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CHEMICAL AND PHYSICAL PROPERTIES OF THE CANADA HARBOUR MARBLE DEPOSIT

A.F. Howse
Mineral Deposits Section

ABSTRACT

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

Chemical analyses of chip samples, systematically collected from the face of the main open cut at Canada Harbour, show that about one fifth of the white marble is dolomitic. This feature distinguishes the deposit from the calcitic marble at the Penny's Pond and Coles Pond deposits. Silica, the chief contaminant is significantly higher in the Canada Harbour marble. This reflects the elevated amounts of impurities, especially quartz, associated with the dolomite units. Total iron as Fe_2O_3, and Al_2O_3 average less than one half percent in the deposit.

The average dry brightness of the Canada Harbour marble (95.96 percent light reflectance) is similar to that of the Penny's Pond (95.83 percent) and Coles Pond (95.95 percent) marble.

Preliminary comparisons indicate the Canada Harbour marble may closely resemble marble deposits identified in the White Arm window, near Croque.

INTRODUCTION

The first determined effort to exploit Newfoundland's marble resource took place at Canada Harbour early in this century. 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 have been significant factors, which 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 use for dimension stone. In 1967, British Newfoundland Exploration Limited investigated the Canada Harbour deposit 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 deposit. This study was primarily concerned with identifying limestone and marble having the chemical specifications for such industrial applications as cement and quicklime manufacturing.

In 1985, the Newfoundland Department of Mines began a reassessment of the province's marble resource. 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 sampling of white, high-purity marble prospects in western Newfoundland (Howse, 1986). In order to meet the requirements of a superior grade filler, marble must have a high-calcium content and possess a minimum of acid-insoluble components such as quartz and other abrasive minerals. High brightness, in the order of 94 to 96 percent light reflectance (compared to a pure ASTM standard), is essential for a premium-grade product (Guillet and Kriens, 1984).

The Canada Harbour marble deposit was investigated during the 1985 survey and chemical and physical analyses of chip samples collected from the deposit showed it to be one of two white marble prospects, located in the Canada Bay—Roddickton area, which warranted follow-up work. The other prospect, located at Penny's Pond near Roddickton, was selected for a follow-up program that included drilling. This led to the delineation of high-purity white marble deposits at Penny's Pond and Coles Pond (Howse, 1987), both of which have been awarded to industry for further assessment and development.

This project is a contribution to the Canada—Newfoundland Mineral Development Agreement, 1984—1989

The purpose of this paper is to comprehensively summarize the geology of the Canada Harbour deposit and compare its chemical and physical features to other white marble deposits in the region.

Location, Access, and Land Status

Canada Harbour, once the site of a now abandoned fishing settlement, is located at the entrance to Canada Bay, on the eastern side of the Great Northern Peninsula (Figure 1). There are no roads to the harbour. Englee, a major fish-processing centre for the region, is located 5 km north across the bay and is linked to the province's highway system. Canada Harbour is a sheltered inlet with deep water suitable for large ships (Plate 1). However, except for one or two small fishing wharves used by local fishermen, there are no docking facilities available in the harbour.

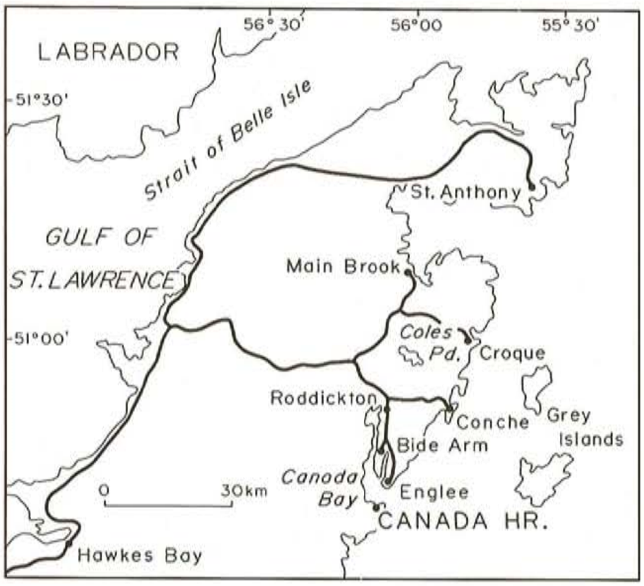

Figure 1. *Location of Canada Harbour, Newfoundland.*

The Canada Harbour marble deposit is encompassed by a Fee Simple Grant (Volume 1, Folios 134, 135), which was granted in 1919 to the Colonial Mineral and Trading Company, an English firm. The property is now held by Extender Minerals Limited of Mississauga, Ontario.

