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LIMESTONE ASSESSMENT ON NEWFOUNDLAND'S GREAT NORTHERN PENINSULA

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ABSTRACT

An assessment of limestone prospects was carried out in the Pistolet Bay and Canada Bay regions of the Great Northern Peninsula. The deposits are found mainly, but not exclusively, in the Middle Ordovician Table Head Group. The purpose of the survey was to identify industrial-grade limestone suitable for a range of applications including cement and lime manufacturing, as well as use in the current high-growth areas of aggregate and environmental clean-up. The most promising prospect (Burnt Island) is a large, readily accessible deposit that underlies a peninsula adjoining the community of Raleigh. Detailed bedrock sampling indicates the deposit to be of exceptional purity. Other deposits of good quality were investigated near Cooks Harbour and in the Canada Bay region.

INTRODUCTION

The lower Paleozoic carbonate sequences of western Newfoundland host important deposits of limestone, marble and dolomite. Current production is confined to limestone deposits located at the southern end of the belt. Producers include the well-established cement-manufacturing plant at Corner Brook (North Star Cement Limited), the newly developed high-volume limestone aggregate quarry at Lower Cove on the Port au Port peninsula (Newfoundland Resources and Mining), and an agricultural limestone quarry at Cormack (Havelock Lime). At the northern end of the belt, industrial attention has focussed on high-purity white-marble deposits in the Roddickton area, where assessment and quarry development have taken place on deposits located near Roddickton and Croque (Aurion Minerals Limited and ECC International Limited). Currently, there is increased interest in the province's limestone resource. This interest stems from a number of factors. These include the successful start-up of the Lower Cove limestone aggregate operation, the imminent start of offshore oil development with its requirement for large volumes of cement, and emerging new uses and markets in pollution control systems. One of the largest growth areas is in the field of environmental clean-up, where most of the techniques being developed to reduce sulphur dioxide emissions, require large amounts of high-purity limestone.

The present study concentrated on deposits of potential commercial interest on the Great Northern Peninsula (Figure 1). Earlier assessments noted the commercial potential of these deposits yet stressed their relative remoteness as a serious impediment to development. General improvements in infrastructure on the Great Northern Peninsula, coupled with a growing recognition of the strategic tidewater location of these deposits, prompted the present survey.

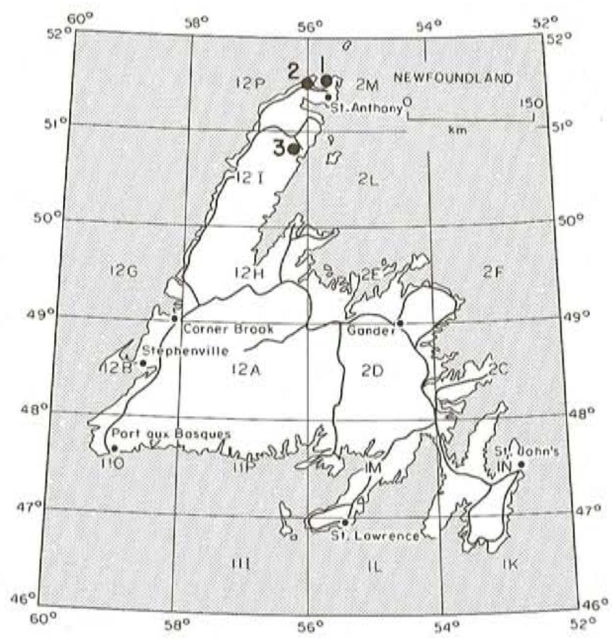

Figure 1. *Location of limestone assessment areas: 1) Raleigh; 2) Cooks Harbour; 3) Canada Bay.*

HISTORY OF LIMESTONE ASSESSMENT AND DEVELOPMENT

The beginning of 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 the thin Cambrian sequences on the Avalon Peninsula, and also with limestone from the higher grade Ordovician deposits at Cobbs Arm. 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 the ore (Harris, 1962).

The limestone industry acquired a more important status in the Newfoundland economy in 1913 when the Dominion Steel and Coal Corporation (DOSCO) established a quarry and loading facility at Aguathuna, on the Port au Port Peninsula. The limestone was shipped to Sydney, Nova Scotia, where it was used as a fluxing agent in the DOSCO steel mills. The Aguathuna operation lasted for 50 years and produced a total of 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 carbonates of the Lower Ordovician St. George Group.

