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DOLOMITE EVALUATION PROJECT

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ABSTRACT

An assessment of insular Newfoundland's dolomite resource was initiated in 1987. The aim of the project is to identify deposits of metallurgical grade.

The Lower Ordovician, carbonate platform rocks of western Newfoundland host a number of high-purity dolomite deposits, most of which are located on tidewater. Deposits were investigated on the Port au Port Peninsula, at Goose Arm in the Bay of Islands, and at several localities on the Great Northern Peninsula.

INTRODUCTION

During the 1987 field season, a project was initiated aimed at locating and assessing potential metallurgical-grade dolomite deposits in the carbonate sequences of western Newfoundland. The objective was to locate a minimum deposit of 10 million tonnes of dolomite with 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. Suitable quarry sites and proximity to tidewater were also considered in the assessment.

Five major prospects (Figure 1) were mapped and sampled together with several other occurrences. Exploration was concentrated on the Lower Ordovician St. George Group, but some sampling was conducted on the Upper Cambrian Petit Jardin Formation of the Port au Port Group. Generally, chip samples were taken perpendicular to bedding over a maximum thickness of 5 m per sample using a 3.6-kg sledgehammer and 0.7-kg geology hammer to remove weathered surfaces. In areas of flat-lying bedding, it was sometimes possible to sample only the top bed. In such cases, the outcrop was sampled over a 5-m radius. Approximately 370 samples were collected; these will be analyzed for a range of chemical elements at the Newfoundland Department of Mines geochemical laboratory.

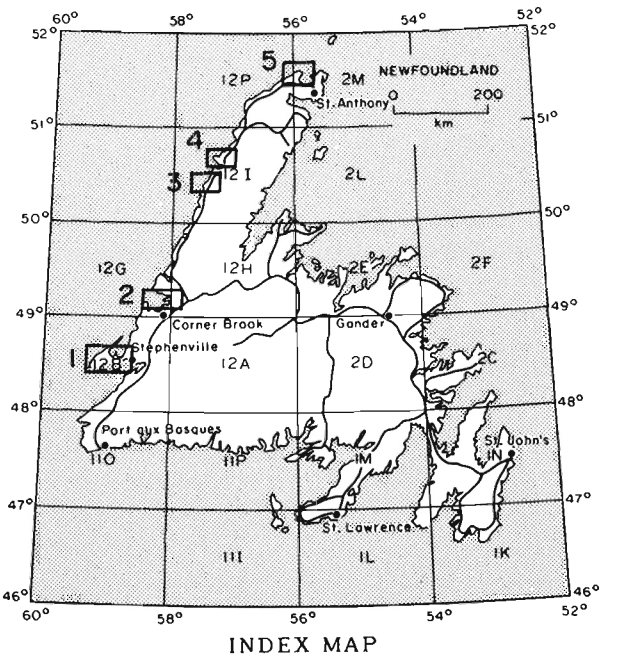

Figure 1. *Location of major dolomite prospects: 1) Port au Port Peninsula; 2) Goose Arm; 3) Deer Cove; 4) Port au Choix; 5) Cape Norman.*

Previous Work

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), there has been little recent work to determine the economic potential of the dolomite. Fong's (1968) survey included the Port au Port Peninsula, Goose Arm, Deer Cove, and Port au Choix areas. Besaw (1974) studied the dolomite potential of the Port au Port Peninsula, and identified a unit of dolomite that he called the Pine Tree unit, as possibly hosting metallurgical-grade stone. This unit is equivalent to the dolomites of the Catoche Formation of Knight and James (1987).

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

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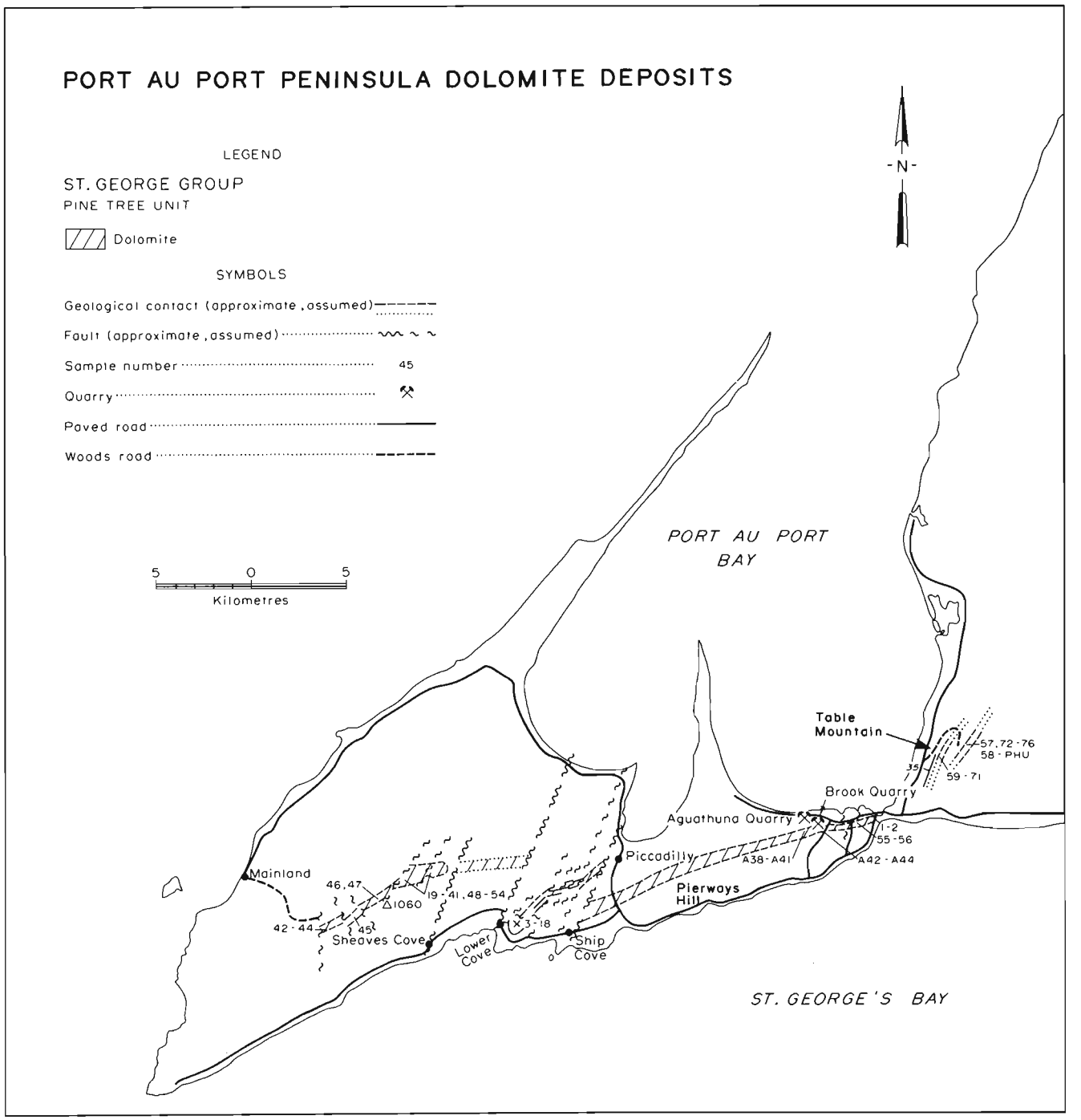