REGIONAL GEOLOGICAL SETTING

Deposits of high-purity white marble have been documented within a continuous belt extending from Canada Bay in the south to an area west of Croque, a distance of more than 50 km (Figure 2). The marble deposits occur in the Lower Paleozoic carbonate rocks, mainly within the Lower Ordovician St. George Group, where they have been deformed and metamorphosed in a series of thrust sheets beneath the Hare Bay Allochthon (Knight, 1987). In the Canada Harbour region, the platformal rocks are narrowly wedged between Precambrian crystalline basement on the west, and the structurally overlying allochthonous rocks to the east (Figure 3). The white marble zone closely parallels the western margin of the allochthon. The precise stratigraphic position of the Canada Harbour marble is uncertain. 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.

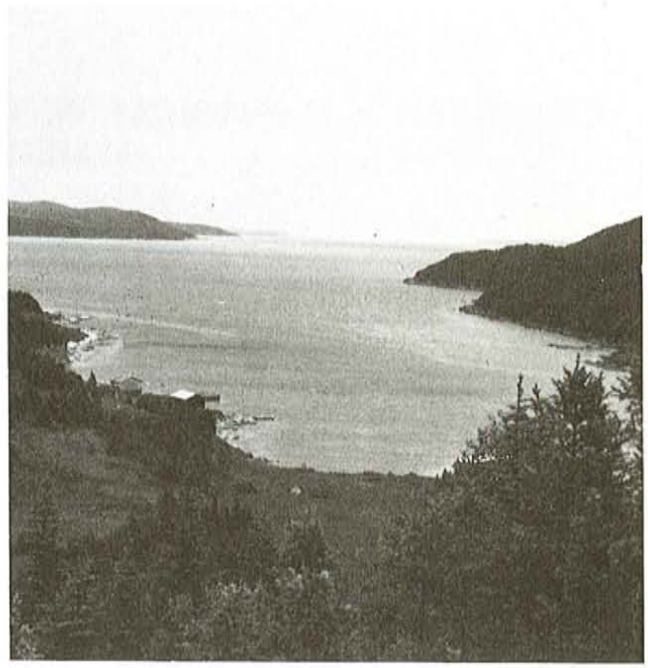

Plate 1. *View of Canada Harbour looking northeast from the main quarry.*

DESCRIPTION OF THE DEPOSIT

The white marble deposit is exposed on Marble Ridge (Plate 2) in the main quarry, an open cut about 42 m by 24 m (Figure 4). A much smaller open cut (Quarry No. 2), which is located near the crest of the ridge, was examined but not sampled during the present study. In the main quarry, the white marble is gradationally 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 thickness of the white marble unit is not known, but in the main quarry, a zone of approximately 35 m was measured and sampled. This measurement allows for the irregular layout (in plan) of the quarry face (Figure 4).

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 or open-cut quarry.

Impurities in the marble include chlorite and sericite, which occur as thin coatings along joints and bedding planes.