The start of the pulp and paper industry in Newfoundland introduced a new but rather modest market for limestone. This demand was supplied by the existing quarries at Aguathuna and Cobbs Arm, and the Dormston quarry at Corner Brook. An idea of the scale of production can be seen from statistics that show between 1943 to 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.

Shortly after Newfoundland joined Canada in 1949, a cement plant was established in Corner Brook. Operated by North Star Cement Limited, it utilizes nearby deposits of limestone and shale and Flat Bay gypsum to manufacture portland cement. About 80,000 tonnes per year (tpy) are produced for the Newfoundland construction industry.

Beginning in the 1950's, 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 in a comprehensive report on insular Newfoundland's limestone resources by DeGrace (1974).

Involvement by industry in the assessment of Newfoundland industrial carbonates up until very recent times has been minimal. The concession system of the 1950's through to the early 1970's wherein a few large companies, preoccupied with metallic exploration, were given exclusive mineral exploration rights over large areas of the province, contributed to the situation. However, British Newfoundland Exploration Limited (Brinex), the mineral-exploration arm of BRINCO, delineated about 50 million tonnes of high-purity limestone at Coney Arm (Bedford, 1957), and about 200 million tonnes of exceptionally pure stone on the Port au port Peninsula. Brinex (now Western Canadian Mining Corporation), are currently reassessing their Port au Port limestone properties.

PRESENT SURVEY

OBJECTIVES AND PARAMETERS

The purpose of the survey was to identify industrial-grade limestone on the Northern Peninsula. For the purposes of this report, the term industrial refers mainly to cement and metallurgical-grade stone but also includes limestone suitable for use in agriculture, in pollution control systems and as aggregate.

The primary component of limestone, which determines whether or not it is metallurgical grade, is its SiO_2 content, where percentages greater than 2.5 are unacceptable. Magnesium oxide content is not critical if it is predictable, but the Al_2O_3 content should not exceed one percent.

The critical criteria in determining whether 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, alkali content (K_2O + Na_2O) can be very deleterious if it exceeds a half of a percent.

The physical and chemical parameters of carbonate rocks have been the subject of much research to determine the factors that affect their performance in the environmental field of sulphur emissions and acid rain. With regard to the specifications for limestone used in a gas scrubber, there are certain conditions required in terms of fineness and chemical purity. A high-grade limestone is required, with a maximum 5 percent acid insolubles, although some systems look for higher standards (Power, 1985). Iron content could be beneficial (as a catalyst in the process) but not if it occurs as pyrite, which reduces reactivity. A fine-grained porous stone is favoured although it should be noted that it is the pore size of the calcined rock that is important, rather than that of the raw limestone (Hamer, 1986).

ACCESS AND METHODS

The Viking Highway (Route 73), which connects with the Trans-Canada Highway at Deer Lake, offers paved access to the western side of the Northern Peninsula. Communities around Pistolet Bay, such as Raleigh and Cooks Harbour, are linked to this highway by short all-weather roads (also partly paved or slated for paving). A strategically located regional airport also serves the area's transportation needs, especially the town of St. Anthony, the headquarters of the Grenfell Mission and the region's chief commercial and service centre. A 40-km trans-peninsular gravel road (up-graded for paving) links communities on the eastern side of the peninsula to Route 73. A network of woods roads and other trails most of which are drivable, provide additional access to limestone deposits. Most importantly, the deposits are located on or close to tidewater.

Three major prospects, along with a number of other occurrences, were investigated during the 1990 field season (Figure 1). 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. Sample sites were plotted on air photographs and 1:50,000-scale NTS map sheets. Approximately 170 samples were collected for analysis at the Newfoundland 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.

LIMESTONE PROSPECTS

RALEIGH (BURNT ISLAND)

One of the most commercially attractive limestone prospects in the province underlies Burnt Island near the community of Raleigh on the east side of Pistolet Bay (Figure 2). Burnt Island is in fact a Peninsula connected by a natural land bridge to Raleigh. A road across this isthmus provides access to all parts of the deposit. The peninsula and Raleigh form a natural harbour that is able to accommodate large ships.

Much of Burnt Island is exposed bedrock consisting of limestone of the Lower Ordovician St. George Group, disconformably overlain by Table Point limestone of the Middle Ordovician Table Head Group. The south and southwest parts of the island are underlain by shales of the Ordovician Goose Tickle Formation. Small, thin deposits of limestone gravels, typical of weathered Table Head formations, are common and these are being exploited locally on a small scale for road aggregate.

