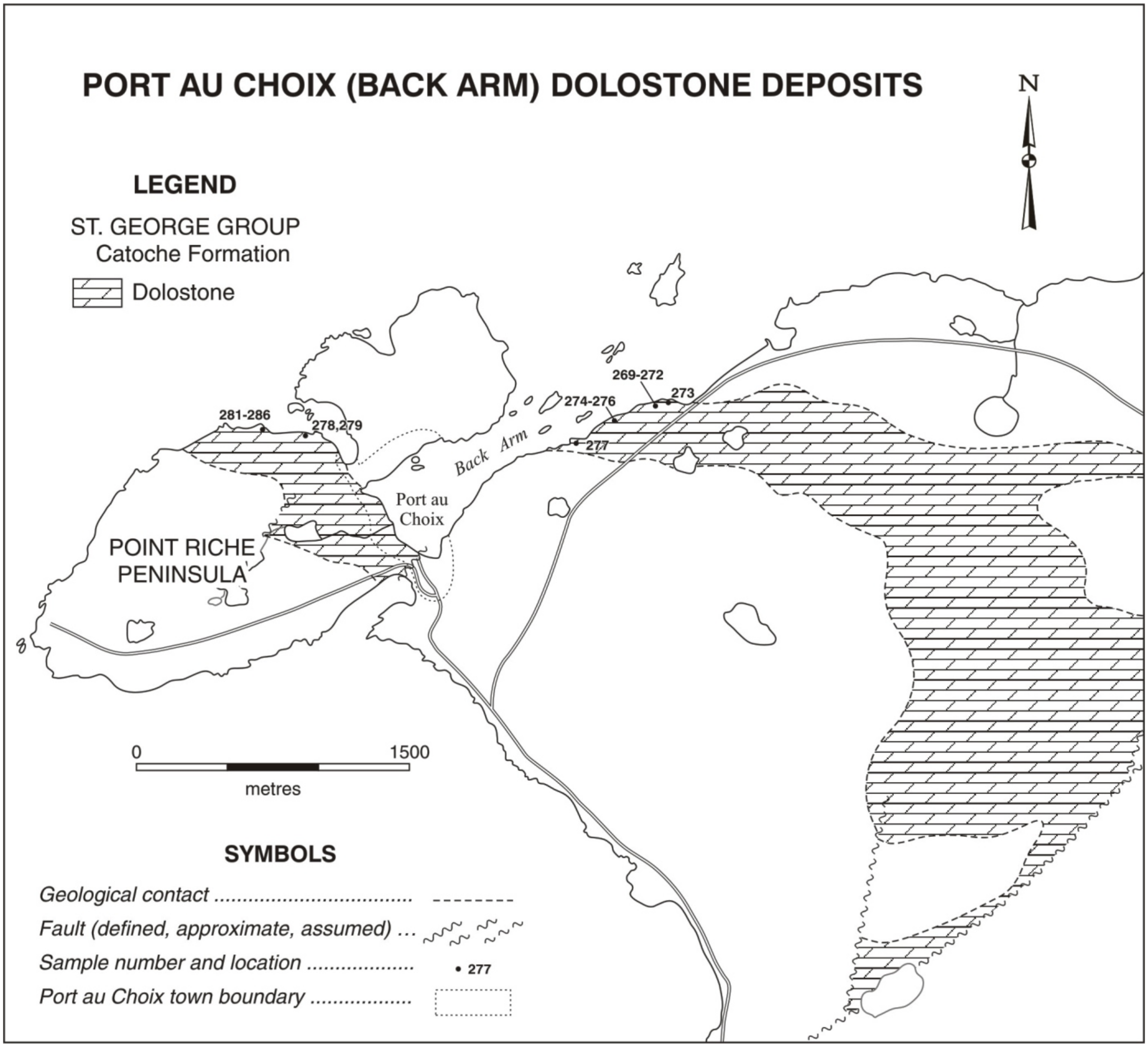


Figure 21. *Port au Choix dolostone prospects.*

Plate 14. *Dolostone exposed at Back Arm near Port au Choix.*

a large area to the east of Back Arm where natural quarry faces are present, and it may be possible to develop a quarry site. Table 23 gives the results of the chemical analyses of 8 representative chip samples from the Back Arm prospect. These are well within the range required for metallurgical applications and indicate follow-up work is warranted.

POINTE RICHE DOLOSTONE PROSPECT

The Point Riche dolostone prospect is located at the northern part of the Pointe Riche Peninsula (Figure 21), 30 km northwest of Hawke's Bay. It comprises a 17-m-thick section of dolostone that is similar to the Back Arm deposit. The prospect comprises a large area and sufficient tonnage should be present for quarrying. A total of 8 representative chip samples of the dolostone was chemically analyzed to help determine its industrial potential. The results, shown in Table 24, indicate the presence of high-purity material that could meet specifications required for metallurgical use. However, this deposit lies within the boundaries of the Port au Choix National Historic Park and is not available for development.

Plate 15. *Mottled and vuggy Catoche Formation dolostone exposed near the northeast shore of Back Arm, Port au Choix.*

Table 23. Chemical analyses in weight percent of chip samples from the Back Arm dolostone deposit

Sample No.	SiO_2	Al_2O_3	Fe total+	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	L.O.I.
9269	0.30	0.12	0.13	21.86	30.37	0.04	0.06	0	0.02	0	47.52
9271	0.57	0.19	0.14	21.71	30.06	0.03	0.08	0	0.02	0	47.24
9272	0.81	0.31	0.21	21.12	29.67	0.05	0.13	0	0.02	0	47.25
9273	0.91	0.19	0.13	21.52	29.95	0.04	0.09	0	0.01	0	46.93
9274	0.38	0.10	0.15	21.72	30.19	0.03	0.05	0	0.02	0	47.32
9275	0.62	0.13	0.12	21.57	29.83	0.03	0.07	0	0.01	0	47.21
9276	0.39	0.11	0.13	21.64	30.08	0.04	0.05	0	0.02	0	47.38
9277	3.41	0.24	0.17	21.95	29.20	0.04	0.11	0	0.02	0	45.71

+Total iron as Fe_2O_3

Table 24. Chemical analyses in weight percent of chip samples from the Pointe Riche dolostone deposit

Sample No.	SiO_2	Al_2O_3	Fe total+	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	L.O.I.
9178	0.74	0.29	0.16	21.5	29.8	0	0.14	0	0	0	47.2
9179	0.67	0.18	0.15	21.6	29.8	0	0.10	0	0	0	47.1
9181	1.49	0.43	0.22	21.2	29.8	0	0.21	0	0	0	46.7
9182	1.00	0.39	0.21	21.5	29.8	0	0.16	0	0	0	47.0
9183	0.90	0.33	0.24	21.6	29.8	0	0.16	0	0	0	47.0
9184	0.90	0.38	0.20	21.3	29.9	0.1	0.14	0	0	0	46.9
9185	0.39	0.13	0.20	21.5	29.7	0	0.10	0	0	0	47.6
9186	0.94	0.25	0.22	21.5	29.8	0	0.10	0	0	0	47.0
Average	0.88	0.30	0.20	21.5	29.8	0	0.13	0	0	0	47.1

+Total iron as Fe_2O_3

CAPE NORMAN DOLOSTONE PROSPECT

The Cape Norman prospect is located at the tip of the Great Northern Peninsula (Figure 22) and occurs within the Catoche Formation of the St. George Group. The dolomite is grey, fine grained, massive and thick bedded. The gently warped unit is approximately 15 m thick, has no overburden (Plates 16 and 17) and has a good quarry face on the coast, west of the lighthouse. The lower 5 m of the section contains abundant lenticular vugs, usually 1 to 2 cm long but rarely up to 20 cm. Vugs in this part of the section are partly lined with quartz or dolomite. Impurities through the rest of the section consist of scattered clumps of fine-grained quartz and chert. The Cape Norman prospect is conservatively estimated at 35 million tonnes of potential metallurgical dolostone. The high MgO (21.4 percent) and relatively low level of impurities, shown by surface sampling (Figure 20 and Table 25) make the Cape Norman prospect a promising site for future follow-up work, which should include core drilling.

Plate 16. *Surface expression of the Cape Norman dolostone prospect looking south from the lighthouse.*

OTHER DOLOSTONE PROSPECTS ON THE GREAT NORTHERN PENINSULA

Sampling was conducted on dolostone of the Catoche and Watt's Bight formations of the St. George Group, and

Plate 17. *Cliffs of limestone and dolostone under lighthouse at Cape Norman. Tip of lighthouse is to the upper left.*

