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INDUSTRIAL POTENTIAL OF THE CONEY ARM LIMESTONE DEPOSIT, WESTERN WHITE BAY, NEWFOUNDLAND

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ABSTRACT

The Coney Arm limestone deposit is located on tidewater at Great Coney Arm in southwest White Bay, Newfoundland. It is part of the Eocambrian to Cambrian Coney Arm Group of clastic-carbonate rock that unconformably overlies the Long Range Complex. 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 flue gas desulphurization systems. Highway construction related to the nearby Cat Arm hydroelectric project has greatly improved access to the deposit. This paper reviews chemical and physical data on the deposit and discusses its commercial potential in light of the region's improved access and infrastructure.

INTRODUCTION

Current industrial enterprises in Newfoundland based on carbonate rocks as raw material include the Portland cement plant at Corner Brook (North Star Cement Limited), the aggregate quarry at Lower Cove on the Port au Port Peninsula (Newfoundland Resources and Mining Company Limited), and a small agricultural limestone operation at Cormack (Havelock Lime). Other deposits are presently the subject of ongoing assessment and marketing studies for dimension stone and industrial filler. Although long recognized as a significant deposit, combining high purity with substantial tonnage, the limestone at Coney Arm has attracted little attention from industry. Vast improvements in regional infrastructure and access, mainly because of the Cat Arm hydroelectric project, suggest that this may be an appropriate time to re-examine attention on the economic potential of the Coney Arm deposit. The purpose of this paper is to discuss the industrial potential of the Coney Arm limestone in the light of these developments.

GEOLOGICAL SETTING

The Coney Arm limestone deposit is part of the Eocambrian to Cambrian Coney Arm Group, an autochthonous belt of clastic-carbonate rocks that unconformably overlies the eastern side of the Long Range Grenville inlier. The group, which consists of basal conglomerate, quartzite and sandstone overlain by phyllite, dolomite and limestone, has been correlated with similar platformal clastic and carbonate rocks that outcrop along the west coast of Newfoundland (Smyth and Schillereff, 1981, 1982; Lock, 1969). The western shore of Coney Arm in White Bay consists almost entirely of recrystallized limestone and dolomite. The limestone deposit discussed in this report comprises a ridge that extends for more than a kilometre southward along the shore from Aspey Cove to the bottom of Coney Arm (Figures 1 and 2).

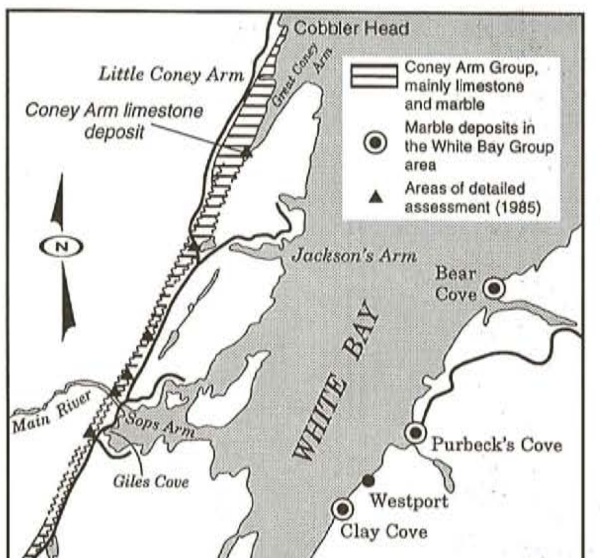

Figure 1. *Location of the Coney Arm limestone deposit showing the nearest access roads and communities.*

LOCATION AND ACCESS

The nearest settlement is Jacksons Arm, a small logging community 7 km south of the deposit. The Cat Arm access road, which intersects Route 420 near Jacksons Arm, passes within 1.5 km of the deposit. Both Jacksons Arm and Sops Arm (a farther 10 km to the south) are connected to the