Figure 2. *Location of dolomite deposits on the Port au Port Peninsula (geology modified from Besaw, 1974).*

More recently, Norsk Hydro conducted reconnaissance exploration for metallurgical-grade dolomite on the west coast of Newfoundland. The objective was to identify dolomite of sufficient quality for the production of magnesium oxide and magnesium metal.

PORT AU PORT PENINSULA

The informally named Pine Tree unit of the St. George Group has been the main focus of interest as a potential source of metallurgical-grade dolomite on the Port au Port Peninsula. The unit forms an east-west trending belt across the peninsula (Figure 2). Northeast-trending faults displace the unit giving rise to three areas of outcrop or belts. The unit is also exposed on the top of Table Mountain about 6 km northeast of the peninsula.

The Pine Tree unit is typically a buff or light-brown, fine- to medium-grained, massive dolomite. Chert is the main

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impurity and occurs as 1- to 5-cm diameter nodules, irregular masses or lenses that are often concentrated in discontinuous layers. Locally, thicker, more continuous layers of chert are present. Chert also occurs as 1- to 3-cm irregular masses intermixed with dolomite. Generally, the chert is most abundant in the lower 15 m of the unit. Bedding in the unit was almost obliterated during the dolomitization process, but a gentle northerly dip is assumed from overlying and underlying units.

The westernmost belt can be reached by a trail heading north from a point near Sheaves Cove, or off a woods road heading eastward from the community of Mainland. The belt is less than 200 m wide in the western half, but widens eastward, due in part to the combined effect of eastern and northeast-trending oblique-slip faults that bring together different levels and lateral portions of the belt. The cherty, lower 10 m of the Pine Tree unit is considered to underly the southern half of the more widely exposed section of the unit. Faulting is more evident here, and this, combined with some dissolution of the Pine Tree unit, has caused windows of the underlying Pigeon Head unit (Besaw, 1974) to occupy depressions and low ground. Dolomite in the northern half appears to be thicker and of better quality, although chert is still present. The top 2 to 3 m of the Pine Tree unit is only partly dolomitized, and consists of a fine grained burrowed limestone. It is the burrows that are locally dolomitized. Quartz crystals and iron staining are more abundant near the top contact, but calcite crystals are scattered throughout the belt. Natural quarry faces of 8 to 15 m are present in the western part of the belt, but the poor quality of the dolomite and rugged terrain, limit the feasibility of development.

The middle belt extends east-northeast from Lower Cove on the south coast to Piccadilly near the north coast. It is offset along several northeast-trending high-angle faults (Figure 2). Chert is a minor constituent through much of the thickness, but is more abundant in the lower part of the unit. Good quarry faces are present at Lower Cove and Piccadilly.

The belt between Ship Cove and the Port au Port isthmus is relatively undisturbed except for minor offset in the eastern portion by north-trending block faulting. Impurities consist of scattered chert nodules and calcite crystals. The roadcut at the isthmus shows an incompletely dolomitized rock consisting of intermixed fine grained burrowed limestone and mottled dolomite on a scale of metres. This incomplete dolomitization continues westward for about 3 km. The terrain throughout this belt is rather flat with few natural quarry sites although the Brook Quarry at Aguathuna can easily be expanded.

The Pine Tree unit as exposed on Table Mountain east of the Port au Port Peninsula (Figure 2), consists of two northeast-trending belts on either side of the mountain. Only the exposures southwest and southeast of the communication facilities at the top of the mountain were mapped and sampled, although the unit is probably exposed farther north along the mountain top. The unit dips 35° northwest and is approximately 10 m thick. The dolomite is vuggy and variably burrowed. Locally, the rock contains only dolomitized burrows. Calcite partially fills 1-cm-diameter vugs, and occurs as coatings on fractures and as 1- to 2-cm blocky crystals. It also forms an intergranular cement to the dolomite, and when absent, the dolomite has abundant intergranular space and often a very crumbly texture. Chert commonly occurs as 1- to 20-cm diameter nodules and lenses, generally concentrated in discontinuous layers up to 8 cm thick. Locally, dolomite grains are coated with white clay.