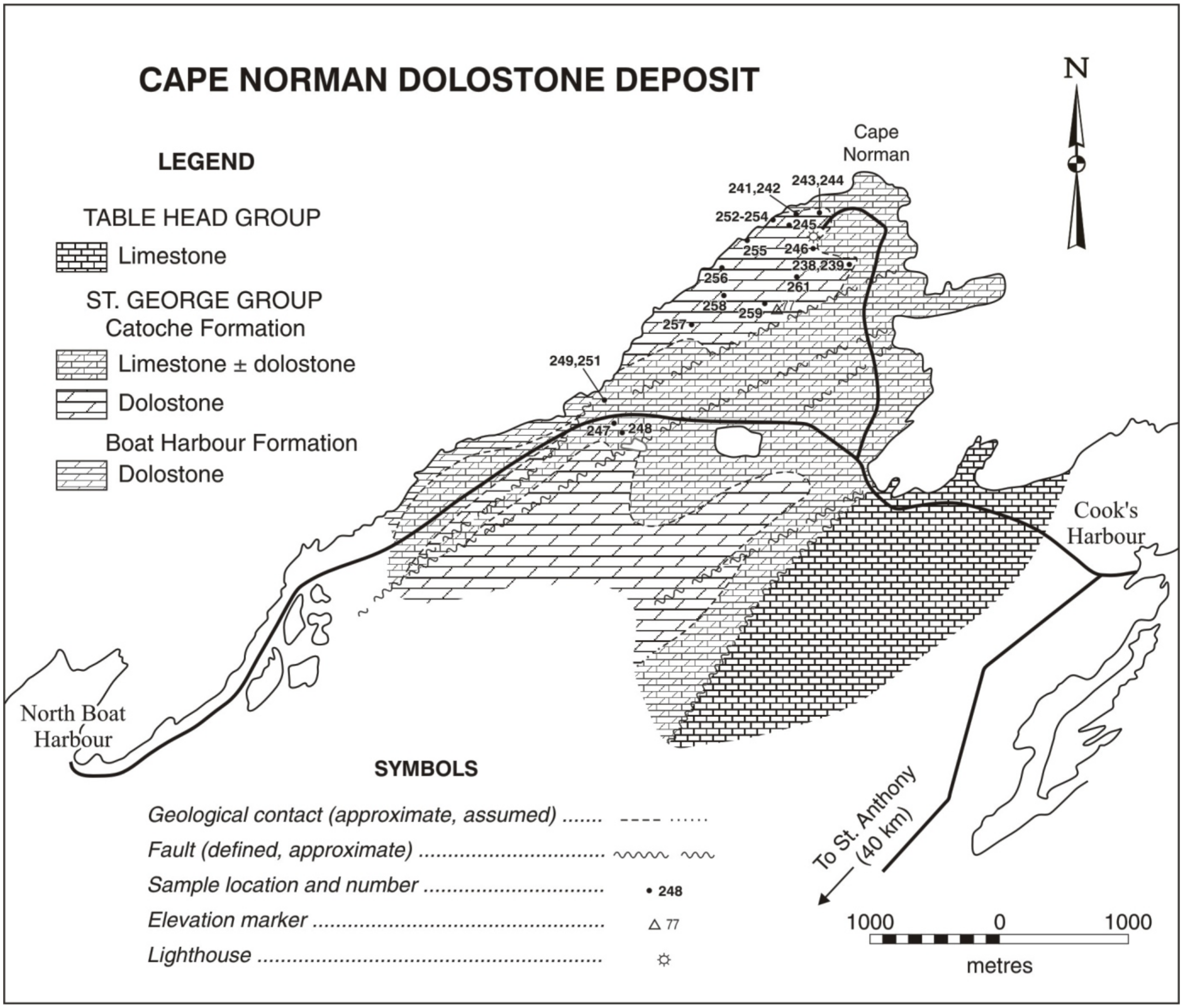


Figure 22. *The Cape Norman dolostone prospect.*

the Petit Jardin Formation of the Port au Port Group at the following locations: 1) Roddickton area; 2) Big Brook; 3) New Ferolle Peninsula; 4) Ten Mile Lake and 5) Castor's River (Figure 23).

Roddickton area: Dolostone of the Catoche Formation was sampled along the highway north of Roddickton. The dolostone is fine to medium grained and very vuggy. Grain-size difference and vugginess in the mottled dolostone are probably the result of an originally burrowed rock. The coarser dolostone is typically light grey and has abundant vug space up to 5 mm; iron staining is common but minor.

Sampling in the Roddickton area included the Watts Bight Formation, which in this area is a grey, fine-grained, medium- to thick-bedded, massive dolostone. The rock contains variable amounts of black chert as lenses and nodules, and quartz and calcite crystals. Minor pyrite and sphalerite were also observed. Low topographic relief in the Roddickton area would be a problem in developing a quarry site.

Big Brook: North of Big Brook, two coastal exposures of dolostone of the Watts Bight Formation were sampled, and in one of the areas approximately 2 m of the underlying Petit Jardin Formation was also sampled. In both localities, the Watts Bight Formation consists of brown, fine-grained, massive to laminated, thin- to thick-bedded dolomite containing discontinuous beds of mixed chert and dolostone. Chert nodules 2 to 3 cm in diameter are scattered throughout the section. The Petit Jardin dolomite is grey to buff, fine grained and mottled and contains chert nodules and 10-cm-diameter rounded masses of fine-grained quartz.

Table 25. Chemical analyses in weight percent of chip samples from the Cape Norman dolostone prospect

Sample No.	SiO_2	Al_2O_3	Fe total+	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	L.O.I.
9238	2.08	0.43	0.17	21.0	29.4	0	0.22	0	0	0	46.3
9239	0.78	0.20	0.13	21.5	29.7	0.1	0.12	0	0	0	47.1
9241	2.24	0.28	0.14	21.0	29.5	0	0.12	0	0	0	46.2
9242	0.85	0.26	0.14	21.6	29.6	0	0.13	0	0	0	47.1
9243	0.86	0.22	0.12	21.6	29.8	0	0.11	0	0	0	47.1
9244	0.70	0.20	0.09	21.5	30.0	0	0.10	0	0	0	47.2
9245	0.86	0.26	0.12	21.5	29.7	0	0.13	0	0	0	47.1
9246	0.84	0.23	0.14	21.6	29.8	0	0.12	0	0	0	47.0
9247	0.34	0.12	0.14	21.7	30.2	0	0.10	0	0	0	47.3
9248	9.88	0.23	0.12	19.1	29.2	0	0.10	0	0	0	42.6
9249	0.77	0.15	0.13	21.5	29.9	0	0.10	0	0	0	47.0
9251	13.6	0.14	0.10	18.6	25.8	0	0.10	0	0	0	40.9
9252	0.94	0.22	0.14	21.8	30.0	0	0.12	0	0	0	47.0
9253	0.74	0.23	0.15	21.8	29.9	0	0.13	0	0	0	47.1
9254	0.54	0.16	0.13	21.7	29.9	0	0.10	0	0	0	47.2
9255	0.35	0.13	O.12	22.0	30.5	0	0.10	0	0	0	47.3
9256	0.54	0.16	0.19	21.7	30.1	0	0.10	0	0	0	47.3
9257	0.76	0.11	0.15	21.6	30.1	0	0.10	0	0	0	47.2
9258	0.96	0.24	0.14	21.6	29.9	0	0.13	0	0	0	47.0
9261	0.81	0.24	0.15	21.5	29.6	0	0.14	0	0	0	47.1
Average	1.97	0.21	0.14	21.3	29.6	0	0.10	0	0	0	46.5
Average[1]	1.36	0.21	0.14	21.4	29.8	0	0.11	0	0	0	46.8

[1] Average excludes sample 9251
+Total iron as Fe_2O_3

New Ferolle Peninsula: The Watts Bight Formation was sampled on the New Ferolle Peninsula. At this locality it consists of brown, fine-grained, variably mottled and vuggy dolostone. Vugs are partly or completely filled with white or cream dolomite crystals and locally the vugs are connected by 1-mm white dolomite veinlets producing pseudobreccia texture. Chert is a common impurity occurring as irregularly shaped masses (1 to 5 cm long) or as discontinuous layers up to 30 cm thick. Quartz and white clay coatings on grains are locally present. The New Ferolle Peninsula is characterized by very low relief, which is not amenable for quarry operations. However, on the western side of the peninsula, broad hills rise 15 to 16 m above sea level.

Ten Mile Lake: In a roadcut and abandoned quarry near Ten Mile Lake, sampling was conducted on a 10-m-thick section of grey, fine-grained massive dolostone of the Petit Jardin Formation. Two 20-cm-thick beds of dark-grey shale occur in the quarry face.

Castor's River: The Watts Bight Formation was also sampled in roadcuts and an abandoned road quarry along the Viking Trail north of Castor's River. The grey dolostone is fine to coarse grained, medium bedded and massive, laminated and vuggy. Dolomite veins intrude along several cleavage trends. Chert occurs in 1- to 2-m irregularly surfaced beds containing angular, pebble- to boulder-sized clasts of limestone and dolostone set in a matrix of coarse-grained creamy dolostone. Chert comprises approximately 25 percent of the beds. Disseminated pyrite is present in the dolostone and along fracture planes.

SUMMARY

The Northern Peninsula is endowed with at least two areas of excellent quality, metallurgical-grade dolostone. The harbour at Port au Choix is flanked by two prospects, one on the northeast side of Back Arm, and the other underlying a large (northeast) portion of the Point Riche Peninsula. The latter lies within the Port au Choix National Historic Park and would be unavailable for development. The Cape Norman prospect also has excellent grade and tonnage (Table 25) and potential quarry sites on western shore of the cape. The dolostone would have to be trucked or shipping facilities developed in this region.

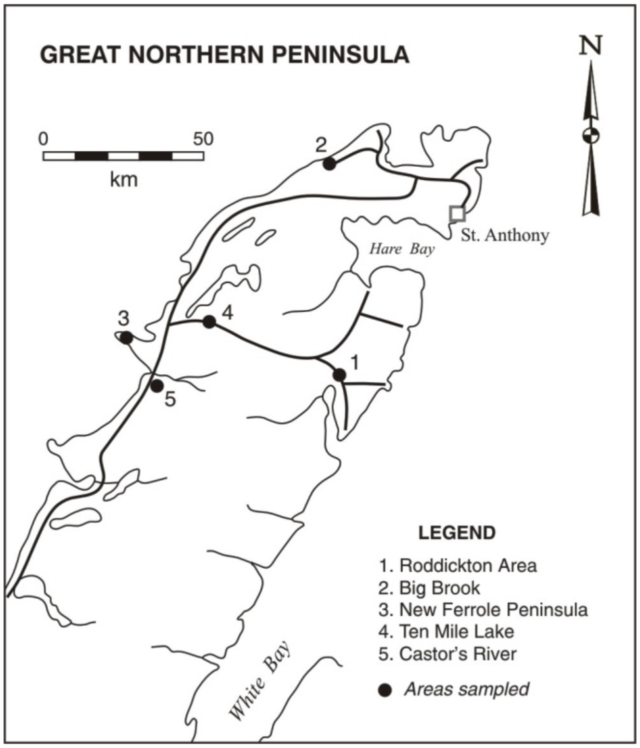


Figure 23. *Location of other dolostone showings examined on the Great Northern Peninsula.*

All of the deposits described will require additional systematic evaluation, including diamond drilling, to determine accurate grades and tonnages.

