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SILICA-RICH SANDS, WESTERN NEWFOUNDLAND

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ABSTRACT

A project was conducted in 1986 to locate a sand deposit having a high-silica content and low percentages of alumina, magnesium and alkalies. This type of deposit is being used by North Star Cement Company to replace a portion of shale presently being used in the production of cement. The shale has a variable geochemistry, which is being stabilized by the silica-rich sand in their cement product. Efforts to locate another high-quality shale deposit have been unsuccessful. A number of potential silica-rich sand deposits have been located in the Corner Brook and Deer Lake areas. Those showing the most potential are situated near Dancing Point, Hughes Brook and Junction Brook, and should supply adequate reserves to meet the long-term requirement of North Star Cement.

INTRODUCTION

Part of the 1986 field season involved a silica-sand-sampling program in western Newfoundland. The project was carried out in conjunction with the North Star Cement Company of Corner Brook. The aim was to locate a deposit of silica-rich sand having geochemical characteristics compatible for use with shale and limestone in the production of cement. This work was concentrated in areas between Flat Bay and Deer Lake (Figure 1), as more distant sources would incur prohibitive transportation costs.

Increased interest in the cement industry results from the potential high demand for cement in the development of the offshore oil industry. Silica-rich, low-alumina sand can be used as raw material, ensuring a quality product for specialized requirements, including those for concrete in offshore oil-production platforms. Each gravity-based platform will require up to 160,000 m³ of concrete, depending upon platform design (Steer, 1986).

The associated impacts of offshore development upon infrastructure, and the industrial, commercial and residential needs of the province may be expected to dramatically increase the need for portland cement.

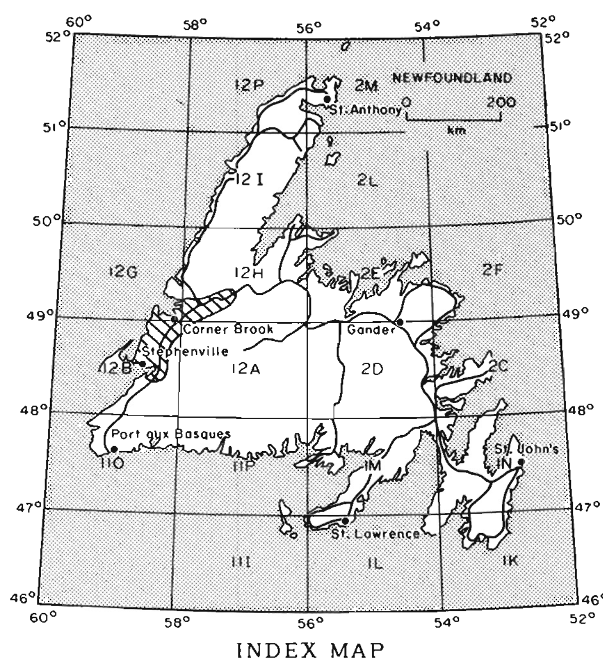

Figure 1: *Location of study area.*

Background

Raw materials used in the production of cement by the North Star Cement Company include limestone, gypsum and shale. Shale constitutes 20 percent of the raw mix used by the company (Dean and Meyer, 1985). The existing shale quarry located next to the plant has variable geochemical characteristics. The boundaries of the shale quarry are vague and locally the alumina content exceeds operating limits. To counter this variability, North Star Cement uses a preblended stockpile of shale and silica-rich sand to attain the desired high-silica content. A supply of sand from the present quarry located near Matthews Brook has a 3- to 5-year life expectancy at present operation capacity. A need for another source of silica is therefore necessary to meet long-term demands of cement production.

Efforts to locate other suitable shale deposits have not been successful. High-silica 'fines' discarded at ERCO's Long Harbour plant and high-silica quartzite in the Corner Brook area are available and chemically suitable. However, high transportation costs in the case of the former, and high quarrying and crushing costs for the latter, make them far from ideal.

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

Table 1. Geochemical constraints for sand used in production of cement

Approaches	Percent sand of total mix	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alkalies	SO_3
Total replacement for shale	20	60-80	9-13	0-8	0-10	2	3	1
Fourth component in cement mix	10	70-95	5-10	0-4	0-4	2	2	0.25

Two approaches were discussed with the North Star Cement Company in an attempt to locate suitable silica-rich sands. The first approach was to find a deposit that could serve as a total replacement for shale. The second approach was to locate a suitable deposit that could be used as a fourth component in the cement mix to maintain chemical consistency of the cement, and possibly to help produce different types of cement. The geochemical restraints for these two approaches are listed in Table 1. Sand used as a total replacement for shale would provide 20 percent of the total mix, whereas sand used as a fourth component in the cement would only consitiute 10 percent of the total mix.

Generally, the higher the silica content in these deposits the better, but it should not be greater than 80 percent if used as a total replacement for shale. Sand containing up to 95 percent silica is acceptable if mixed with shale because the shale reduces the effect of the high-silica content. Low levels of other components will ensure long-term strength and stability of the concrete products in which the cement is used.

Other desired qualities would be 1) easy access, 2) uniform grain size and ease of screening (if needed at all), 3) uniform geochemical characteristics, and 4) a deposit that could provide up to 15,000 tonnes a year for ten or more years.

Previous Work

Geochemical analyses were compiled on selected sand samples collected under the Inventory of Aggregate Resource Program (Kirby *et al.*, 1983). Results from these samples provided preliminary data to help determine potential deposits of silica-rich sand in the study area.