Port facilities are not presently available on the Port au Port Peninsula, but Bay St. George is relatively ice-free and should be adequate for year-round shipping. Port au Port Bay was once used to ship limestone from the Aguathuna Quarry but the dock no longer exists. The bay is usually filled with drift ice during the spring.

GOOSE ARM

Large quantities of fair- to good-quality dolomite were located in the Goose Arm area of the Bay of Islands (Figures 1 and 3). There are at least five potential deposits along Goose Arm and Penguin Arm, namely: 1) Penguin Cove; 2) South Goose Arm; 3) The Narrows; 4) Penguin Hills and 5) Penguin Arm deposits. A sixth site, the Goose Arm Road deposit, can be accessed by a woods road from Deer Lake.

The Hughes Brook Formation 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 (Knight, personal communication).

The dolomite is typically very hard, massive, light grey, very fine grained and medium to thick bedded. Chert, calcite and quartz are rare in the dolomite but in three of the deposits (3, 5 and 6 in Figure 3) the dolomite 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 only seen on the woods road north of the head of Goose Arm.

The following are brief descriptions of sampled Goose Arm dolomite deposits considered to be of potential metallurgical grade. Chemical analyses of the samples, currently in progress, will help decide which deposits warrant follow-up work.

Penguin Cove Deposit

The purest dolomite deposit occurs east of Penguin Cove where beds of dolomite about 1 m thick, dipping 20° east (Plate 1), are exposed in a 150-m-high vertical cliff. Approximately 75 m of bedding are exposed along the shore and 11 samples were taken perpendicular to bedding over a thickness of 5 m each. This section of the Hughes Brook Formation varies from dark grey, generally massive dolomite,

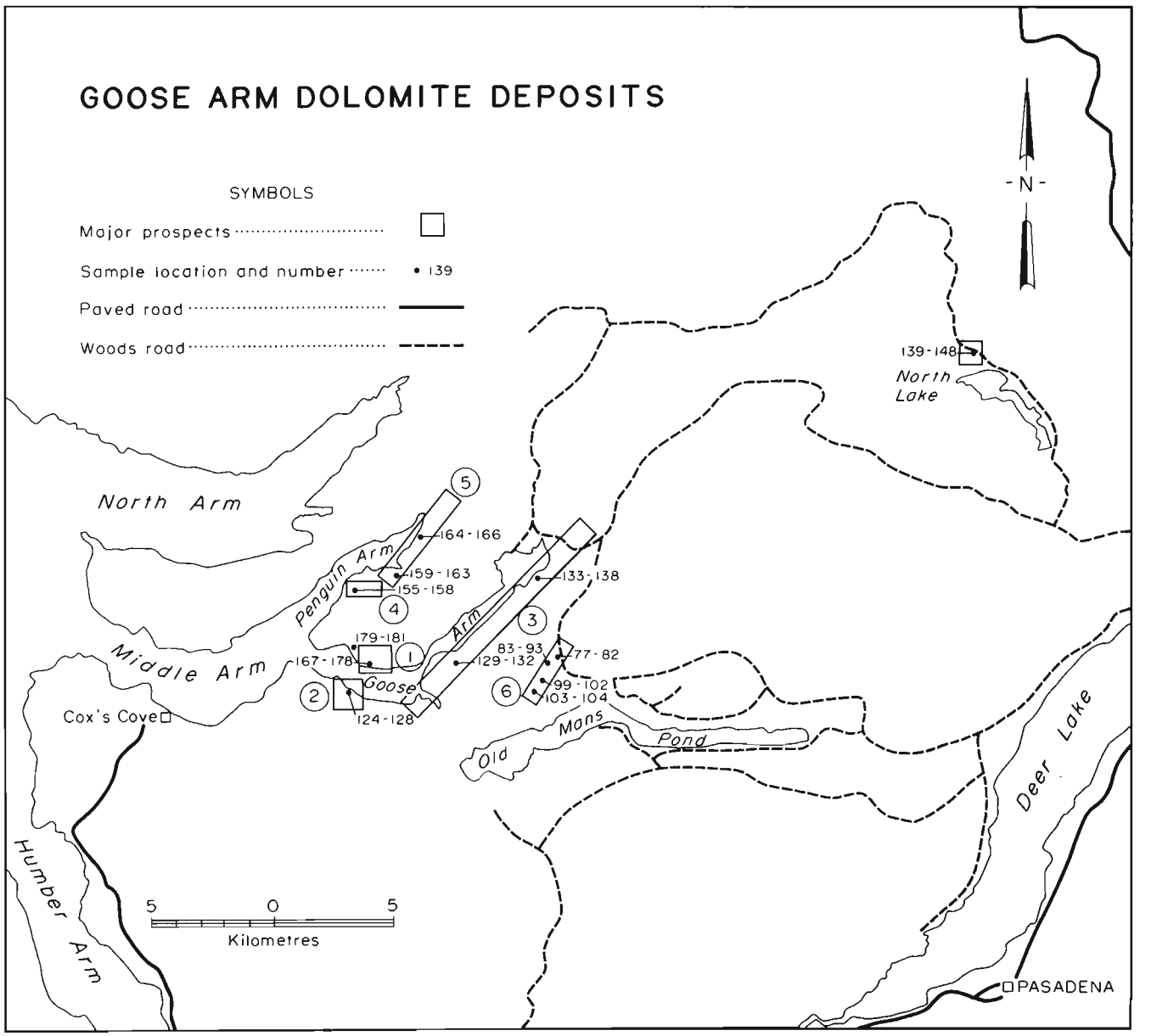

Figure 3. *Goose Arm dolomite prospects.*

but with some beds heavily cleaved in the lower 25 m of the section, to a light grey, stylolitic dolomite in the upper part. Impurities were noted in only one sample that contained trace amounts of fine grained pyrite and probable 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 dolomite 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).