LIMESTONE PROSPECTS ON THE NORTHERN PENINSULA

A 1990 assessment of limestone by Howse (1991) on the Great Northern Peninsula examined several promising prospects in the Pistolet Bay and Canada Bay regions. The purpose of the survey was to identify high-purity, chemical-grade stone, suitable for high-growth markets such as pollution control and environmental cleanup. The best limestone was found mainly, but not exclusively, in the Middle Ordovician Table Head Group. One of the areas investigated, located near Raleigh on the eastern shore of Pistolet Bay, was later declared an ecological reserve (now known as the Burnt Cape Ecological Reserve) based on botanical research that had revealed several species of rare plants. This limestone is therefore precluded from commercial exploitation. However, other areas underlain by excellent quality limestone were investigated at Beaver Arm in Canada Bay, and near Cooks Harbour on the western shore of Pistolet Bay.

Three major prospects, along with a number of other occurrences, were investigated during the 1990 field season. The limestone beds were systematically chip sampled along lines perpendicular to their strike using a 4 kg sledgehammer and a geology hammer to remove weathered surfaces. Approximately 170 samples were collected for analysis by the Newfoundland and Labrador Department of Mines and Energy geochemical laboratory. In addition, 10-kg representative samples were taken for tests to determine the limestone's suitability as a reagent for flue-gas desulphurization.

COOKS HARBOUR LIMESTONE

Table Head formations on the west side of Pistolet Bay were also investigated for industrial-grade limestone. The most promising unit, the Table Point Formation, as delineated by Knight (1986a), extends from Cooks Point southward to the old Viking Highway and beyond. Two areas that received the most attention were the Cooks Point area to the immediate north of the community of Cooks Harbour (Plate 18) and an area inland, consisting of a zone of high-purity limestone that intersects the old Viking Highway about 2.5 km west of the Cooks Harbour road junction (Figure 24).

A 4-km strike length of the inland deposit was investigated and sampled. The flat-lying limestone beds (dips average 5° to southeast) are exposed along a low northeast-trending ridge. The limestone has a strongly developed vertical cleavage which parallels its northeast strike. In many shattered and jointed areas, weathering has produced a thin covering of limestone gravel. Two lines located approximately one kilometre apart were sampled at 50 m intervals across the width of the formation.

The limestone formations that underlie the area between the community of Cooks Harbour and the north coastline have been cited by previous investigators as being particularly well suited for a limestone quarry (e.g., Harris, 1962). However, information was lacking with regard to the quali-

Plate 18. *High-purity limestone of the Table Point Formation underlies much of the coast and inland area around Cooks Harbour.*

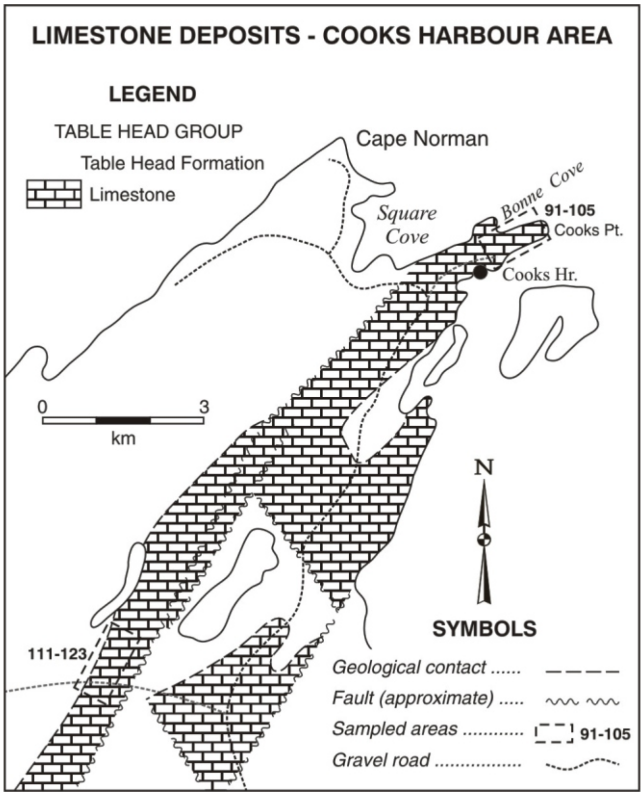


Figure 24. *Cooks Harbour limestone prospect.*

ty of the stone because, prior to the present program, virtually no sampling had been carried out.

The limestone is medium dark grey, fossiliferous, and contains extensive calcite veining. Sampling encountered minor seams of argillaceous limestone throughout the section from Cooks Point to Square Bay, and argillaceous zones 20 to 30 cm wide were observed on the east side of Bonne Cove. The limestone beds have been deformed and contorted, with dips up to 40° (southeast) recorded. Again, some of the more fractured areas have been reduced by weathering to a limestone gravel and this material is used locally on a very small scale for road aggregate (Plate 19).

Plate 19. *A small aggregate quarry in Table Point Formation limestone near Cooks Harbour.*

Results and Reserve Potential

Tables 26a and b show the results of the sampling program in the Cooks Harbour area. The results indicate that there are significant deposits of good quality stone available. The chemistry of the limestone is well within the specifications for a range of industrial applications, although the level of impurities (silica, iron, aluminum) in each of the two sampled areas is higher than that of the Burnt Island deposit.

A representative 10 kg sample of Cooks Harbour limestone was tested to determine its suitability in flue gas desulphurization (*see* Tables 29 and 30). The sample was evaluated using sulphuric acid and sulphurous acid reactivity tests and petrographic analyses. The test indicated an acceptable reactivity rating (Burns and McConnell, 1991).

At least 20 million tonnes of limestone could be quarried from the low-lying ridge north of the old Viking Highway (Figure 24 and Table 26a), but potential reserves are much greater when one considers the areal extent of the Table Point Formation. The small peninsula north and west of Cooks Harbour, despite its relatively flat relief, could also provide a quarry site. This investigation concluded that the best stone underlies an area south of Square Cove and Bonne Cove. Table 26b gives the results from a line of representative chip samples collected from that zone. The results indicate the presence of good-quality limestone although the recoverable amount is probably limited to less than 10 million tonnes.

CANADA BAY LIMESTONE

The eastern side of the Northern Peninsula also hosts little-known but significant deposits of limestone. Knight (1987) observed that cement-grade stone underlies a large area to the north of Canada Bay (Figure 25). He further noted that the limestone may also have potential as a building stone because it is thick bedded and contains attractive features such as fossils and depositional patterns.

A total of 28 limestone samples were collected for geochemical analysis. Unlike the flat-lying, denuded limestone beds on the eastern side of the Great Northern Peninsula, the limestone consists of poorly exposed formations underlying densely wooded ridges and valleys that have been extensively harvested for pulpwood.

Beaver Arm

The best exposures of limestone were noted about 5 km northwest of Beaver Arm and are accessible from the main highway via the Horse Chops access road (Figure 25). The thick-bedded limestone, which outcrops along a ridge, is

Table 26a. Chemical analyses in weight percent for representative chip samples of Table Point Formation limestone near Cooks Harbour

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	$CaCO_3$	$MgCO_3$
91	1.44	0.26	0.12	94.41	2.95
92	1.27	0.39	0.16	93.80	3.36
93	0.08	0.21	0.08	95.62	2.47
94	1.08	0.31	0.13	95.60	2.84
95	1.31	0.27	0.11	94.73	3.92
96	0.65	0.17	0.07	96.67	1.69
97	0.64	0.25	0.10	96.62	1.82
98	0.92	0.16	0.07	96.58	1.61
99	1.53	0.45	0.17	94.30	3.72
101	0.77	0.17	0.08	97.38	1.86
102	0.95	0.23	0.09	96.49	1.88
103	0.97	0.23	0.10	95.09	2.76
104	0.79	0.14	0.07	95.89	2.36
105	1.01	0.26	0.10	95.60	2.82
Average	1.02	0.25	0.10	95.63	2.58

+Total iron as Fe_2O_3

Table 26b. Chemical analyses in weight percent for chip samples of Table Point Formation limestone near the old Viking Highway about 10 km southwest of Cooks Harbour

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	$CaCO_3$	$MgCO_3$
111	0.46	0.16	0.06	97.86	1.09
112	0.34	0.10	0.04	97.06	2.24
113	1.04	0.33	0.10	93.91	4.99
114	0.48	0.17	0.05	97.86	1.46
115	2.05	0.67	0.25	91.35	4.30
116	0.44	0.09	0.06	97.38	2.70
117	0.23	0.06	0.04	96.83	2.17
118	0.19	0.07	0.05	97.37	2.74
119	0.64	0.25	0.08	94.48	3.57
121	0.44	0.44	0.06	96.96	2.32
122	0.91	0.91	0.12	93.20	3.85
123	0.50	0.50	0.08	95.00	3.55
Average	0.64	0.31	0.09	95.77	2.91