On the eastern side of the island, the stone is typical Table Point but is more contorted and recrystallized than other occurrences in the region. The limestone is fine grained, quite hard and contains abundant white calcite veins and stringers. Along sample lines, zones of brecciated limestone and thin argillaceous seams were observed. The argillite is too thin and localized to significantly dilute the overall quality of the stone. The limestone beds are folded in an undulating manner but the average dip is about 10 to 12° eastward.

White and grey limestone and dolomitic limestone of the St. George Group underlies the western side of Burnt Island. This stone is extremely pure and resembles the Catoche limestone (White Hills limestone) on the Port au Port Peninsula. It is estimated to be about 15 m thick. The white limestone is underlain by dolomitic limestone along the western margin of the island.

One of the commercially enhancing features of the deposit is that it is extremely well suited for quarrying. The plateau-shaped peninsula (maximum elevation 75 m) has a pronounced yet easily accessible slope on its harbour side (Plate 1) that would facillitate quarry development. Also, there is almost a complete absence of overburden (Plate 2).

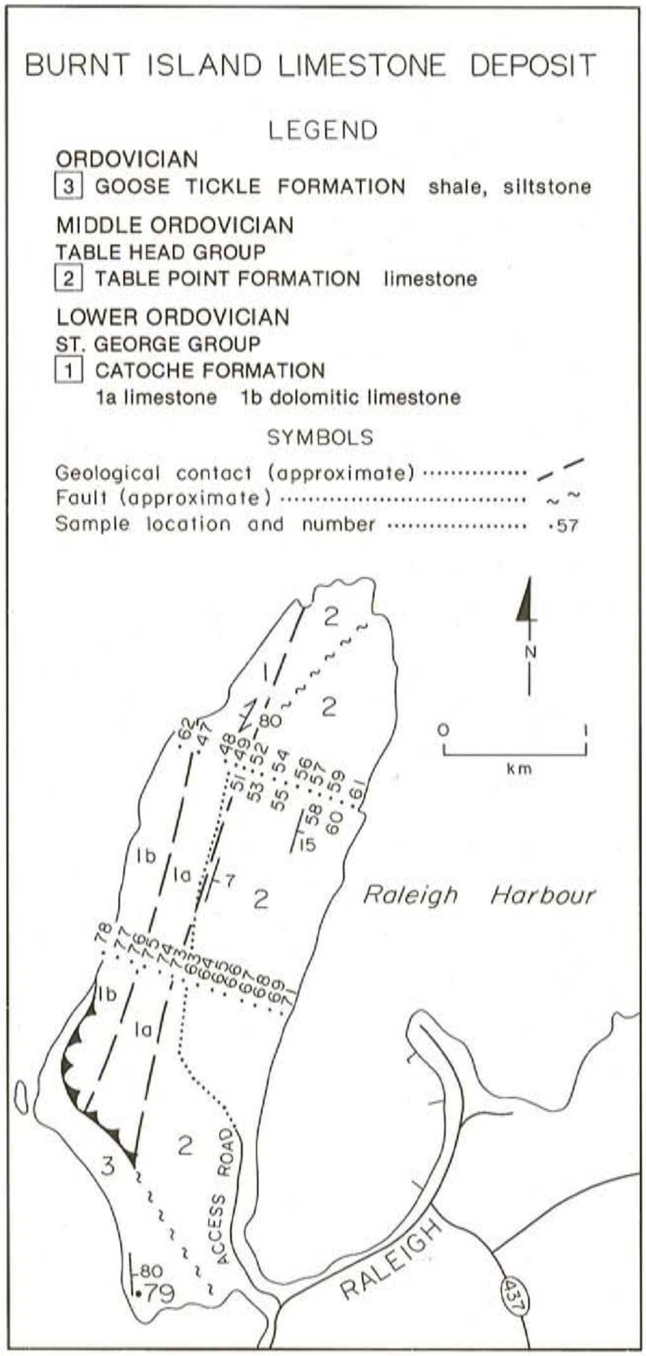

Figure 2. *Location of the Burnt Island–Raleigh limestone deposit. (Geology modified after Knight, 1986a)*