Goose Arm South Deposit

An approximately 85-m-thick section of Hughes Brook dolomite is exposed along the shore due south across Goose Arm from the Penguin Cove deposit. The dolomite dips 42° east and has a conformable eastern contact with a fine grained burrowed limestone, and a high-angle fault contact with steeply west-dipping (65-70°) black shale and limestone on the west. The dolomite is similar to the Penguin Cove deposit but the vertical stratigraphic change in lithology and cleaved beds observed at the Penguin Cove deposit were not observed in this section. The dolomite near the fault contact is iron stained and consists of clasts of grey dolomite set in a creamy,

Plate 1. *Thick-bedded dolomite of the Hughes Brook Formation exposed in an approximately 150-m-high cliff east of Penguin Cove, Goose Arm.*

Plate 2. *Dolomite cliffs, about 200 m high, at the narrows of Goose Arm.*

coarse grained vuggy dolomite matrix. The land surface rises rapidly away from the shore, indicating that significant tonnage may be present at this site.

The Narrows Deposit

The Narrows dolomite deposit outcrops in northeast-trending cliffs up to 230 m high that parallel the strike of Goose Arm (Plate 2). The dolomite is predominantly massive but fine laminations and an oolitic bed are also present in the section. Extensive quartz veins less than 1 cm thick, dipping 35° northeast are present. Calcite locally coats fractures. An approximately 60-m-thick section of horizontally bedded dolomite 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 hard to define, but Lilly (1963) puts the thickness of the Hughes Brook Formation in the Goose Arm area at more than 400 m. Thick wedges of 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.

Penguin Hills Deposit

This site consists of heavily cleaved, laminated dolomite with cobble-sized pieces of dolomite 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 dolomite. The beds dip 20° north. More than 10 million tonnes of dolomite are estimated for this deposit.

Penguin Arm Deposit

Hughes Brook Formation dolomite 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 dolomite dipping 65° northwest. At this locality, the dolomite contains solitary blocky crystals of pink dolomite and zones containing clasts of fine grained dolomite set in a coarse grained dolomite matrix. No visible impurities were noted in outcrop but chert was observed in the talus slope at the base of the cliff. Near the head of Penguin Arm, the dolomite is extensively veined by quartz and calcite trending in several different directions. More detailed assessment, including diamond drilling, would be required to accurately define the high-purity dolomite zones in this area.

Goose Arm Road Deposit

A deposit of good quality dolomite was identified and sampled along a woods road about 5 km east of Goose Arm. A roadcut exposes a minimum stratigraphic thickness of 60 m of medium-bedded stone dipping 42° northeast. It is cut by up to 1 cm thick dolomite veins and local quartz veins. This block of dolomite 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 plan view) consist of 30-m cliffs (Plate 3) that encompass an area of approximately 400 m by 100 m. The dolomite 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.

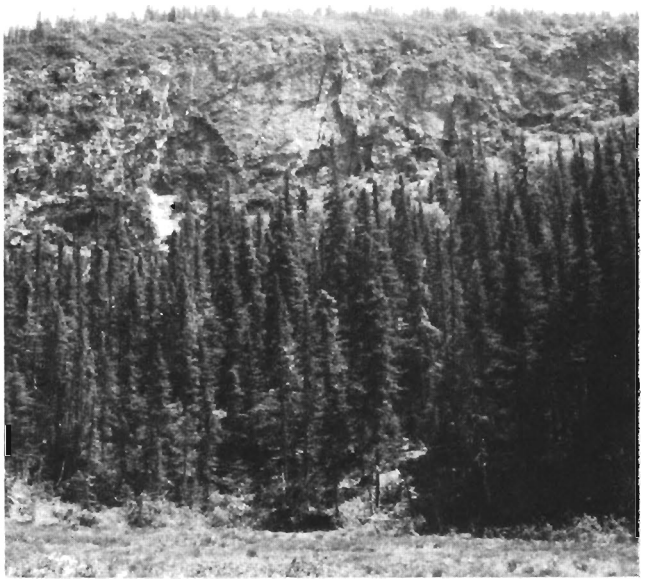

Plate 3. *Thirty-m-high cliffs along the south side of the larger block of dolomite; Goose Arm Road.*

The woods road that provides access to the dolomite connects to the Deer Lake–Nicholsville road near the northeast tip of Deer Lake. Although the area is particularly well suited, topographically, for quarrying, additional work is required to define more precisely the size and quality of the deposits.

GREAT NORTHERN PENINSULA

Deer Cove Deposit

This deposit is located approximately 5 km north of Bellburns on the Great Northern Peninsula between the Viking Trail (Route 430) and the sea (Figures 1 and 4). The dolomite comprises a section of the Catoche Formation of the Lower Ordovician St. George Group. The flat-lying to gently westerly dipping beds are up to 2 m thick. The dolomite has a fine- to medium-grained crystalline texture and is varible in colour from light- to dark-grey-brown. A maximum thickness of 20 m is exposed along the coast; the deposit can be traced at least 3 km along a northerly strike but only about 200 m inland. This represents a deposit of nearly 35 million tonnes.