+Total iron as Fe_2O_3

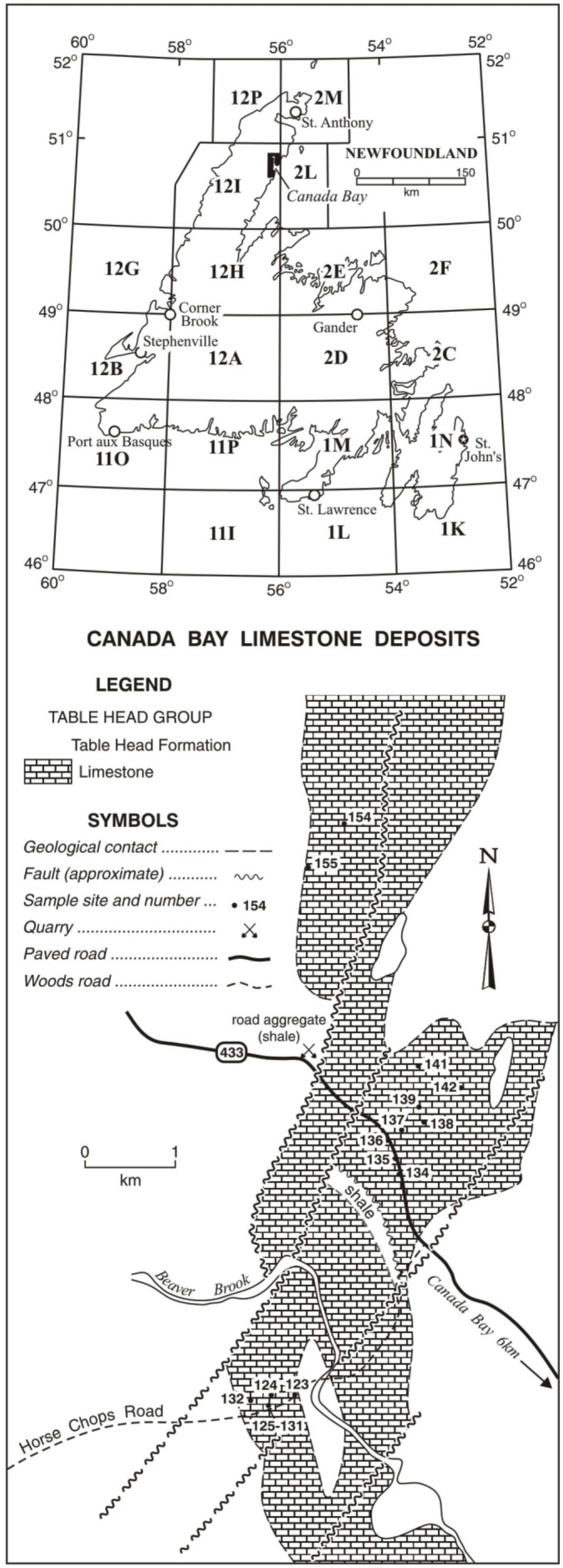


Figure 25. *Beaver Brook–Canada Bay limestone prospect.*

light grey, has a fine-grained texture and looks fairly pure. The weathered surface is smooth and massive but the presence of a strongly developed cleavage precludes the use of this limestone for building purposes. The light-grey limestone overlies a 12 m section of dark-grey fossiliferous limestone, which contains thin seams of argillite near its top. At one point about midway through the section, the limestone is weathered to a typical Table Head Formation gravel. Black chert in minor amounts was noted in a highly fossiliferous, worm-burrowed outcrop of limestone a few metres west of the above section.

The northeast extension of the above-mentioned belt of Table Head Formation limestone was examined along Route 433 and along a network of woods-roads immediately north of the highway. The topography in this area is very flat and in fact the road beds frequently consist of flat-lying beds of limestone. The dark-grey to black limestone is weathered to a smooth surface and white veins of calcite are ubiquitous. The areal extent of this stone is extensive and it would appear to have potential as a dimension stone; however, the lack of relief would make quarrying difficult.

Sampling Results

The results of the sampling (Table 27) shows that the grade of the limestone in the sampled areas is remarkably similar to that found in the Cook's Harbour deposits (*see* Tables 26a and b). The average grade of $CaCO_3$ (95.5 percent) is virtually the same as that for Cook's Harbour (95.7 percent), and the levels of impurities (silica, iron and aluminum) are also comparable. Also, the percentage of $MgCO_3$ at 2.24 percent is only marginally lower than the 2.74 percent average for the Cook's Harbour limestone.

These results indicate that significant deposits of good- to excellent-quality limestone can be delineated in the areas underlain by the Table Point Formation north of Canada Bay. However, the flatness of the topography makes it difficult to find good quarry sites.

Table 27. Chemical analyses in weight percent for representative chip samples from Table Point Formation limestone north of Beaver Arm, Canada Bay

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	$CaCO_3$	$MgCO_3$
91	1.44	0.26	0.12	94.41	2.95
123	0.50	0.13	0.08	94.99	3.66
124	0.54	0.23	0.07	96.87	1.82
125	1.24	0.44	0.11	95.85	2.22
126	1.11	0.30	0.10	95.07	2.67
127	0.94	0.28	0.14	95.91	1.80
128	0.52	0.13	0.05	96.60	1.63
129	2.84	0.74	0.27	92.28	3.15
131	1.71	0.36	0.14	91.46	5.66
132	4.43	0.53	0.20	89.45	3.91
133	0.45	0.15	0.04	98.67	0.96
134	0.39	0.15	0.07	97.67	1.46
135	0.82	0.25	0.10	96.80	1.25
136	0.78	0.08	0.04	97.40	0.98
137	0.22	0.08	0.04	97.29	0.98
138	0.30	0.10	0.05	96.99	1.30
139	0.40	0.15	0.08	96.71	1.44
141	0.50	0.14	0.07	95.25	3.09
142	0.87	0.14	0.07	94.46	2.53
154	0.36	0.12	0.05	96.87	0.86
155	1.02	0.28	0.11	93.25	3.36
Average	1.00	0.23	0.09	95.49	2.24

+Total iron as Fe_2O_3

SUMMARY

The Great Northern Peninsula is endowed with huge reserves of limestone suitable for most, if not all types of industrial uses, including chemical and metallurgical applications. The present study focused on deposits that are easily accessible by roads and located on or very close to tidewater. Their suitability for quarry development in terms of topographic relief was also considered.

Sampling of two areas in the Cook's Harbour region showed that good quality limestone is available, although the general flatness of the topography makes good quarry sites difficult to find and greatly reduces recoverable reserves. The same observations are valid for similar quality deposits north of Canada Bay on the eastern side of the Northern Peninsula. However, a thin although pervasive overburden cover presents an additional problem to potential developers

WESTERN WHITE BAY

INTRODUCTION

On the west side of White Bay, clastic-carbonate rocks of the Eocambrian–Cambrian Coney Arm Group (Locke 1969; Smyth and Schillereff, 1982) flank and unconformably overlie the Long Range Complex. The Coney Arm Group, which consists of basal conglomerate, quartzite and sandstone, overlain by phyllite, marble, dolostone and limestone, has been correlated with similar platformal clastic and carbonate rocks which outcrop along the west coast of Newfoundland (Smyth and Schilleref, 1982).

A belt composed mainly of limestone and dolostone extends southwest from Cobbler Head for approximately 40 km (Figure 26). The carbonates are more deformed and recrystallized southward and marble deposits near Sops Arm were early considered as possible sources of ornamental building stone (Bain, 1937) and as material for terrazzo tiles (Goudge, 1965). Also, a deposit of high-purity limestone located on the western shore of Great Coney Arm similarly attracted early commercial interest (Lee, 1956; Bedford, 1957).

Vast improvements in regional infrastructure, mainly because of the Cat Arm Hydroelectric development, have greatly improved access to the region. In 1985, the carbonate rocks were re-examined to determine their potential in light of emerging markets in industrial fillers, pollution control systems, and dimension stone (Howse, 1986, 1995). The following account summarizes the results of these surveys.

SOP'S ARM–JACKSON'S ARM MARBLE OCCURRENCES

Multi-coloured and veined marble outcrops discontinuously parallel the Doucers Fault between Sop's Arm and Jackson's Arm. A 30-m-wide north–south-trending, steeply dipping zone of marble is prominently exposed in a gravel quarry on the north bank of Main River, approximately 100 m west of highway 420. The marble is a fine-grained, cream breccia cut by an extensive network of slender, wavy, reddish-brown and orange calcite veins, which impart a pale orange-brown colour to the marble. The marble is bounded on the west by granite and on the east by shale, although the actual contacts with these rocks are not exposed. Irregular fractures are exposed throughout the quarry but are more pronounced in the western parts. In the eastern part of the quarry, the marble is fine grained and homogeneous and is cut by numerous red calcite veins. The unsound, fractured condition of the rock eliminates any potential as dimension stone. However the marble is highly decorative and is thus a potential source of chips for terrazzo tiles if adequate reserves could be delineated. Similar marble is sporadically exposed in a cliff that parallels Route 420, about 4 km north of Main River. The red-tinted stone contains pink, white, and grey bands. It, too, is highly fractured, although the degree of fracturing is variable from outcrop to outcrop.