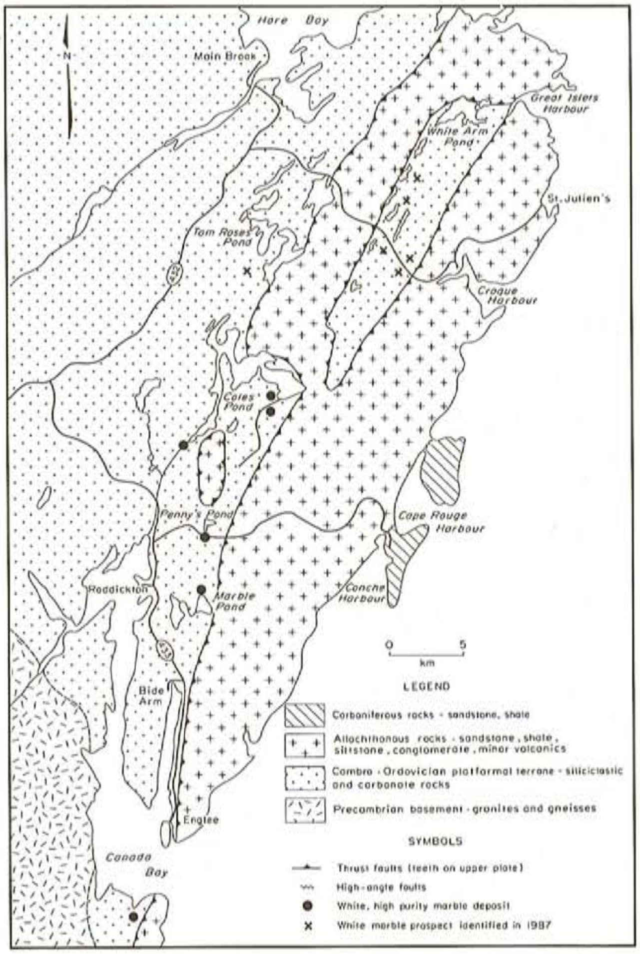

Figure 2. *Geological elements of the Canada Bay–Hare Bay region showing location of white marble deposits. Geology simplified after Knight (1987) and Stouge (1983a,b).*

Quartz is usually 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.

Barron (1967), identified two diabase dykes in exploration trenches that were dug across the white marble zone on Marble Ridge. The dykes have irregular widths ranging up to 4.5 m in width, are steeply dipping and cut the marble zone at 10 to 30°. They have porphyritic chill boundaries but the surrounding marble is relatively unaltered. The trenches are now refilled and thus inaccessible. However, this author noted a basic dyke on the shore of Canada Harbour about 300 m northeast of the main quarry, which is up to 4 m in width, and cuts the blue marble on the east flank of the white marble zone. Its 30° strike indicates it would intersect the white marble in the Marble Ridge area, if it were continuous.