The Deer Cove deposit is located on an exposed area of the coast where the nearest harbour and shipping facilities are found at Hawkes Bay, 40 km to the north. Work carried out to date, including Fong's (1968) assessment, indicates a high degree of variation in the silica content of the dolomite along its strike. In order to determine an accurate grade for this deposit, a follow-up assessment including drilling will be required.

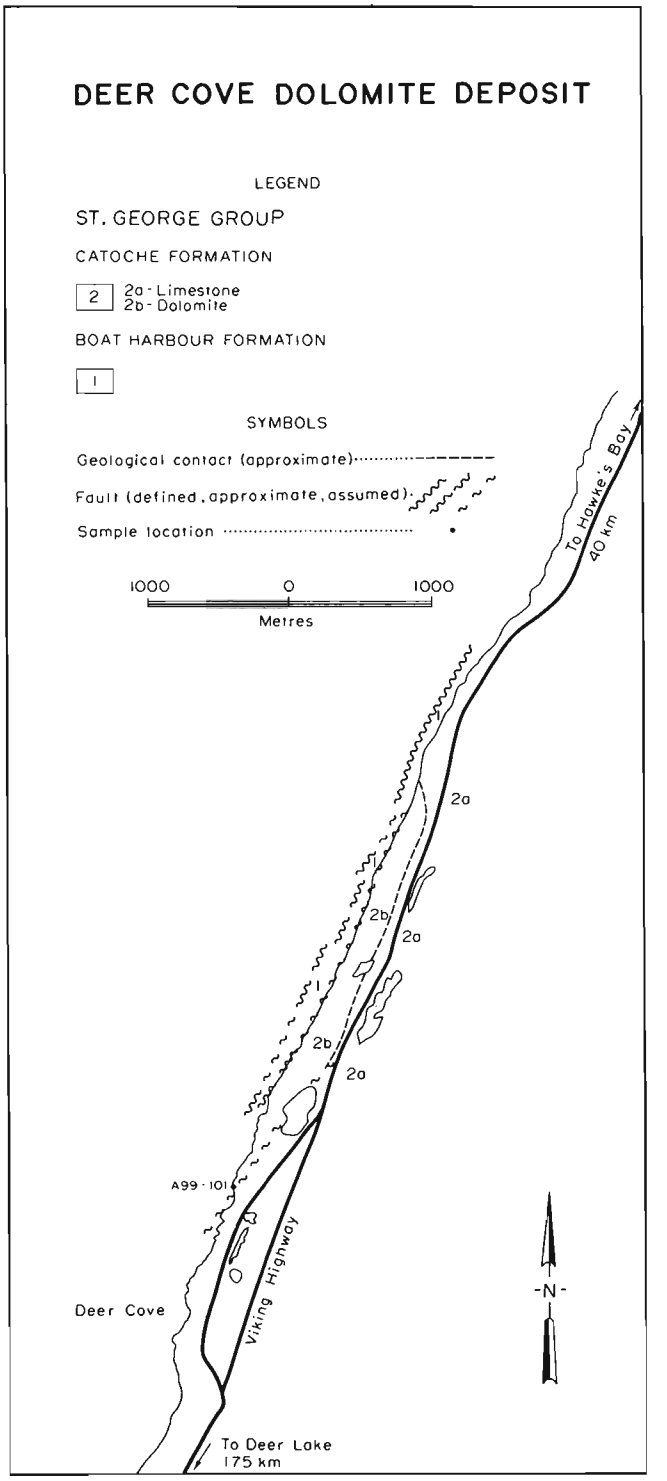

Figure 4. *Deer Cove dolomite deposit (geology after Knight, 1985). Geology seaward of strand line is based on low-tide exposures.*