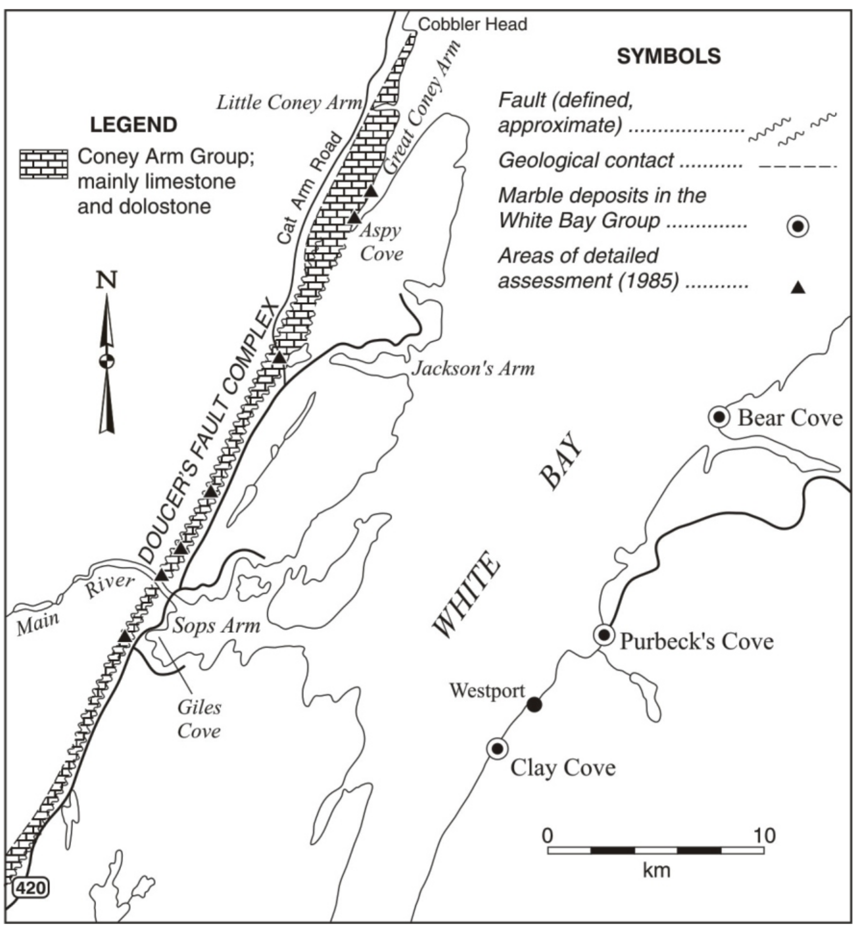


Figure 26. *Location of marble and limestone deposits, and other related prospects in the White Bay region.*

A great variation in colour and texture is characteristic of the Sop's Arm marbles. South of Main River, for example, the marble is generally lighter coloured, more massive and more competent. An example of this can be seen on the west bank of Doucer's Brook, just 250 m west of the highway near Giles Cove. This deposit has a uniformly light colour and contains less veining than the material described previously. The relative hardness and attractive colour of the marble favour its use as terrazzo chips.

Marble breccia is exposed in a cliff near the southwest corner of a small pond about 2.5 km north of Main River, just west of the main highway to Jackson's Arm. It has a very distinctive texture consisting of prominent small, dark-grey marble clasts set in a white calcite matrix. The marble is strongly fractured, containing one set of vertically dipping joints trending 030°, and another dipping subhorizontally into the outcrop. The marble tends to form vertical sheets along the vertical joints. Samples of the marble were cut with a tile saw and polished. The results indicate a unique, highly decorative stone that potentially could be used for such purposes as trophy bases and other small ornamental objects.

CONEY ARM LIMESTONE PROSPECT

The Coney Arm limestone prospect is located on the coast of Great Coney Arm on the southwest shore of White Bay, Newfoundland (Figure 27). Limestone and marbles in the Coney Arm Group have been periodically assessed for their industrial potential since the 1950s. Evaluations have included surface chip- and channel-sampling programs that indicated a minimum of 47 million tonnes of high-calcium limestone. More recent studies included testing of the limestone for filler and extender, and preliminary testing of its suitability for use in FGD systems.

Limestone underlies a ridge that extends for more than a kilometre along the coast from Aspey Cove to the bottom of Coney Arm (Figure 27, Plate 20). The nearest settlement is Jackson's Arm, a small logging community 7 km south of the deposit. The Cat Arm access road, which intersects Route 420 near Jackson's Arm, passes within 1500 m of the deposit. Both Jackson's Arm and Sop's Arm (a farther 10 km to the south) are connected to the province's highway system by Route 420. The abandoned village of Little Coney Arm,

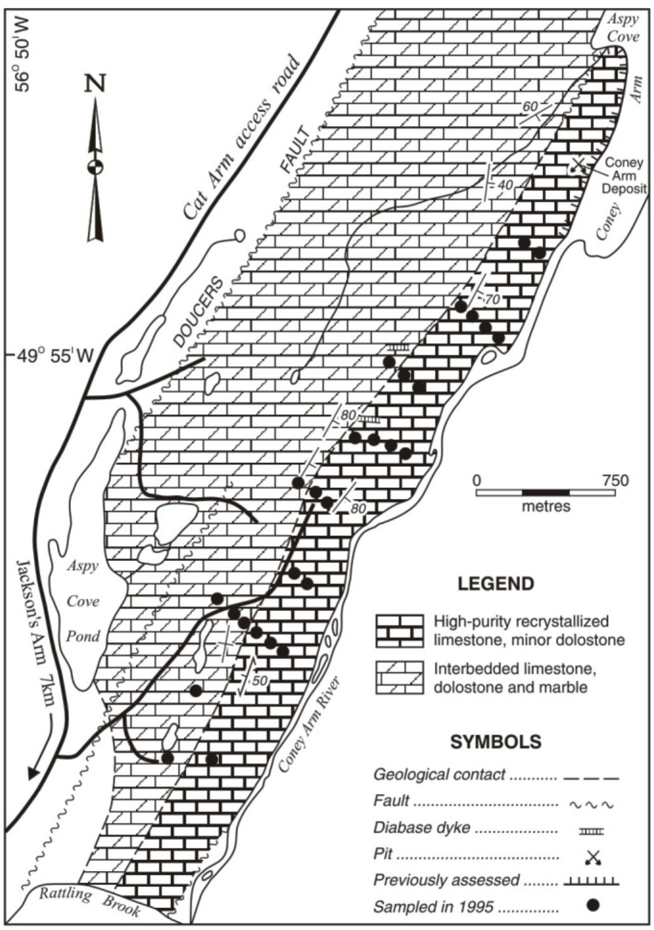


Figure 27. *Coney Arm limestone prospect showing the area sampled in 1995.*

Plate 20. *Coney Arm limestone exposed at Aspey Cove.*

which was used as a port (for barges) during construction of the Cat Arm hydroelectric project, is located 2.54 km north of the deposit and is connected to the Cat Arm access road. These communities are located on good natural harbours but adequate port facilities are lacking. From December to June, shipping is restricted by frozen harbors and bays and heavy drift ice although it can be aided and prolonged by federal ice-breakers.

Assessment Review

Limestone exposed along the west shore of Coney Arm first began to attract attention for its industrial potential in the 1950s. After a brief reconnaissance survey, Lee (1956) estimated a reserve of some 187 million tonnes of limestone in the area. Bedford (1957) did a more detailed and selective study that included some cross-sectional channel sampling (Table 28). He concluded that the ridge along the coast between Aspy Cove and the head of Coney Arm contained approximately 30 million tonnes of limestone grading over 96 percent $CaCO_3$ and 1.20 percent $MgCO_3$. The estimate was based on a 1200 m strike length and a minimum quarryable distance inland of 150 m. This figure was subsequently revised by Brinco Limited to over 46 million tonnes grading 97.1 percent $CaCO_3$ and 0.7 percent MgO. On the basis of these data, the Coney Arm limestone was promoted by Brinco as a high-purity deposit suitable for a wide range of industrial applications in the chemical, metallurgical, and related fields.

The Coney Arm limestone, along with other industrial carbonates in the Coney Arm Group were examined by Howse (1986) as part of survey of Newfoundland marble occurrences. The main objective was to determine its suitability for filler applications so emphasis was placed on stone with high purity and high brightness. Extensive sampling for physical and chemical analyses was carried out along the west side of Coney Arm and along the Cat Arm access road near Jacksons Arm Pond. Results showed the

Table 28. Chemical analyses in weight percent of channel samples from a trench south of Aspey Cove. Trench runs westward from the shore approximately normal to the strike of the limestone formations (*after* Bedford, 1957)

Composite sample (m)	CaO	MgO	CO_2	SiO_2	Al_2O_3	Fe_2O_3+	SO_3	P_2O_5
12.96	54.48	0.48	43.20	0.70	0.25	0.16	0.03	.009
4.1	53.00	1.26	42.90	1.47	0.56	0.26	0.07	.013
19.06	54.69	0.47	43.43	0.57	0.12	0.18	0.05	.009
Average	54.42	0.57	43.28	0.72	0.22	0.19	0.04	.010

+Total iron as Fe_2O_3

Coney Arm limestone lacks the degree of brightness required for premium grade filler but chemical analyses supported earlier accounts describing the existence of a major limestone deposit suitable for many industrial end uses (Table 29). In 1991, limestone samples from the Coney Arm prospect, along with samples from other Newfoundland occurrences were tested to determine their suitability for use in flue-gas scrubbing systems. Limestone reactivity tests, and chemical and petrographic analyses showed that the stone is a good candidate for such use (Burns and McConnell, 1991; Tables 30 and 31).

Description

The limestone beds are exposed almost continuously along the Coney Arm shoreline, striking about 035° and dipping 75 to 80° to the east. On the weathered surface, the limestone is medium dark grey and has a fairly massive appearance although on the shoreline the rock is extensively fractured. Narrow veins and stringers of white carbonate are common throughout the rock and impart a brecciated look in some of the more strongly veined exposures. The fresh surface reveals a medium dark to light grey recrystallized limestone containing white carbonate stringers. In the vicinity of the old pit midway between Aspey Cove and mouth of Coney Arm Brook, the limestone has a slightly lighter colour and appears to be purer. From thin-section studies, the limestone (sample taken near the old pit) was classified as intrasparite with fine crystals of calcite in an interlocking mass. Veins of calcite, 0.5 to 2 mm thick, form dendritic patterns throughout the sample. The porosity of the stone was estimated to be low (Burns and McConnell, 1991).

North of the deposit (Aspey Cove to the northeast point of Little Coney Arm Harbour), the rocks consist of dark grey, recrystallized, interbedded dolostone and limestone and marble equivalents. Extensive sampling of the formations showed a significantly lower $CaCO_3$ content and a marked increase in impurities, particularly silica. Narrow, east-trending diabase dykes cut the formations at several locations along the coast north of Aspen Cove.