SAMPLING RESULTS AND RESERVE POTENTIAL

Table 1 (a and b) shows the chemical analyses of representative chip samples from the Burnt Island limestone deposit. These results indicate the presence of a large deposit grading around 98 percent calcium carbonate. Silica content is low at just over a quarter of a percent and iron and aluminum add up to 0.11 percent. Magnesium carbonate content is less than one and a half percent. Sodium oxide and K_2O (not shown in Table 1) averaged 160 ppm and 450

Plate 1. *Burnt Island looking across its eastern slope and across Raleigh Harbour.*

Plate 2. *Burnt Island limestone deposit looking north along strike.*

ppm, respectively. The results support field observations that the deposit is underlain by dolomitic limestone exposed along the western margin of the island (Figure 2). This is reflected in sample 62 and samples 76 to 78, which averaged 28.7 percent magnesian carbonate (Table 1b).

The sampling program indicates a large reserve of quarryable limestone on Burnt Island, a significant proportion of which is of very high quality. A conservative estimate of 150 million tonnes on the middle and eastern half of the island would appear to exceed the specifications for most industrial applications. At present, there is no information available on the limestones's suitability for use as aggregate or in the field of pollution control. However, the low level of impurities, especially silica, suggests the stone may have good aggregate potential.

It should be emphasized that the 1990 assessment sampled limestone bedrock exposed on the surface. This was done in a systematic manner and care was taken to collect unweathered representative samples. However, in order to provide more accurate and definitive information on the size and quality of the deposit, a diamond-drilling program would have to be carried out.

Table 1. a) Chemical analyses for chip samples from the Burnt Island limestone deposit; see Figure 2 for sample locations

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	$CaCO_3$	$MgCO_3$
47	0.20	0.06	0.02	98.50	0.50
48	0.31	0.15	0.02	98.54	0.67
49	0.24	0.07	0.02	98.48	1.06
51	0.18	0.05	0.01	98.98	0.60
52	0.30	0.06	0.02	98.33	1.00
53	0.26	0.06	0.03	98.06	0.96
54	0.32	0.08	0.02	97.43	2.26
55	0.15	0.04	0.03	97.76	1.02
56	0.31	0.06	0.02	99.31	0.92
57	0.36	0.12	0.04	99.13	1.53
58	0.18	0.06	0.02	99.86	1.19
59	0.23	0.06	0.02	98.24	1.27
61	0.33	0.09	0.03	97.12	2.47
63	0.21	0.07	0.03	98.84	1.11
64	0.34	0.08	0.03	98.38	1.52
65	0.15	0.04	0.01	98.47	1.17
66	0.17	0.06	0.01	99.23	1.29
67	0.18	0.05	0.01	97.33	3.32
68	0.26	0.04	0.04	98.93	1.50
69	0.22	0.05	0.02	97.42	1.92
71	0.45	0.12	0.06	96.69	2.17
72	0.42	0.15	0.06	96.94	1.44
73	0.09	0.04	0.02	99.45	0.40
74	0.23	0.07	0.06	99.50	0.42
75	0.36	0.19	0.07	98.78	0.56
AVERAGE	0.26	0.08	0.03	98.38	1.31

b) Chemical analyses of chip samples from dolomitic limestone on western side of Burnt Island; see Figure 2 for sample locations

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	$CaCO_3$	$MgCO_3$
62	0.35	0.19	0.11	67.76	31.39
76	0.20	0.08	0.06	72.62	26.88
77	0.69	0.28	0.15	58.19	38.44
78	2.36	0.42	0.14	78.37	18.22
AVERAGE	0.90	0.24	0.12	69.23	28.73

COOKS HARBOUR DEPOSITS

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, and an inland high-purity limestone zone that intersects the old Viking Highway about 2.5 km west of the Cooks Harbour road junction (Figure 3).