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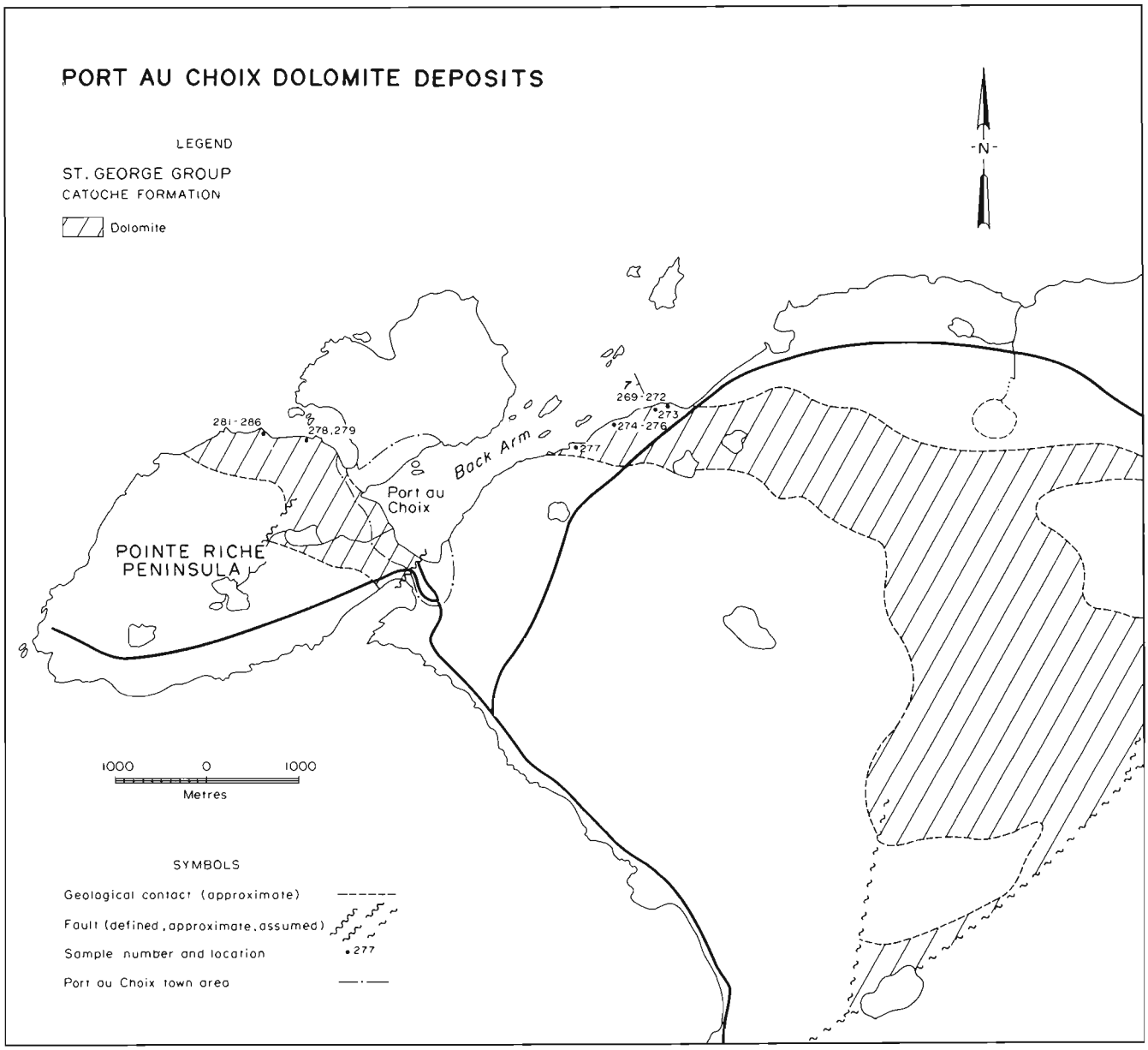

Figure 5. *Port au Choix dolomite deposits (geology after Knight* et al., *1983).*

Back Arm Deposit

This site, on the east side of Back Arm near the town of Port au Choix (Figure 5), consists of a gently (5 to 10°) southwest-dipping, 16-m-thick section of Catoche Formation dolomite. It is buff to medium brown and is variably mottled and vuggy. The dolomite is medium to thick bedded and has a fine- to medium-grained texture. 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. 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 in content, also occurs as 1- to 4-cm diameter nodules that are most abundant in the upper portions of the section. The unit underlies a large area to the east of Back Arm and, although natural quarry faces are not present, it may be possible to develop a quarry site.

Pointe Riche Deposit

The deposit is located on the northern part of the Pointe Riche Peninsula, 30 km northwest of Hawke's Bay (Figure 5). It comprises a 17-m-thick section of dolomite that is lithologically similar to the Back Arm deposit. The deposit comprises a large area and sufficient tonnage should be present for quarrying. However, this deposit lies within the boundaries of the Port au Choix National Historic Park and may not be available for development.