Chemistry

Table 29 shows the chemical analyses of chip samples from the Coney Arm limestone deposit. These results show the limestone grades well over 96 percent $CaCO_3$. The silica content is low at 0.78 percent, and the mean iron and aluminum total 0.30 percent. The MgO content is 0.65 percent. Na_2O and K_2O each averaged less than 0.1 percent respectively, and TiO_2 is less than one percent.

The results identified several zones having slightly elevated MgO values and corresponding higher silica. In these more dolomitic areas, the CaO content is up to 2 percent lower than the overall average for the deposit. By omitting these zones, the average grade of the deposit is significantly improved. Thus by selectively avoiding or reducing production from these zones the overall quality of the limestone would be significantly improved.

Potential Uses

Potential uses for Coney Arm limestone include applications in the metallurgical, chemical and agricultural industries as well as cement manufacturing. Its suitability for environmental uses should also be considered because of growing demand for limestone for protection and cleanup of the environment.

In 1991, a representative sample of the Coney Arm limestone, along with samples from three other Newfoundland prospects, was tested to determine suitability in FGD systems. The samples were evaluated using sulphuric acid and sulphurous acid reactivity tests and petrographic analyses. These tests indicated an acceptable reactivity rating for the samples. (Tables 30 and 31). The report by Burns and McDonnell (1991) recommended that should an FGD vendor and process be selected, additional testing be performed to address any process specific-requirements that may exist.

With regard to potential aggregate use for the Coney Arm limestone, data is lacking on such physical characteristics as crushing strength, abrasion resistance and hardness. However, by analogy with descriptions of other Newfoundland deposits of similar purity on the Port au Port Peninsula it would appear the Coney Arm limestone has excellent potential for aggregate use. The low level of SiO_2 and alkalies suggest that alkaline reactivity, the deleterious

Table 29. Chemical analyses in weight percent of chip samples from the Coney Arm limestone deposit. One sample represents a 5 m interval and samples were grouped and averaged as shown. A total of 260 samples were collected from Aspey Cove to Coney Arm bottom

Sample Numbers	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3+	Na_2O	P_2O_5	K_2O	MnO	LOI
5067-5074	54.51	0.36	0.72	0.15	0.07	0.01	0.02	0.03	0.03	43.30
5075-5084	54.65	0.41	0.37	0.12	0.08	0.01	0.02	<.01	0.04	43.37
5085-5094	54.22	0.64	0.54	0.16	0.10	0.01	0.02	0.02	0.07	43.26
5095-5104	54.63	0.37	0.37	0.13	0.08	0.01	0.02	<.01	0.03	43.46
5105-5113	54.07	0.41	0.38	0.13	0.07	0.01	0.02	0.01	0.01	43.54
5114-5123	54.44	0.52	0.41	0.09	0.07	0.01	0.02	0.01	0.03	43.10
5124-5133	55.12	0.42	0.43	0.16	0.08	0.01	0.02	0.02	0.03	43.38
5134-5143	54.81	0.38	0.37	0.12	0.06	0.01	0.02	0.01	0.03	43.27
5144-5153	54.96	0.38	0.31	0.96	0.06	0.01	0.02	0.01	0.01	43.10
5154-5163	54.98	0.32	0.50	0.15	0.10	0.01	0.02	0.02	0.08	43.39
5164-5168	54.94	0.26	0.41	0.15	0.13	0.01	0.02	0.02	0.12	43.41
5169-5178	52.98	1.24	0.75	0.32	0.14	0.01	0.01	0.02	0.04	43.58
5179-5188	52.99	1.09	1.01	0.32	0.13	0.01	<.01	0.07	0.02	43.68
5189-5198	54.28	0.66	0.54	0.16	0.09	0.01	0.01	0.03	0.02	43.68
5199-5209	54.81	0.31	0.30	0.10	0.05	0.01	0.02	0.01	0.02	43.86
5210-5219	52.66	1.04	1.62	0.30	0.12	0.01	0.01	0.03	0.03	43.18
5221-5225	52.52	1.04	1.33	0.32	0.13	0.01	0.01	0.05	0.02	43.61
5226-5235	54.59	0.94	1.00	0.26	0.12	0.01	0.02	0.04	0.02	43.00
5236-5245	54.40	1.23	0.61	0.19	0.12	0.01	0.02	0.01	0.03	43.43
5246-5255	54.36	0.37	1.17	0.24	0.10	0.01	0.02	0.04	0.04	42.91
5256-5265	51.56	1.99	2.48	0.30	0.15	0.01	0.02	0.06	0.03	42.94
5266-5275	54.29	0.55	1.08	0.02	0.11	0.01	0.02	0.04	0.03	43.05
5276-5281	53.91	0.47	1.24	0.31	0.09	0.01	<.01	0.03	0.02	43.24
5282-5291	54.62	0.51	0.77	0.27	0.11	0.01	<.01	0.05	0.02	43.44
5292-5297	54.99	0.44	0.70	0.19	0.09	0.01	0.01	0.03	0.03	43.11
Average	54.17	0.65	0.78	0.20	0.10	0.01	0.01	0.02	0.03	43.33

+Total iron as Fe_2O_3

Table 30. Results of the sulphuric acid reactivity test. Sample AH-94-1 was collected from the Coney Arm limestone deposit approximately midway between Aspey cove and the bottom of the arm. Samples AH-94-2 to AH-94-4 came from Raleigh, Cooks Harbour and White Hills (Port au Port Peninsula) respectively

Sample	Value	Rating
AH-90-1	99.7	Acceptable
AH-90-2	98.4	Acceptable
AH-90-3	100.0	Acceptable
AH-90-4	100.0	Acceptable

Source: Burns and McDonnell (1991)

Table 31. Results of the sulphurous reactivity test. Locations of samples as in Table 27

Sample	Value	Rating
AH-90-1	< 20 minutes	Excellent
AH-90-2	< 10 minutes	Excellent
AH-90-3	< 10 minutes	Excellent
AH-90-4	< 10 minutes	Excellent

Source: Burns and McDonnell (1991)

reaction of silica with cement, should not be a concern for potential developers.

Reserve Potential and Future Work

Estimates vary on the amount of quarryable limestone available at Coney Arm. Lee (1956) estimated that over 180 million tons having an average grade of 97.02 percent $CaCO_3$ could be recovered from Coney Arm, based on coastal chip samples collected from Aspen Cove to Great Coney Arm bottom. Bedford (1957), in a more detailed and selective evaluation, estimated that about 32 million tonnes averaging 97.0 percent $CaCO_3$ could be quarried within 150 m of the coast. The 1985 chip-sampling program involved detailed sampling at 5 m intervals over the strike and dip of the deposit. The average grade compared very favourably with the previous assessments. Based on the 1985 sampling, it is estimated that about 50 million tonnes could be recovered from the limestone ridge between Aspen Cove and Coney Arm bottom. This is based on a strike length of 1200 m, a width of 150 m and depth of 50 m (assuming a limestone density of 2.75 tonnes per cubic metre). Information resulting from geological mapping and limestone outcrops exposed by construction of the Cat Arm access road, indicates that the unit of high-purity limestone continues southward from Coney Arm for a considerable distance. The same crystalline limestone is present in a 030°-trending cliff along the western shore of Jacksons Arm Pond and is also exposed in road cuts just 500 m along strike from the cliffs. Representative samples from the road cut averaged close to 55 percent CaO (97 percemt $CaCO_3$) for the best limestone section.

An assessment of the southward extension of the Coney Arm limestone deposit was carried out in 1995 (Howse, 1996). The limestone forms a relatively narrow unit, dipping to the east at 60 to 70°, paralleling and forming part of the west slope of Coney Arm River valley. The west slope of the valley effectively forms the eastern boundary of the deposit. Mapping and chip sampling over a reconnaissance grid encountered good quality limestone near, and along, the valley slope. Samples were collected along cross-sectional lines which were positioned at 400 m intervals along the deposit's northeast strike. The average analysis of 17 representative chip samples taken from the dark-grey limestone unit showed 53.27 percent CaO, 0.76 percent MgO, and 1.88 percent SiO_2. Fe_2O_3, Al_2O_3 and K_2O averaged 0.33 percent, 0.24 percent and 0.14 percent respectively. L.O.I, was 42.96 percent.

No estimate has been made of potential tonnages available in this deposit, which underlies a wooded slope and is also poorly exposed. More work including trenching and drilling would be necessary to accurately delineate its width and depth.

Summary

The Coney Arm limestone deposit combines high purity with substantial potential reserves though tonnage figures have not yet been satisfactorily established. A preliminary examination of available chemical and physical data shows that the limestone is suitable for a wide range of industrial applications including emerging uses related to environmental cleanup and pollution control. Major improvements in roads and infrastructure and its location on deep water in a sheltered inlet are assets. A program of core drilling would have to be carried out along the ridge between Aspen Cove and the bottom of Coney Arm. For use as aggregate, information is lacking on such features as crushing strength, abrasion resistance and alkali reactivity. Also, only very preliminary testing of suitability for use in flue-gas scrubbing systems has been done and more work is warranted.

Although some carbonates in the Coney Arm Group may have economic potential as dimension and decorative stone, limestone of the Coney Arm deposit appears to be too fractured to be considered a possible source of dimension stone. Also, its generally dark-grey colour rules out the possibility of use as a high-quality filler. The limestone has good potential for use in agriculture as aglime.

UPPER HUMBER (SILVER MOUNTAIN) MARBLE

The Upper Humber marble prospect is located along the north bank of the Upper Humber River about 12 km west of the Sops Arm Highway (Figure 28). Excellent access from the highway to the deposit is provided by 12 km of upgraded gravel road. The coastal communities of Hampden and Sop's Arm are a farther 18 km and 20 km respectively via paved routes 420 and 421. Both communities have deep-water harbours although adequate port facilities would have to be developed.