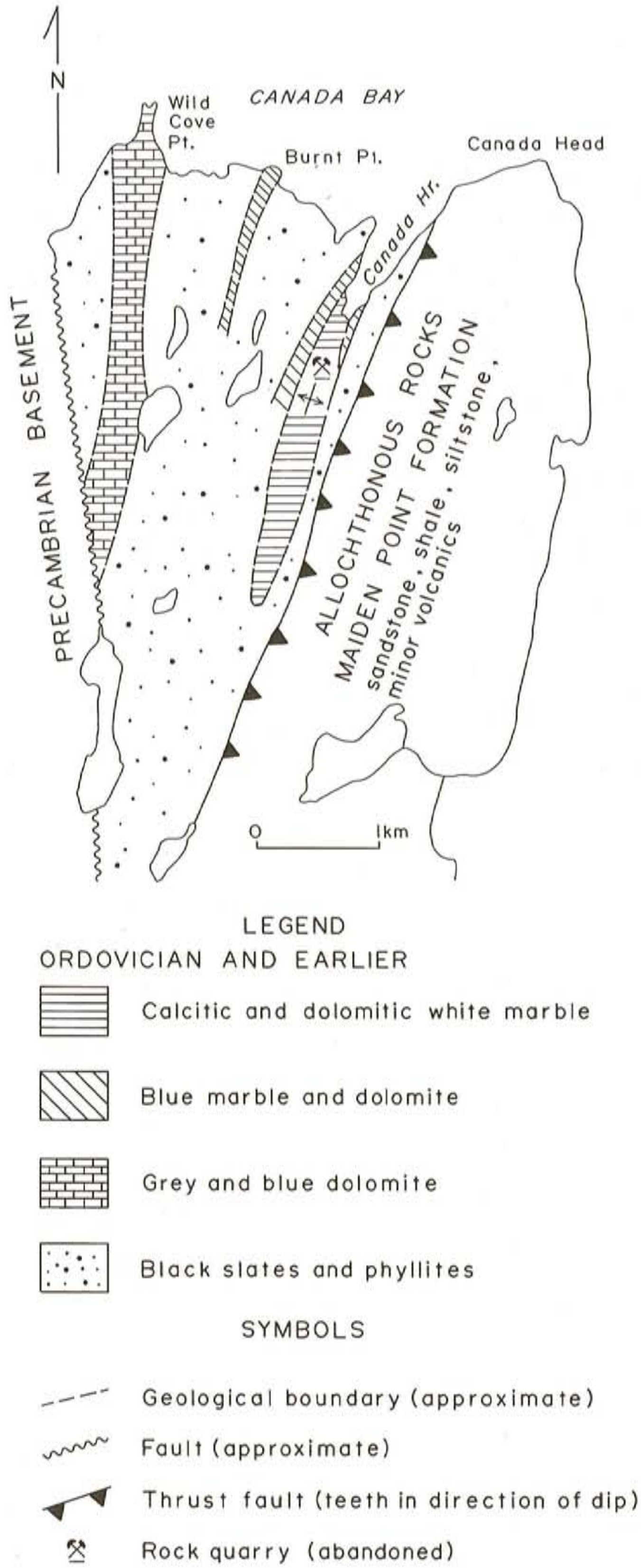

Figure 3. *Geological sketch map of the Canada Harbour area; modified after DeGrace, 1974.*

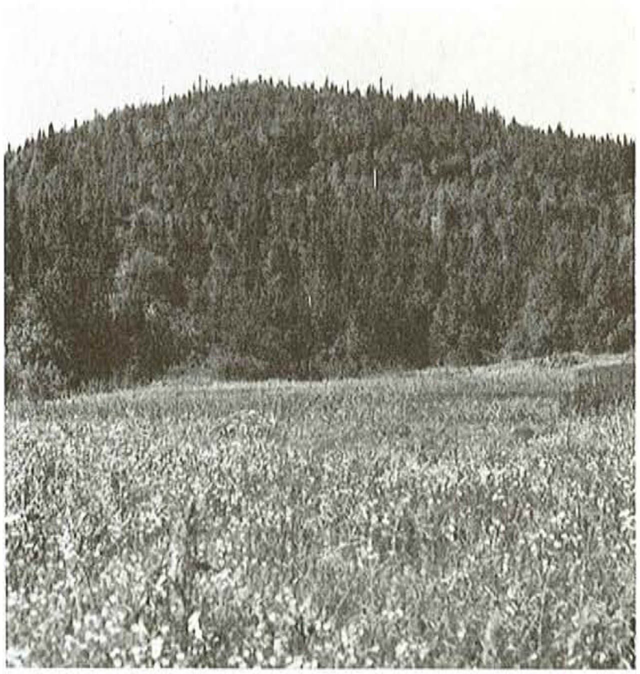

Plate 2. *Marble ridge as viewed from the abandoned settlement of Canada Harbour.*

Reserve Potential

Given the present information available on the Canada Harbour marble it is difficult to estimate the size of the deposit. The marble is exposed on the coast at Canada Harbour, 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 very pervasive blanket of till, therefore, 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 density (specific gravity) of 2.17 g/cm^3. The actual mining depth that might be realized by a potential developer is a major uncertainty. The presence of diabase dykes of unknown dimensions in the deposit is a major concern that underscores the need for further work.

It is clear that a systematic drilling program is essential in order to confirm and accurately measure the tonnages and grades of the deposit.

Chemistry and Dry Brightness of the Marble

The chemical analyses show that approximately 20 percent of the white marble unit in the main quarry is dolomite (Table 1). The dolomite beds are high in impurities, especially quartz, and are intimately interbanded with the calcitic marble. The calcitic marble is fairly pure with the main contaminant, silica, averaging 1.03 percent, and alumina and iron totalling well below one half percent. The average grade, making no distinction between the dolomite and calcite, is about 89 percent $CaCO_3$, 2.5 percent silica, and $MgCo_3$ at just over 6.2 percent. Alumina and iron together, total less than one half percent.