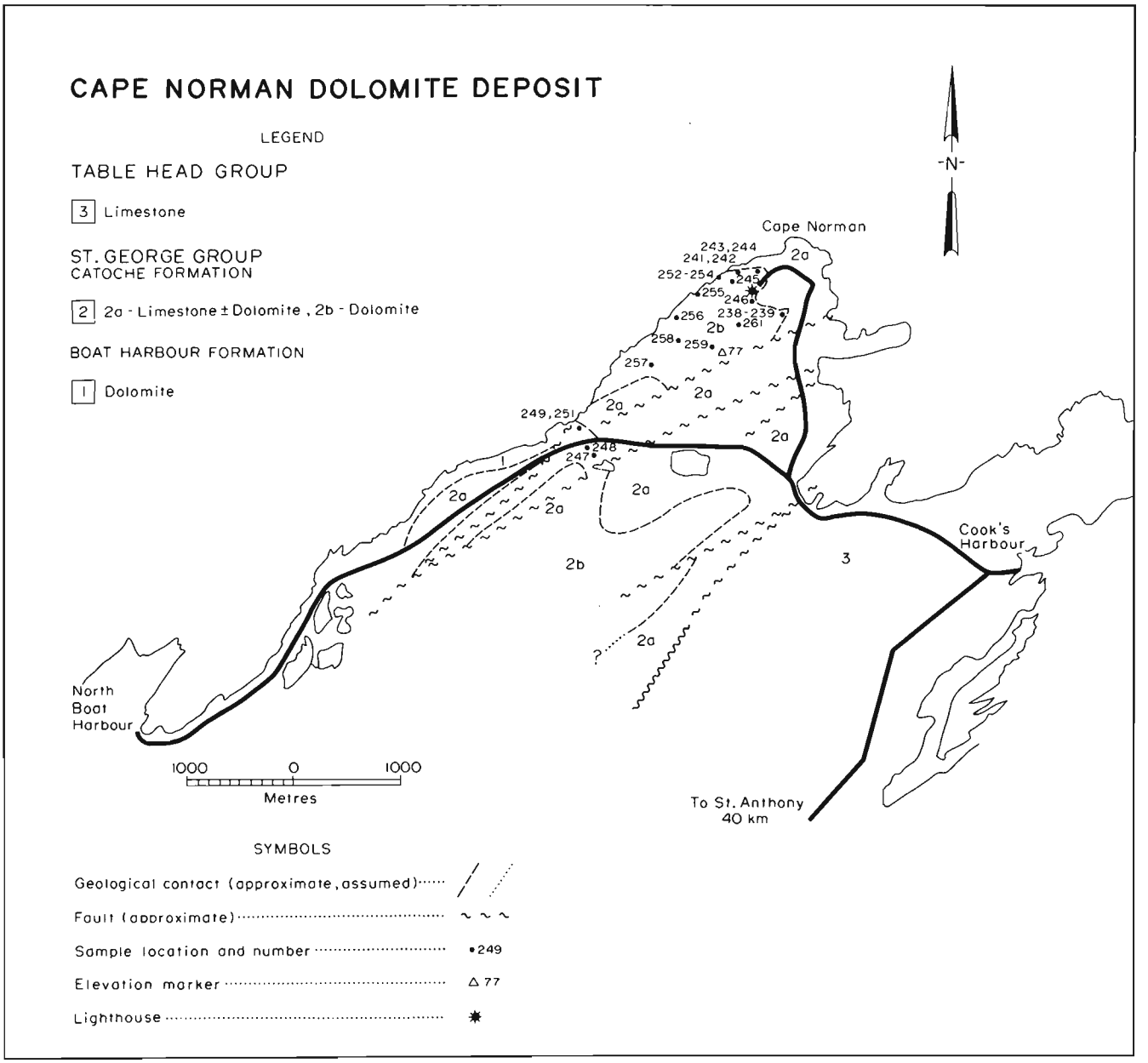

Figure 6. *Cape Norman dolomite deposit (geology after Knight, 1986).*

Seasonal shipping facilities for the Port au Choix deposits are available at Hawke's Bay.

Cape Norman Deposit

The Cape Norman deposit is located on the tip of the Great Northern Peninsula and occurs in the Catoche Formation of the St. George Group (Figures 1 and 6). The dolomite is grey, fine grained, massive and very thick bedded. The gently warped unit is approximately 15 m thick, has no overburden (Plate 4) and has a good quarry face on the coast, west of the lighthouse (Plate 5). 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 deposit is conservatively estimated at 35 million tonnes of good grade metallurgical dolomite. No shipping facilities exist in the immediate area of Cape Norman. However, at Cooks Harbour, 5 km to the southeast, there is potential for port development.

Other Areas Sampled on the Great Northern Peninsula

Sampling was conducted on the Catoche and Watt's Bight formations of the St. George Group, and 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. These areas are shown in Figure 7.

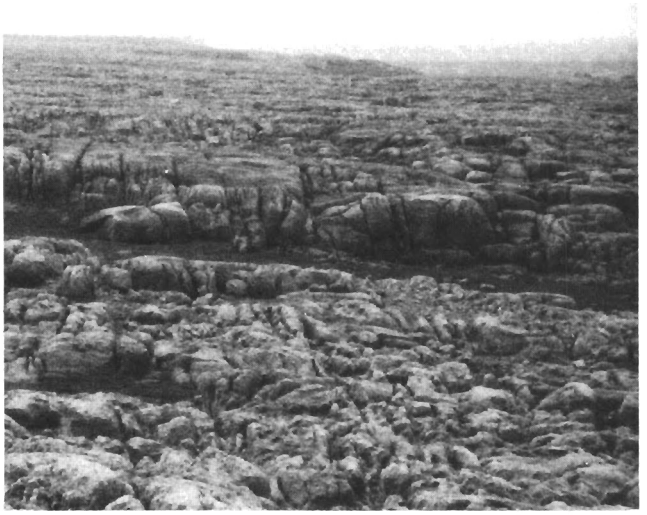

Plate 4. *Barren, massive dolomite of the Catoche Formation at Cape Norman; maximum relief on this barren plain about 1.5 m.*