Geological Setting

The Silver Mountain marble prospect is located on the southeast side of the Long Range Grenville inlier (Erdmer, 1984). This part of the inlier (the zone between Taylor's Brook and Western Brook Pond) was mapped by Erdmer (1984). The dominant rocks of the area are the Grenvillian basement gneiss complex, part of which is metasedimentary, and younger gabbro–anorthosite and granitic rocks. The Silver Mountain marble prospect comprises a 4.5-km lensoid sliver that flanks the southwestern margin of a large gabbro massif (Taylor's Brook Gabbro Complex). The marble appears to be interlayered with quartzofeldspathic gneiss and is intruded by gabbro.

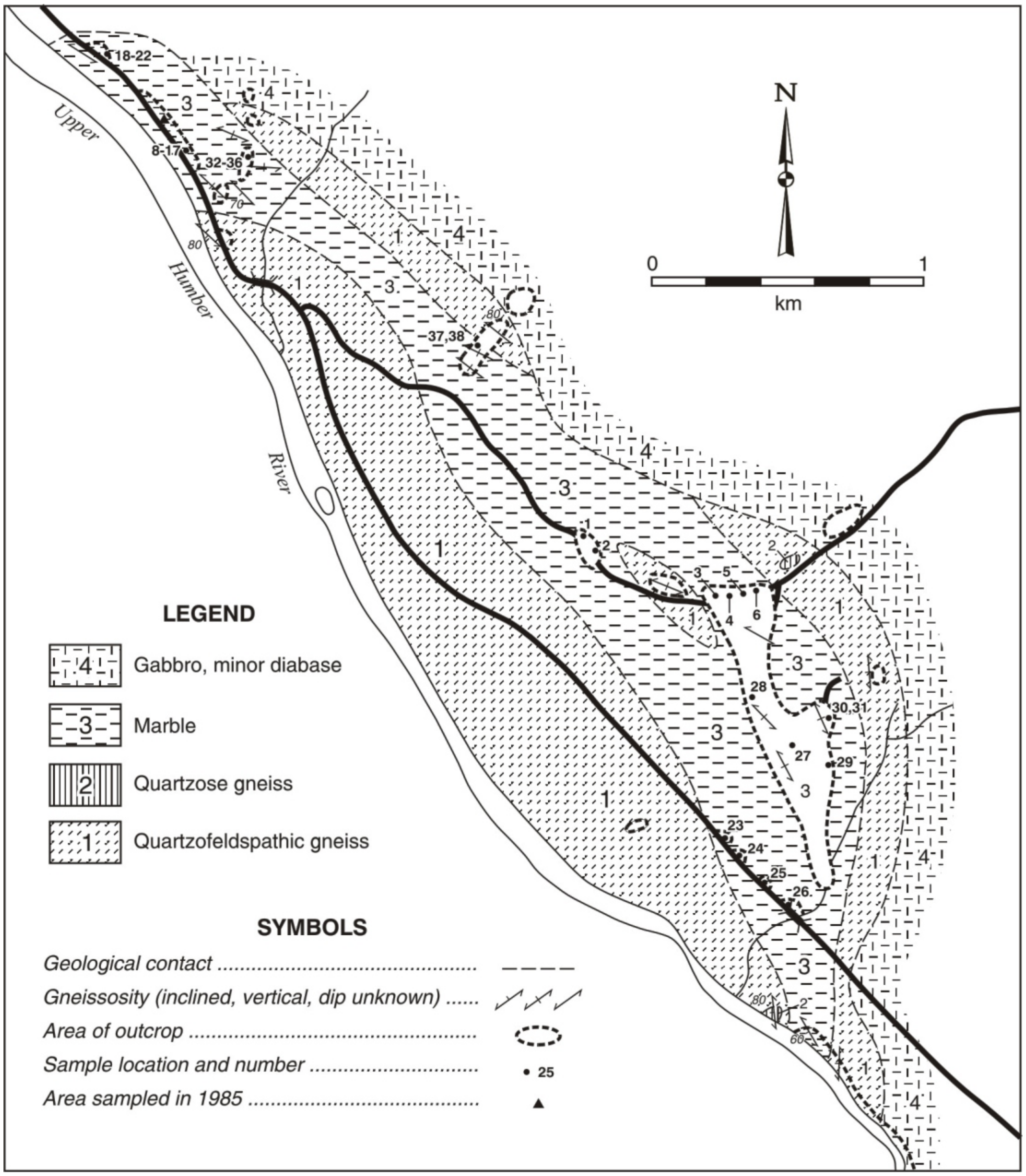


Figure 28. *Silver Mountain (Upper Humber) marble prospect.*

Assessment Review

The Silver Mountain marble deposit (named after a prominent nearby hill) was discovered by Doug Reusch in March, 1983. Reusch carried out preliminary geological mapping and laboratory work, and established a single claim centered on an exposure of pure white stone that he considered easily accessible and well located for quarrying (Reusch, 1985). He also extracted a 10 kg sample of white marble, which was ground and sieved to various size fractions (coarse gravel, sand, fine sand). Samples of white and light blue-grey marble were pulverized to fine powders, and additional samples of white, blue-grey, and cream samples were slabbed and polished. Reusch (*op. cit.*) concluded from the results that the white marble chips were superior in quality to those used locally (e.g., Hotel Newfoundland). Furthermore, he believed that the calcitic sand is equivalent or superior in quality to similar material from the Steep Rock calcitic marble quarry in Ontario, used locally in the manufacture of synthetic marble. The results from the polished slabs were also very promising. All three colours of the slabbed stone took on an attractive appearance when polished. Reusch (*op. cit.*) suggested the white marble strongly resembled marbles from the Tate district of Georgia, considered to be the finest in North America.

Mapping by Erdmer (1984) defined the deposit as part of a unit of marble and calc-silicate rocks exposed in two slices within and at the margins of a body of gabbro–anorthosite, east the Upper Humber River. Erdmer (*op. cit.*) briefly described the marble as "mostly white to pale grey, coarsely crystalline, in places graphitic marble with some grey impure quartz-rich layers". The other exposure noted by Erdmer is located about 8 km to the east of the Silver Mountain deposit and comprises a small isolated knoll of fine-grained, grey and brown mainly calc-silicate rocks within a body of gabbro.

In 1985, during a survey of Newfoundland marble occurrences, the Silver Mountain showing was briefly examined and samples were collected from a cliff exposure of grey and white marble at the north end of the deposit (Howse, 1986) for physical and chemical analyses. The chemical analyses showed a mixture of calcitic and dolomitic marble beds grading just under 90 percent $CaCO_3$. The dry brightness tests averaged 93.5 percent light reflectance with little variation in the degree of brightness between the calcitic and dolomitic samples (Table 32).

Description

The Silver Mountain marble prospect consists of a lens-shaped body of marble about 4.5 km long and nearly 1 km wide at its maximum width. The marble outcrops along the river bank, in numerous exposures on the well-drained southeast-facing hills, and in road cuts. The only significant overburden thickness is found on the lower flanks of the hills and near the river bank. The higher ground appears to have only a thin cover of till but like the rest of the property is tree-covered.

Table 32. Chemical analyses in weight percent and dry brightness (DB, percent) tests for representative chip samples from the Silver Mountain marble deposit (white zone)

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	$MgCO_3$	$CaCO_3$	DB*
5946016	3.09	0.97	0.47	15.32	80.72	94.7
5946017	1.63	0.39	0.19	15.05	82.82	93.4
5946018	1.02	0.17	0.09	1.27	95.62	94.9
5946019	1.7	0.45	0.15	1.94	94.11	91.1
5946021	1.72	0.42	0.15	3.26	93.91	93.3
Average	1.83	0.48	0.21	3.53	89.43	93.5

*Chemical analyses by Newfoundland and Labrador Department of Mines and Energy, Geochemical Laboratory. Brightness tests by IMD Laboratories (1986).

+Total iron as Fe_2O_3

The marble is composed of mainly coarse- grained (3 to 5 mm), equigranular calcite. In its purest form, the stone is brilliantly white, and examples can be seen in outcrops and roadcuts particularly at the north end of the deposit. Light blue-grey, and cream-coloured varieties are spatially associated with the white zones. The cream colour may reflect a more dolomitic composition (and/or the presence of trace amounts of iron?), and the blue-grey tints are possibly caused by minute amounts of graphite. A distinctive unit of thin-banded marble is widely exposed and is especially evident along the network of older woods roads that traverse the interior of the deposit (Plate 21). The bands are defined by different shades of grey, brown, and pale green. They may range in thickness from less than a centimetre to several centimetres and in some case they grade into a more irregular pattern dominated by very dark shades possibly due to increased graphite content. Impurities include minute (<1 mm) widely scattered pyrite crystals and minor amounts of quartz. Trace amounts of an epidote mineral and chlorite may also be present.

The texture of the marble varies from massive, as in the lighter coloured stone, to gneissic in the banded material. The gneissic fabric dips steeply, sometimes changing dip direction over a short distance. It has a northwest strike paralleling the general trend of the deposit. The main fabric is locally folded in outcrops by irregular asymmetric folds. Erdmer (1984) inferred that the banding in the marble was transposed original bedding. Except where disturbed by

Plate 21. *Banded marble of the Silver Mountain marble prospect.*

blasting due to road construction, the marble is not severely fractured or sheared and joints are commonly widely spaced.