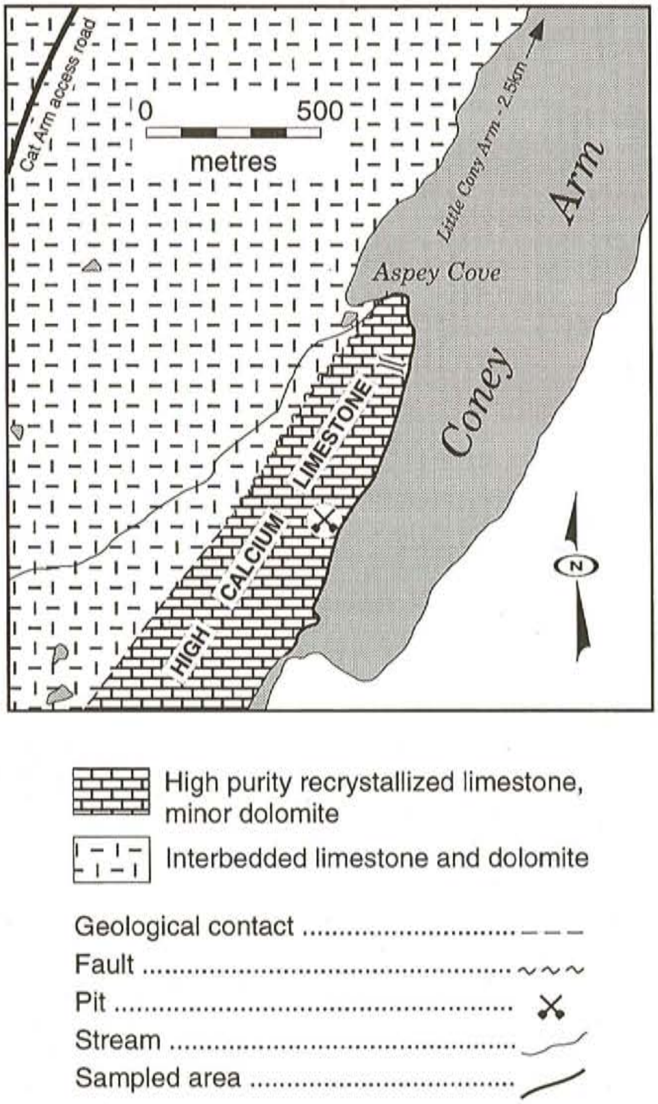

Figure 2. *Geological sketch map of the Coney Arm limestone deposit.*

province's highway system by Route 420. The abandoned village of Little Coney Arm, 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 harbours and bays and heavy drift ice although it can be aided and prolonged by ice-breakers.

ASSESSMENT OF INDUSTRIAL CARBONATE ROCKS IN THE CONEY ARM GROUP

Carbonate rocks of the Coney Arm Group first attracted commercial attention for their building- and decorative-stone potential. Bain (1937) examined marble deposits near Sops Arm as possible sources of ornamental building stone. These consist of multi-coloured and veined marbles that discontinuously parallel the Doucers Fault (Figure 1). Bain (*op. cit.*) concluded that the stone was generally too fractured and dark coloured to be of commercial interest.

Plate 1. *View of Aspey Cove which marks the northern limit of the high calcium limestone zone.*

In the mid 1960s, British Newfoundland Exploration Limited examined marble showings near Sops Arm to evaluate their suitability as sources of terrazzo chips for use in floor tiles (Goudge, 1965); also investigated during the same survey were black and white marbles of the Table Head and St. George groups respectively, near Corner Brook. The study concluded that the Sops Arm marble had the most potential, and specifically mentioned the deposit of orange marble on the north bank of Main Brook as warranting further assessment.