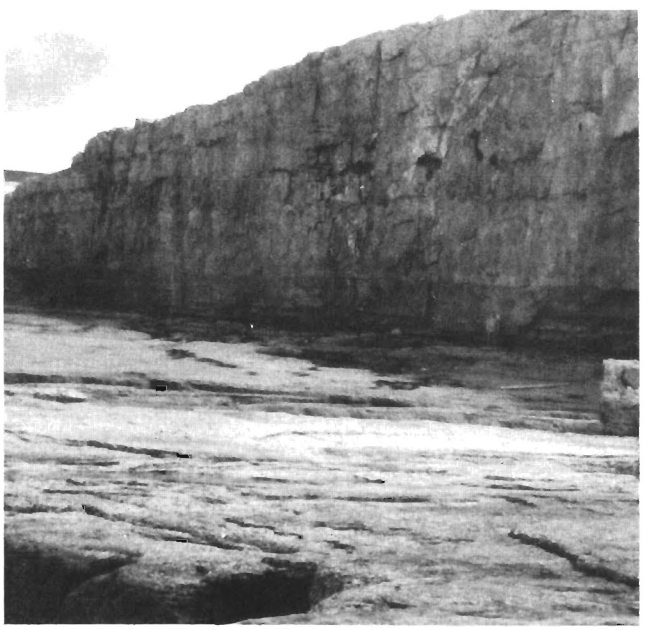

Plate 5. *Cliffs of Catoche Formation, about 20 m high, at Cape Norman.*

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

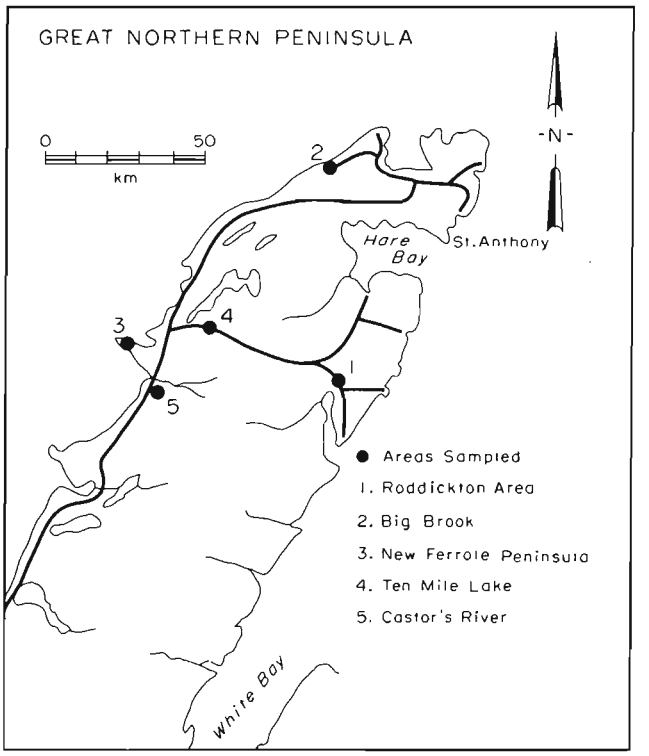

Figure 7. *Location of other dolomite prospects investigated in 1987.*

Sampling in the Roddickton area included the Watt's Bight Formation, which in this area is a grey, fine grained, medium- to thick-bedded, massive dolomite. 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 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 dolomite. 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.

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 dolomite. Vugs are partly or completely filled with white or creamy dolomite crystals and locally the vugs are connected by 1-mm white dolomite veinlets producing pseudobrecccia

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 road cut and abandoned quarry near Ten Mile Lake, sampling was conducted on a 10-m-thick section of grey, fine grained massive dolomite 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 dolomite 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 dolomite set in a coarse grained creamy dolomite. Chert comprises approximately 25 percent of the beds. Disseminated pyrite is present in the dolomite and along fracture planes.

SUMMARY

Detailed geological mapping and sampling were conducted on various deposits of dolomite on the west coast and Great Northern Peninsula of Newfoundland. The objective was to identify deposits of metallurgical grade, located on tidewater, and suitable for quarrying. Five areas of good potential were outlined, most of which occur within the Lower Ordovician St. George Group. These areas are: 1) the Port au Port Peninsula; 2) Goose Arm; 3) Deer Cove; 4) Port au Choix and 5) Cape Norman.

The Pine Tree unit between Piccadilly and Lower Cove on the Port au Port Peninsula offers sufficent tonnage, good grade, good quarry face and proximity to tidewater.

In the Goose Arm area, large tonnages are present at tidewater in five separate deposits. Relief is excellent in all deposits, but in some, the large amount of silica in the form of quartz veins may be detrimental to development. A sixth deposit occurs 5 km inland along a woods road and has good relief and tonnage but possibly high silica.

The Deer Cove deposit is poorly located on a straight unsheltered section of coastline. The nearest good harbour is 40 km to the north at Hawkes Bay. Also, the deposit has a flat topography and is thus not a good site for quarrying.

At Port au Choix, two deposits with similar features occur. They both underlie areas large enough to provide sufficient quantities of good-grade dolomite. Relief is low but the rock may be quarryable. Shipping facilities are available at Hawkes Bay, 30 km to the south. One deposit lies within the Port au Choix National Historic Park and thus may be unavailable for development. The Cape Norman deposit has good tonnage, good grades and a quarry face on the western shore. The ore would have to be trucked, or shipping facilities developed. Ice would be a problem to shipping in the area for much of the year.

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

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REFERENCES

Besaw, D.M.
1974: Limestone-dolomite evaluation. Newfoundland Department of Mines and Energy, Mineral Development Division. Unpublished report, 21 pages.

Chow, N. and James, N.P.
1987: Cambrian Grand Cycles: a northern Appalachian perspective. Geological Society of America Bulletin, Volume 98, pages 418-429.

DeGrace, J.R.
1974: Limestone resources of Newfoundland and Labrador. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 74-2, 117 pages.

Fong, C.C.K.
1968: Preliminary report on dolomite exploration, western Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division. Unpublished report, 7 pages.

Haywick, D.W. and James, N.P.
1984: Dolomites and dolomitization of the Lower Ordovician St. George Group of western Newfoundland. In Current Research, Part A, Geological Survey of Canada, Paper 84-1A, 6 pages.

Knight, I.
1977: The Cambrian-Ordovician platformal rocks of the Northern Peninsula. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-1, pages 27-34.

1985: Geology map of Bellburns (12I/5,6), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 85-63.

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1986: Geology map of Raleigh (2M/12), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 86-26.

1987: Geology of the Roddickton (12I/16) map area. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, pages 343-357.

Knight, I. and Boyce, D.
1984: Geological mapping of the Port Saunders (12I/11), St. John Island (12I/14) and parts of the Torrent River (12I/10) and Bellburns (12I/6) map sheets, northwestern Newfoundland. In Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 84-1, pages 114-123.

Knight, I. and James, N.P.
1987: The stratigraphy of the Lower Ordovician St. George Group, western Newfoundland: the interaction between eustacy and tectonics. Canadian Journal of Earth Sciences, Volume 24, pages 1927-1951.

Knight, I., Boyce, W.D. and Austin, K.
1983: Geology map of Port Saunders (12I/11), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 83-111.

Lilly, H.D.
1963: Geology of the Hughes Brook–Goose Arm area, west Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, 122 pages.