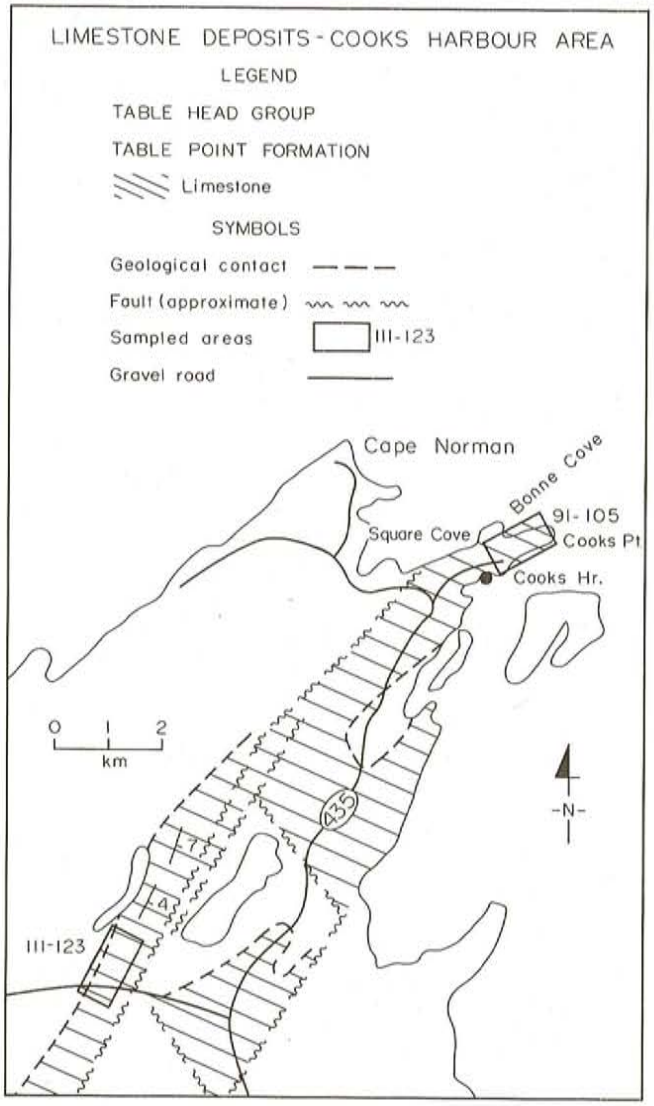

Figure 3. *Location of limestone deposits near Cooks Harbour. (Geology after Knight, 1986a)*

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, and in many shattered and jointed areas, weathering has produced a thin covering of limestone gravel. Two lines located approximately a kilometre apart were sampled at 50 m intervals across the width of the formation.

COOKS HARBOUR

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

The limestone is medium dark grey, fossiliferous, containing extensive calcite veining. Sampling encountered minor seams of argillaceous limestone throughout the section from Cooks Point to Square Bay, and 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 3).

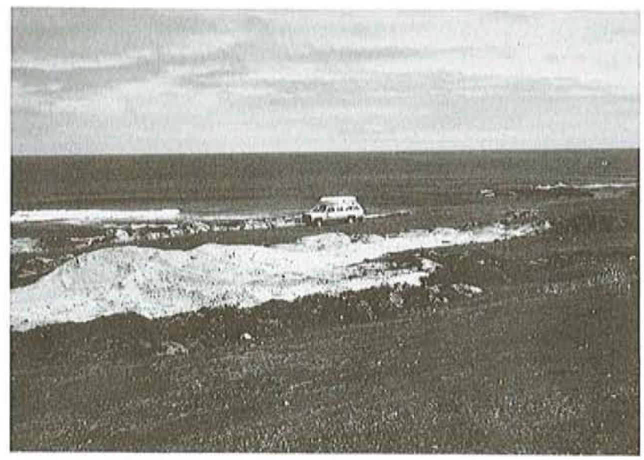

Plate 3. *Small limestone pit north of Cooks Harbour. The stone is used locally for road aggregate.*

RESULTS AND RESERVE POTENTIAL

Table 2 (a and b) shows the results of the sampling program in the Cooks Harbour area. The results suggest 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.

At least 20 million tonnes of limestone could be quarried from the low-lying ridge north of the old Viking Highway (Figure 3), 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 2a depicts 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. Cooks Harbour, a well-sheltered port, provides ocean access to the area's limestone resource.

Table 2. a) Chemical analyses for representative chip samples collected near Cooks Harbour; refer to Figure 3 for sample locations

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

b) Chemical analyses for chip samples collected across the Cooks Harbour (old Viking Highway) limestone; see Figure 3 for sample locations

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

CANADA BAY AREA

In addition to the high-purity white marble deposits currently under assessment by industry, the eastern side of the Northern Peninsula also host 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 4). He further noted that the stone may also have potential as a building stone since it is thick bedded and contains attractive features such as fossils and depositional patterns.