Limestone exposed along the west shore of Coney Arm first began to attract attention for its industrial potential in the 1950s. These rocks consist of dark-grey recrystallized limestone, dolostone and marble (Plate 1). After a brief reconnaissance survey, Lee (1956) estimated a reserve of about 187 million tonnes of limestone in the area. Bedford (1957) did a more detailed and selective study, which included some cross-sectional channel sampling. He concluded that the ridge along the coast between Aspy Cove and the head of Coney Arm contained approximately 30 million tonnes of stone, grading over 96 percent calcium carbonate and 1.20 percent magnesium carbonate. The estimate was based on a 1200-m-strike length and a minimum quarryable distance inland of 150 m. This number 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 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 deposits. The main objective was to determine its suitability for filler applications with emphasis placed on stone with high purity and high brightness. Extensive sampling for physical and chemical analyses was carried out along the west coast of Coney Arm and along the Cat Arm access road near Jacksons Arm Pond. Results showed the 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.

In 1991, limestone samples from the Coney Arm deposit, along with samples from other Newfoundland deposits, 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 McDonnell, 1991).

DESCRIPTION OF THE CONEY ARM LIMESTONE

The limestone beds are exposed almost continuously along the Coney Arm shoreline, striking N35°E and dipping 75 to 80°SE. On the weathered surface, the limestone is medium dark-grey and has a fairly massive appearance except on the shoreline where the rock is extensively fractured and deformed (Plates 2 and 3). Narrow veins and stringers of white calcite are common throughout the rock, imparting a brecciated look in some of the more strongly veined exposures. The fresh surface reveals a medium-dark to light-grey recrystallized limestone with white carbonate stringers. In the vicinity of the old pit midway between Aspey Cove and the mouth of Coney Arm Brook, the limestone has a slightly lighter colour and appears to be purer.. In thin section, 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 occur in dendritic patterns throughout the sample. Porosity of the stone was estimated to be low (Burns and McDonnell, 1991).

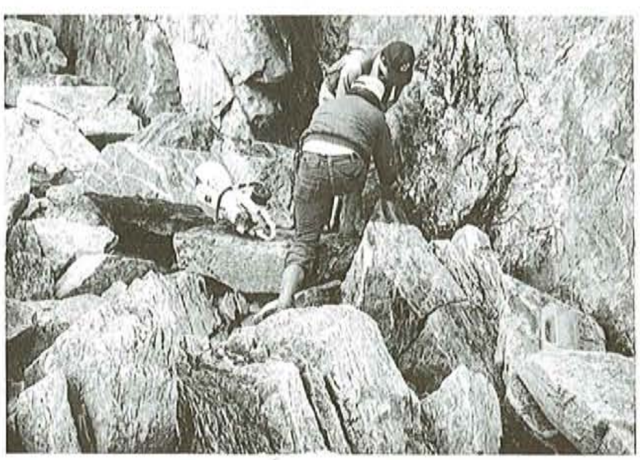

Plate 2. *Sampling the Coney Arm limestone deposit. Note the highly fractured and blocky coastal outcrops.*

Although not delineated beyond Coney Arm, the limestone deposit extends southward beyond the present assessment limits. The limestone cliffs on the west side of Jacksons Arm Pond (DeGrace, 1974) and intersected by the

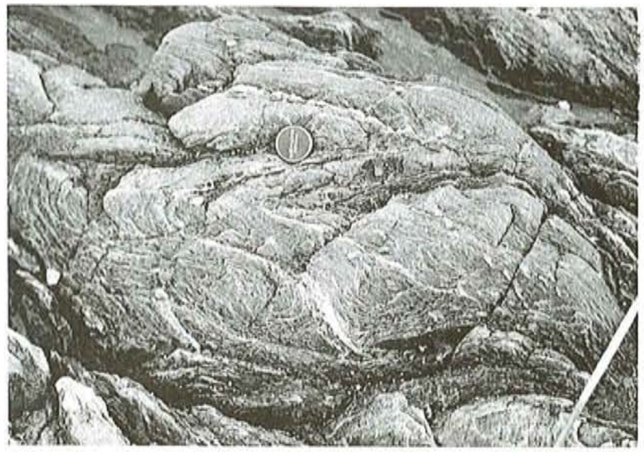

Plate 3. *Folded and deformed limestone of the Coney Arm Group.*

Cat Arm access road (Howse, 1986) may prove to be extensions of this limestone unit.