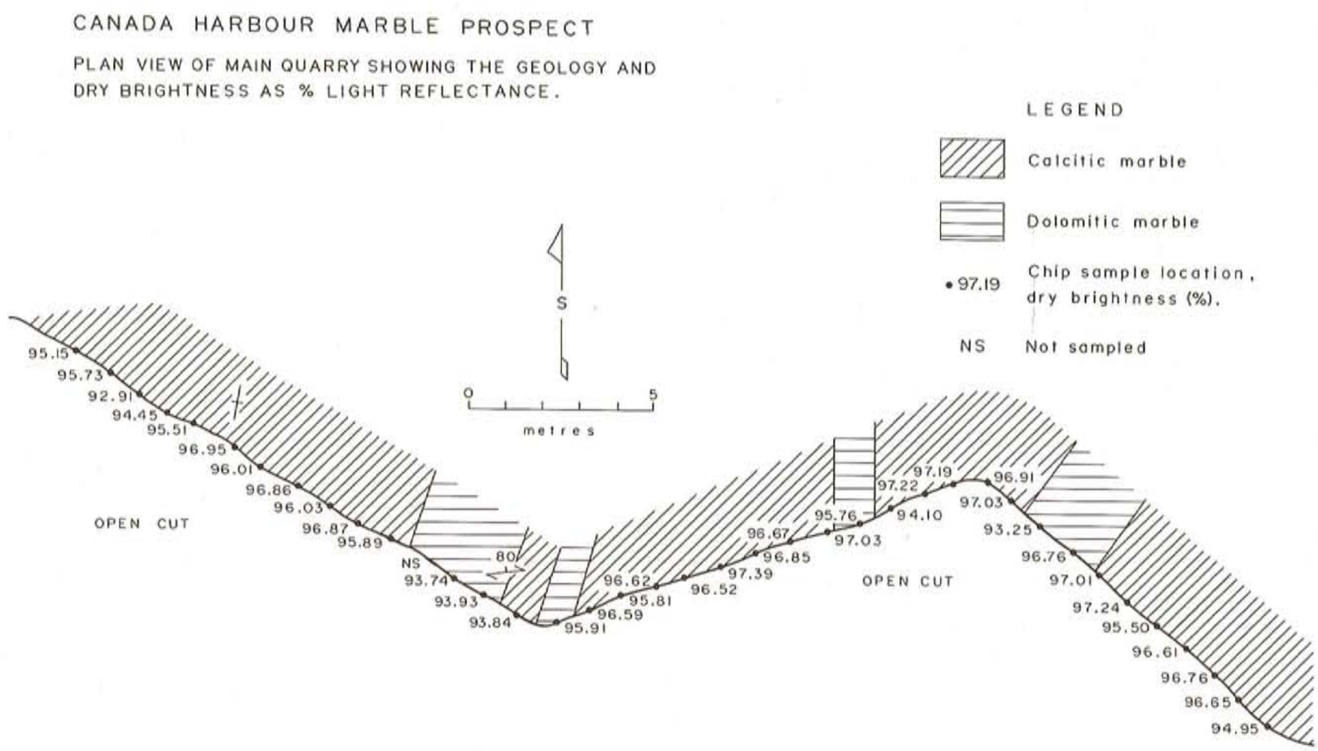

Figure 4. *The plan view of the main quarry, showing the geology and the dry brightness as a percentage of light reflectance.*

Table 1: Chemical analyses 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 (see Figure 4).

	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	**	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	combined average
AVERAGE	1.03	0.25	0.10	1.13	96.21	96.16	calcitic marble
AVERAGE	8.19	1.16	0.45	26.06	61.51	94.75	dolomitic marble

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

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 dolomite beds, which average 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.

Table 2. Average chemical analyses and dry brightness from the Coles Pond (North) and Penny's Pond deposits.

Coles Pond (North) Drill Core Analyses

DDH	Metreage	SiO_2+	Al_2O_3+	Fe_2O_3+	$MgCO_3$+	$CaCo_3$+	DB*	T
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
	overall average	1.52	0.39	0.13	0.63	96.60	95.95	

Penny's Pond Drill Core Analyses

DDH#	Metreage	SiO_2+	Al_2O_3+	$Fe_2O_3$12+	$MgCO_3$+	$CaCo_3$+	DB*	T
1	2.14-51.85	1.42	0.38	0.14	1.08	93.99	95.66	260,000
2	3.05-51.85	1.62	0.39	0.13	0.65	96.36	96.01	308,100
3	32.02-57.95	1.88	0.36	0.13	0.98	96.34	96.02	347,700
4	3.05-59.48	1.49	0.35	0.15	0.65	96.61	95.82	386,250
5	1.52-69.54	1.48	0.35	0.12	0.86	97.02	96.08	483,200
11	2.75-10.68	1.09	0.27	0.09	0.56	96.95	96.00	14,400
	overall average	1.58	0.36	0.13	0.84	96.58	95.83	

* Dry Brightness Index
\+ Weight Percent
T Metric Tonnes

Tests for brightness by I.M.D. Laboratories (1987).