The Silver Mountain marble is in contact with black garnetiferous metaquartzite, quartzofeldspathic gneiss and gabbro. The marble is considered to be interlayered with the gneiss and intruded by gabbro, the main body of which flanks the east side of the deposit. The marble is also cut by diabase dykes, part of the ubiquitous swarm found throughout the Long Range inlier. In at least three outcrops near its southwestern margin, the marble is in contact with a conglomeratic rock consisting of subangular dark fragments varying from pebble to cobble size in a carbonate matrix. Reusch (1985) noted that the marble locally grades into metaquartzite via a transitional zone containing psammitic boudins. Erdmer (1984) observed that near the contact with the gabbro the marble grades into a brown and green (diopside-bearing?) fine-grained rock several metres thick. The marble is bordered to the east side by quartzofeldspathic gneiss and gabbro, and to the west by quartzofeldspathic gneiss. Within the main body of marble there is also a small body of gneiss about 150 m wide and of uncertain length.

There are good potential quarry sites near the centre of the deposit consisting of dry ridges with good relief and generally thin overburden. Potential industrial applications for the whiter zones include use as filler in products requiring good to excellent brightness. This would include a diversity of products ranging from jointing compounds to paper, plastics and paint.

Unlike the fine-grained white marble deposits that have been identified in Newfoundland's Lower Paleozoic carbonate sequences, the Upper Humber marble is a coarse-grained stone and probably not as amenable to the same degree of fine polishing as the former. However, there are varieties of stone within the the Silver Mountain prospect that need to be examined closely for dimension-stone potential. The presence of dark silicates and streaks of graphite in marble from other deposits are known to give striking effects on polished surfaces.

Reserve Potential and Future Work

The Silver Mountain marble is a sizable deposit. It is well exposed in rock cuts particularly at its northern extremity. The southern part is also revealed by road construction and in river bank exposures. Woods roads branching from the main trunk road have exposed the marble almost continuously over a strike length of approximately 5 km. However, the presence of interlayered gneiss within the deposit has been noted and there is a possibility that other such potential impurities exist. The amount of overburden varies considerably. As may be expected overburden is thickest in the low ground near the river, but construction of the woods access road and the rapid rise in elevation along the river's east bank, would make the opening of an access quarry relatively easy. Near the center of the deposit the overburden cover is thin and in some places absent. The presence of dry ridges having good relief make this an ideal site for quarrying.

Future evaluation should be aimed at identifying marble zones of specific economic interest within the deposit. The whiter stone at the north end of the deposit, for example, may be suitable for filler applications and/or chips for landscaping. The banded marble exposed along roads in the interior may be suitable for dimension stone. Additional work consisting of more detailed mapping and diamond drilling is required. Should units with specific industrial potential be identified, efforts should be aimed at delineating reserves of consistent quality. Removal of blocks will be necessary for testing. Among the standard ASTM tests considered critical in the dimension-stone industry for estimating product potential are those required to measure such features as water absorption, compressive strength, resistance to abrasion, and flexural strength.

The location of the deposit in the scenic region near the Upper Humber River, underscores the need to minimize environmental damage in conducting any assessment or development. One way to help accomplish this would be to extract blocks without the use of explosives, wherever possible. This would also protect the stone from fractures that could negate its commercial value. The location of work sites, whether stripping sites or development quarries, in visually obscured areas would also be a prudent practice.

EASTERN WHITE BAY

Marble occurrences are found within the Eocambrian White Bay Group at Purbeck's Cove, Clay Cove and Bear Cove (Figure 26) on the western coast of the Baie Verte Peninsula (Hibbard, 1983). These occurrences were investigated for potential industrial uses (Howse, 1986) and descriptions are given below.

PURBECK'S COVE

White marble forms a cliff overlooking the north side of the community of Purbeck's Cove (Figure 26). The marble exhibits great variation in grain size from fine grained to coarsely crystalline and is highly fractured and cut by conjugate joints. Although the exact size of the deposit is unknown because of structural complications and lack of exposure, 225 m of continuous marble was measured, with an average outcrop width of 9 m. The marble strikes 040°. It is unsuitable for dimension stone because of severe jointing. A total of 12 representative chip samples were collected from the occurrence and the results of the chemical analyses are shown in Table 33. The high silica content precludes potential use as a premium industrial filler although the brightness is relatively good. Small quantities of the stone have been used for agricultural lime.

CLAY COVE

A deposit of white marble at Clay Cove, approximately 6 km south of Purbeck's Cove (Figure 26) was worked on a small scale in the late 1920s. The marble is greyish-white to white, with local brown streaks, and varies from aphanitic material to coarsely crystalline stone. A small brook which flows across the deposit has polished some of the quarried fragments to a brilliant white. The rocks are strongly jointed but generally the degree of fracturing is less than at Purbeck's Cove. The size of the deposit could not be accurately determined because of lack of bedrock exposure. It was traced for 37 m along strike (180°), and is at least 30 m wide and it has a block configuration. The deposit was sampled along its strike and dip (80°West) and results indicate high-calcium marble having good brightness but elevated levels of silica would preclude use as a premium quality filler (Table 34).

An exposure of blue marble underlies a point of land on the south side of Clay Cove. Projecting offshore, the marble strikes 030° and dips vertically. A central 4-m-wide band of black and grey marble containing calcite veinlets is flanked by mixed blue marble and carbonate schist. This occurrence is too small to be of economic significance.

Table 33. Chemical analyses in weight percent and dry brightness (DB, percent) tests for representative chip samples from the Purbeck's Cove marble showing

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	MgO	CaO	DB*
5015	2.40	0.55	0.19	0.24	52.84	95.04
5016	1.64	0.52	0.16	0.22	53.53	92.92
5017	1.46	0.46	0.17	0.21	54.13	92.94
5019	3.53	0.83	0.31	0.38	51.40	95.05
5020	1.12	0.34	0.15	0.20	54.30	94.61
5021	1.43	0.53	0.19	0.19	53.77	95.18
5022	1.93	0.64	0.25	0.26	54.87	94.08
5023	3.53	0.88	0.31	0.38	51.40	90.21
5024	1.12	0.34	0.15	0.20	54.30	92.98
5027	13.8	3.75	1.15	1.00	42.80	94.57
5028	1.13	0.12	0.11	0.12	54.16	92.26
5029	9.70	3.32	1.02	0.80	45.59	89.97
Average	3.56	1.02	0.34	0.35	51.92	93.31

*Chemical analyses by Newfoundland and Labrador Department of Mines and Energy, Geochemical Laboratory. Brightness tests by IMD Laboratories (1986).

+Total iron as Fe_2O_3

Table 34. Chemical analyses in weight percent and dry brightness (DB, percent) tests for representative chip samples from the Clay Cove marble showing

Sample No.	SiO_2	Al_2O_3	Fe_2O_3+	MgO	CaO	DB*
5031	0.90	0.31	0.17	0.22	54.39	94.61
5032	1.45	0.47	0.16	0.20	53.40	95.60
5033	0.98	0.30	0.13	0.13	54.55	95.78
5034	2.65	0.90	0.21	0.23	53.06	93.68
5035	2.42	0.88	0.26	0.25	53.02	92.88
Average	1.68	0.57	0.19	0.21	53.68	94.51

*Chemical analyses by Newfoundland and Labrador Department of Mines and Energy, Geochemical Laboratory. Brightness tests by IMD Laboratories (1986).

+Total iron as Fe_2O_3

BEAR COVE

Highly decorative crystalline marble and marble breccia are exposed in several localities on the west shore of Bear Cove, an abandoned but very scenic community, situated near the entrance to Western Arm (Figure 26). The small but well-exposed deposit at White Point is a pod-like structure surrounded on three sides by metaclastic rocks. Hibbard (1983, pages 35-36) interpreted the marble as "a debris flow, a channel or a depositional block" and suggested a similar origin for the marble at Clay Cove and Purbeck's Cove. The latter occurrences are significantly larger and also appear to have blocky configurations. The white marble at Bear Cove contains pink bands and is highly fractured. It has a very coarse texture and is flanked by carbonate breccia. Similar carbonate-breccia float was observed near the Purbeck's Cove occurrences. Though relatively remote and isolated, this marble could be of interest to rock and mineral collectors, and could possibly be a source of small ornamental blocks.

CONCLUSIONS

Western Newfoundland hosts large reserves of limestone and dolostone that could supply raw material for industries that produce a variety of commodities including cement, agricultural limestone, limestone aggregate, and chemical-grade limestone and dolostone products.

Extensive, undeveloped, high-purity dolostone resources occur on the Port au Port Peninsula, Goose Arm, and at several localities on the Northern Peninsula. Undeveloped, high-purity, white marble deposits have been delineated near Roddickton and significant dimension stone-prospects are found in marbles in the southern regions of the belt around Corner Brook and west of Deer Lake.

Assessment work by government and private industry has provided a good database for many of these deposits including new information on the chemistry and physical characteristics of the different commodities. However, the most glaring weakness in this database is the lack of three-dimensional information on the various deposits, which can only be provided by core drilling.

Newfoundland's strategic location on major North Atlantic trade routes, and its relative proximity to the populous eastern seaboard of the USA (a strong traditional market), suggest significant advantages for trade in industrial minerals including industrial carbonates. The attractive economics of marine transportation afforded by large bulk carriers, have in the past, figured prominently in the trade of such commodities and will continue to be a critical advantage in the future development of these commodities.

ACKNOWLEDGMENTS

Thanks are expressed to all those who helped in the preparation of this report. A special acknowledgment is made of the field work ably performed by Greg Stapleton, Barry Wheaton, Brett Morrey, Dwayne Simms and Jacob Lushman. Paul Delaney was responsible for most of the field assessment work on dolostone. All of the work benefitted from the expertise of Ian Knight who shared his knowledge whenever called upon, which was often. Paul Dean, Richard Wardle and Baxter Kean are thanked for their encouragement and support. Lawson Dickson improved the manuscript with many comments and suggestions. Geochemical analyses were carried out by the staff of the Geochemical Laboratory of the Newfoundland and Labrador Department of Mines and Energy. Drafting expertise was provided by the Cartographic Unit, Department of Mines and Energy.

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