From Aspey Cove to the northeast point of Little Coney Arm Harbour, the rocks consist of recrystallized, dark grey, interbedded dolomite and limestone and their marble equivalents (Plate 4). Extensive sampling of the formations showed significantly lower calcium carbonate content and a marked increase in impurities, particularly silica. Narrow, east–west-trending diabase dykes cut the formations at several locations along the coast north of Aspey Cove.

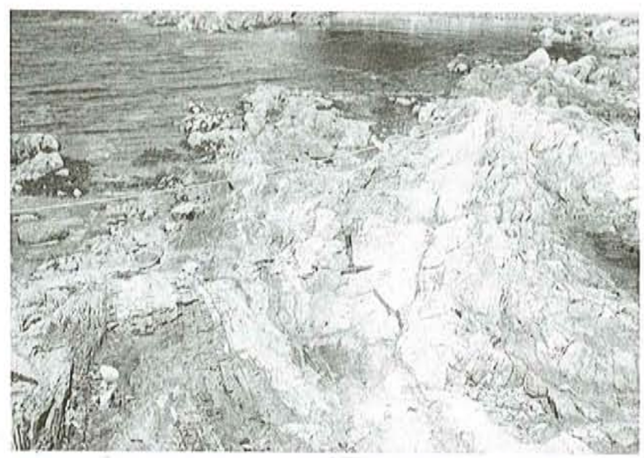

Plate 4. *Interbanded limestone, dolostone, and marble on the coast of Coney Arm, north of Aspey Cove.*

CHEMISTRY

Table 1 shows the chemical analyses of chip samples from the Coney Arm limestone deposit. These results show the limestone grades well over 96 percent calcium carbonate. Silica content is low at just 0.78 percent, and iron and aluminum combined are 0.30 percent. Magnesium oxide content is 0.65 percent, and sodium oxide and potassium oxide 1 and 2 ppm, respectively.

Table 1. Chemical analyses 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	Mn	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

Chemical analyses by Newfoundland Department of Mines and Energy, Geochemical Laboratory.

The results identified several zones having elevated magnesium oxide values and correspondingly higher than average silica content. In these more dolomitic areas, the calcium carbonate content is as much as 3 percent lower than the overall average for the deposit. Thus, selective quarrying, with reduced production from these zones, could greatly improve the overall quality of limestone.

These grades compare closely to the revised figures of Brinex Limited as shown in Table 2.

POTENTIAL INDUSTRIAL APPLICATIONS

Potential uses for Coney Arm limestone include applications in the metallurgical, chemical, and agricultural industries as well as cement manufacturing. Its suitability for additional uses should also be considered because of growing demand for limestone in environmental protection and cleanup. The location of the deposit on deep water and close to major trade routes is a major asset. The following are potential end uses for the Coney Arm limestone.

Table 2. Chemical analyses 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

METALLURGICAL–CHEMICAL

Dead burnt limestone (lime) is used in steel manufacture as a flux, which reacts with and separates chemical impurities (slag) from the steel. The primary component of limestone that determines whether or not it is metallurgical grade is its silica content, which must be less than 2.5 percent. Magnesium oxide content is not critical if it is predictable, but the Al_2O_3 content should not exceed one percent. Using these parameters, the Coney Arm limestone falls well within metallurgical specifications.

CEMENT MAKING

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_2) can be very deleterious if it exceeds half percent. Using these criteria, the limestone at Coney Arm would require the addition of aluminum and silica, as in other plants operating with high calcium limestone.

POLLUTION CONTROL–FLUE GAS DESULPHURIZATION

Public pressure and resulting government legislation concerning the control of air pollution have hastened the development of scrubbing devices to reduce sulphur emissions from flue gases at coal-fired electrical plants. Limestone, because of its relative low cost and availability, has become the dominant scrubbing agent. The scrubbers commonly exist in two forms, wet and dry injection systems. Limestone and lime can be used in the wet system but only lime is suitable for dry scrubbers. The electrical industry predicts that wet scrubbers will be the dominant system used for medium to high sulphur coal, for the predictable future (Atlantic Consulting Economists Limited, 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 behaviour. A high-purity stone is desirable because calcium carbonate is the active reagent in removing sulphur from the flue gases. Acid insolubles should not exceed 5 percent. Iron content could be beneficial 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.