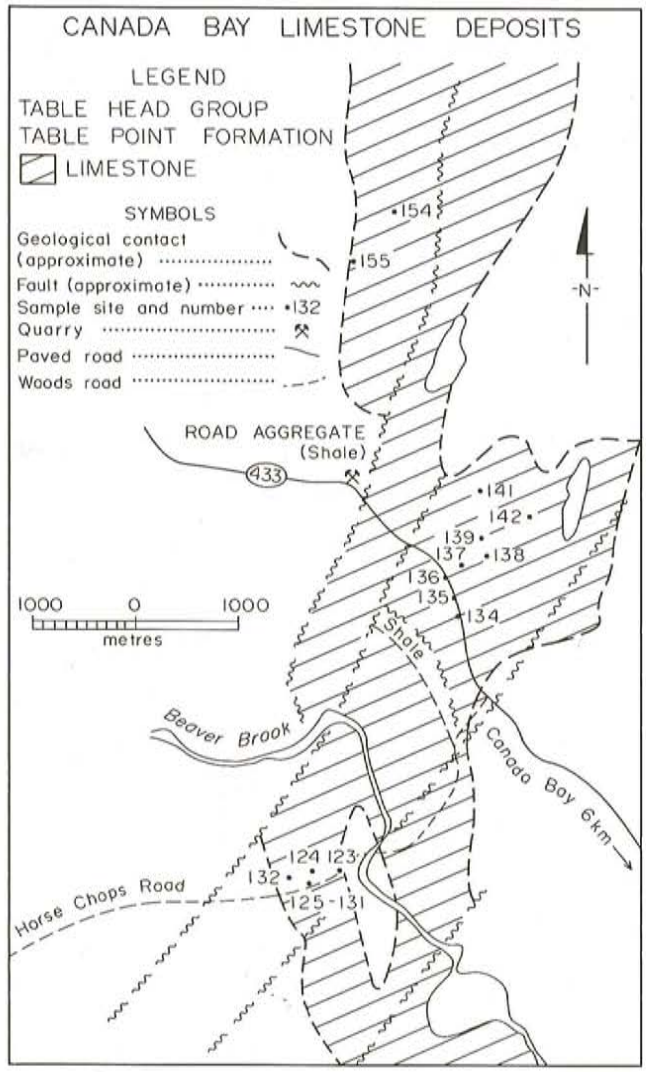

Figure 4. *Location of limestone deposits north of Canada Bay. (Geology after Knight, 1986b)*

During the present survey, a total of 28 samples were collected in order to provide essential chemical data on the limestone. Unlike the flat-lying, denuded limestone beds on the eastern side of the Great Northern Peninsula, here the limestone consists of poorly exposed formations underlying densely wooded ridges and valleys that have been extensively harvested for pulpwood.

The best exposures were noted about 5 km northwest of Beaver Arm and are accessible from the main highway via the Horse Chops access road (Figure 4). The thick-bedded limestone, which outcrops along a ridge, is 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 stone for building purposes. The light-grey stone 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 stone is weathered to a typical Table Head 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 belt of Table Head limestone was examined along Route 73 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 stone is weathered to a smooth surface and white veins of calcite are ubiquitous. The aerial 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 3) shows that the grade of the limestone in the sampled areas is remarkably similar to that found in the Cooks Harbour deposits (see Table 2a and b). The average grade of $CaCO_3$ (95.5 percent) is virtually the same as that for Cooks Harbour (95.7 percent), and the levels of impurities (silica, iron and aluminum) are also comparable. Also, the percentage of magnesium carbonate at 2.24 percent is only marginally lower than the 2.74 percent average for the Cooks Harbour limestone.

Table 3. Chemical analyses for representative chip samples from limestone formations north of Canada Bay; refer to Figure 4 for sample locations

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	$CaCO_3$	$MgCO_3$
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

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.

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.

Chemical analyses of detailed representative chip samples confirmed field observations that Burnt Island, an unoccupied peninsula adjoining the fishing port of Raleigh, contains large reserves of extremely pure limestone. The deposit is also well suited for quarry development.

Sampling of two areas in the Cooks Harbour region showed that good-quality limestone is available, though 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. There, however, a thin although pervasive overburden cover presents an additional problem to potential developers. All of the limestone deposits examined during the present program require additional follow-up drilling assessments in order to provide more precise information on tonnages and grades.

ACKNOWLEDGMENTS

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