COMPARISONS BETWEEN THE CANADA HARBOUR AND RODDICKTON–CROQUE DEPOSITS

There are obvious similarities between the Canada Harbour marble and that found in the Roddickton area, i.e., Penny's Pond and Coles Pond. In each case, the marble is very fine grained and slightly cleaved in weathered outcrops, a feature not apparent in drill core (Penny's Pond and Coles Pond) or in quarry faces (Canada Harbour). Chlorite is ubiquitous as a minor contaminant occurring as thin films along fractures and in bands of carbonate schist several centimetres thick. Other impurities include very minor amounts of sericite along some fractures, and rare quartz. Detailed sampling, however, shows that there are significant differences in the chemistry of the deposits. Chemical analysis of the drill log for both the Penny's Pond and Coles Pond deposits (Howse and Delaney, 1987) show that the white marble is almost 100 percent calcitic (Table 2). The analyses of continuous drill core (at 1.52-m intervals), show a complete absence of dolomite, and the average $MgCO_3$ content for the two deposits is 0.74 percent. By contrast, about one fifth of the white marble in the Canada Harbour main quarry is dolomite and the average $MgCO_3$ content is over 6 percent. The silica content for the Canada Harbour marble (2.5 percent), is about 1 percent higher than the average at Penny's Pond and Coles Pond. There is no significant difference in the alumina and iron content, both of which total less than 0.5 percent in the three deposits.

There is little variation in the average marble brightness for the three deposits. For the Canada Harbour deposit, the 95.96 percent reflectance is very close to the 95.83 and 95.95 percentages, respectively, for the Penny's Pond and Coles Pond deposits. Locally, some bands of Canada Harbour marble, however, have a superior brightness (>97 percent light reflectance). The brightness of the dolomitic marble is surprisingly high, ranging between 93.74 and 95.91 percent (average 94.74). The brightness dilution from the interbanded dolomite does not appear to significantly lower the average for the deposit.

There is evidence to suggest that the Canada Harbour marble may closely resemble the white marble in the White Arm Window (Croque area). For example, the Powerline prospect (Howse, 1988) on the eastern side of the White Arm Window consists of intimately interbedded calcitic and dolomitic marble of high brightness (Table 3). The brightness of the dolomitic marble at 93.03 percent and the calcitic marble at 95.43 compares favourably to the Canada Harbour stone. The marble deposit of Aurion Minerals (W. MacQuarrie, personal communication, 1988), located just

Table 3: Chemical analyses and dry brightness tests for representative chip samples from the Powerline marble occurrence near Croque.

	PERCENT						
Sample No.	SiO_2	Al_2O_3	Fe_2O_3	$MgCO_3$	$CaCO_3$	DB*	ROCK TYPE
5948119	1.84	0.29	0.07	0.75	96.96	94.33	calcitic marble
5948121	0.42	0.15	0.06	0.48	98.68	96.54	calcitic marble
5948122	11.03	0.98	0.49	33.69	52.26	93.03	dolomitic marble
average	4.43	0.47	0.20	11.64	82.63	94.63	

NOTE: * Dry brightness; Tests for brightness by I.M.D. Laboratories (1988)

north of the Powerline prospect, has similar characteristics including bands of superior dry brightness calcitic marble interbanded with dolomitic sections.

CONCLUSION

The Canada Harbour white marble prospect has several features that make it economically attractive. It is located at tidewater, close to shipping lanes, and although relatively isolated it can be easily reached by boat across Canada Bay from Englee, a prosperous fishing centre. The deposit is located on a ridge having natural quarrying advantage, and there is ample room for development.

The present assessment indicates the Canada Harbour marble is less pure, chemically, than the Roddickton deposits. Nevertheless, the dry brightness of the deposit is excellent. This is a critical factor in determining its suitability for industrial uses that require premium quality filler. It seems certain, however, that for such applications the marble would require secondary processing in order to reduce impurities to an acceptable level.

The Canada Harbour deposit needs to be accurately delineated by diamond drilling. Such a program should be designed to trace the marble southward from the area of the main open cut on Marble Ridge. The present evidence suggests that this area may be underlain by a significant reserve of high-quality stone, but this can only be confirmed by further work.

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NOTE: Geological Survey of Newfoundland file numbers are included in square brackets.