In 1991, a representative sample of the Coney Arm limestone along with samples from three other Newfoundland deposits were tested to determine suitability in FGD systems (Howse, 1991). 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 submitted (Tables 3 and 4). The report recommended that should an FGD vendor and process be selected, additional testing be performed to address any process specific requirements that may exist (Burns and McDonnell, 1991).

Table 3. Results of the Sulphuric Acid Reactivity Test. Sample AH-90-1 was collected from the Coney Arm limestone deposit approximately midway between Aspey cove and the bottom of the arm. Samples AH-90-2 to AH-90-4 came from Raleigh, Cooks Harbour and White Hills (Port au Port Peninsula) respectively

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

Source: Burns and McDonnell Engineering Company Ltd. (1991)

Table 4. Results of the Sulphurous Reactivity Test. Locatons of samples as in Table 3

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

Source: Burns and McDonnell Engineering Company Ltd. (1991)

AGGREGATE

With regard to aggregate use for the Coney Arm limestone, data is lacking on such physical characteristics as crushing strength, abrasion resistance and hardness. However, by comparing descriptions of other Newfoundland deposits of similar purity on the Port au Port Peninsula (D. Bragg, personal communication, 1995), it would appear the Coney Arm limestone has excellent potential for aggregate use. The low level of silica and alkalies suggests that alkaline reactivity, the deleterious reaction of some limestone with cement, should not be a concern for potential developers.

OTHER USES

Coastal exposures of the Coney Arm limestone are too fractured to be considered a possible source of dimension stone, and 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 to neutralize excess soil acidity. A useful figure used in the industry to compare the theoretical acid-neutralizing capacities of various limestone and dolomite products is their calcium carbonate equivalent or CCE (Goodwin, 1979). 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. Using the formula CCE = (1.785 x wt. percent CaO + 2.483 wt. percent MgO) and the average grades 54.17 and 0.65 for CaO and MgO respectively, for the Coney Arm limestone, its CCE is calculated to be 98.30 percent. 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.

RESERVE POTENTIAL AND FUTURE WORK

Estimates vary on the amount of quarryable limestone present 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 Aspey Cove to 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 chip 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 33 million tonnes could be recovered from the limestone ridge between Aspey Cove and Coney Arm bottom. This is estimated on a strike length of 1200 m, a width of 200 m and depth of 50 m (assuming a limestone density of 2.75 tonnes per cubic metre).

Information resulting from geological mapping and limestone exposed by construction of the Cat Arm access road have provided evidence that the unit of high-purity limestone continues southward from Coney Arm for a considerable distance. The same crystalline limestone is present in a N30°E trending cliff along the western shore of Jacksons Arm Pond and is also exposed in road-cuts 500 m along strike from the cliffs. Three representative samples of limestone from the road-cut averaged close to 97 percent calcium carbonate.

In order to get more precise figures on reserves and grade, a program of core drilling would have to be carried out along the ridge between Aspey Cove and the bottom of Coney Arm. There is an excellent possibility of greatly increasing the tonnage through a more precise definition of the southern extent of the deposit.

With regard to potential use as aggregate, information is lacking on such features as crushing strength, abrasion resistance and alkalic reactivity. Also, only very preliminary testing of suitability for use in flue gas scrubbing systems has been done and more work is warranted.

SUMMARY

The Coney Arm limestone deposit combines high purity with substantial 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 those related to environmental cleanup and pollution control. Major improvements in roads and infrastructure and its location on deep water in a sheltered inlet, should make this deposit attractive to potential developers.

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Note: Geological Survey file numbers are included in square brackets.