Bob Collins of North Star Cement and Doug Vanderveer of the Newfoundland Department of Mines and Energy conducted previous sampling and geochemical analyses on a number of sand quarries in the vicinity of the North Star Cement plant. These deposits were generally unfavorable because of unsuitable geochemical characteristics, insufficient quantities, expensive mining costs, and environmental concerns. One suitable deposit was located near Matthews Brook at Little Rapids. However, this silica-rich sand deposit is nearing depletion, and other sources must be located.

A Corner Brook shale survey (Dean and Meyer, 1985) was conducted to locate other deposits of suitable shale.

SILICA-SAND PROJECT

Field Program

The objective of the field program was to locate sand deposits and collect samples for geochemical and grain-size analyses. In additon, ten samples were selected and additional geochemical analyses were conducted by both North Star Cement and the Department of Mines and Energy. These materials will be used as reference samples in future analytical work on silica at the North Star Cement plant.

Study areas were selected from mapped data compiled under the Inventory of Aggregate Resource Program (Kirby *et al.*, 1983). Where possible, samples were taken from natural exposures such as stream cuts, shorelines and road cuts. From these exposures, samples were obtained that were free of plant debris and topsoil. Where natural exposures were not present, samples were taken from hand-dug pits that extended into the C horizon, in order to provide a fresh sample unaffected by weathering. Backhoe test pitting was conducted in selected areas near the end of the field season.

Data Analysis

Samples collected in the early part of the field season were, by prior arrangement, analysed by the North Star Cement Company. In areas that indicated positive geochemical results, extra sampling was undertaken to provide a broader range of analyses. A separate set of analyses (Table 2) were also conducted at the Department of Mines and Energy laboratory to correct analytical variations. Grain-size analyses (Table 3) were conducted on deposits that had staisfactory geochemical results.

Resource Areas

Thirty-seven sand and gravel deposits were sampled between Flat Bay and Deer Lake. The deposits have varying potential for use as a silica sand, based on the geochemical results. Areas that showed a low potential were deleted from further evaluation. Deposits having good or marginal potential are briefly described.

Humber River. The Humber River deposit is a large, predominantly sand deposit located on the west bank of the Humber River opposite the community of Little Rapids (Figure 2). Access is achieved by crossing a narrow one-lane

Table 2. Average analyses of potential silica-rich sand deposits in western Newfoundland

Deposit	NTS	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	SO_2	L.O.I.
West bank of Humber River	12A/13	74.3	11.55	3.55	1.35	1.06	2.66	2.12	0.48	0.16	0.07	0.01	2.67
Matthews Brook	12A/13	78.65	9.54	2.66	0.03	0.99	2.51	1.78	0.47	0.08	0.10	0.04	1.87
Little Rapids	12A/13	76.90	10.48	2.96	1.15	0.83	2.49	2.11	0.44	0.09	0.10	0.03	2.24
North Harbour - Grand Lake	12A/13	74.55	11.31	4.81	1.30	0.80	2.28	1.93	0.68	0.11	0.13	0.03	1.97
Trout Creek	12A/13	79.50	8.61	3.60	1.10	0.53	1.88	1.51	0.54	0.10	0.10	0	2.04
Summerside	12A/13	57.80	7.06	2.97	4.13	11.75	1.33	1.31	0.39	0.08	0.08	0.07	13.22
Dancing Point	12A/13	73.05	10.88	4.21	1.17	2.37	2.36	1.84	0.70	0.10	0.11	0	3.10
St. Teresa	12B/7	66.00	16.70	3.31	1.41	4.49	3.75	1.27	0.49	0.06	0.09	-	2.35
Muddy Hole	12B/7	62.73	18.83	3.79	1.68	4.94	4.28	1.15	0.53	0.06	0.09	-	1.81
Little Barachois	12B/8	57.67	16.89	6.86	3.95	6.60	3.55	1.28	0.92	0.12	0.21	0.05	1.75
Journois Brook	12B/8	65.42	17.29	3.45	1.75	4.46	3.97	1.10	0.39	0.06	0.08	-	1.87
Flat Bay Brook	12B/8	64.78	17.28	4.04	1.79	4.46	3.84	1.19	0.55	0.08	0.09	-	2.22
Southwest Brook	12B/8	60.21	16.24	6.97	3.31	6.62	2.96	1.55	0.75	0.11	0.21	0.04	1.49
Bottom Brook	12B/9	64.55	16.13	5.26	2.38	4.66	3.41	1.68	0.60	0.10	0.11	0.06	1.20
Moose Pond Road - Harrys River	12B/9	61.29	13.94	5.92	3.76	6.43	3.14	1.76	0.74	0.11	0.13	-	4.74
Crescent Pond Road	12B/9	63.0	14.07	6.62	3.58	4.35	3.33	1.74	0.78	0.13	0.12	0.04	2.23
Grand Lake Road	12B/9	61.53	14.13	5.79	3.28	5.10	3.26	1.70	0.80	0.13	0.12	0.04	2.99
Trout Brook (East)	12B/9	73.47	13.80	1.89	0.28	1.15	4.12	4.35	0.27	0.04	0.05	0.04	2.20
Trout Brook (Central)	12B/9	62.10	14.64	7.39	3.51	4.02	3.45	1.56	0.92	0.13	0.14	0.05	2.07
Trout Brook (West)	12B/9	61.45	14.55	7.43	3.75	4.91	3.30	1.58	0.87	0.14	0.13	0.05	2.43
Noels Pond	12B/10	59.82	13.87	6.55	3.49	18.67	3.08	1.80	0.77	0.12	0.12	0.04	4.56
Cold Brook Pond	12B/10	58.98	11.08	4.43	2.86	9.95	2.38	1.91	0.58	0.10	0.09	0.05	8.16
Cooks Cove	12B/16	57.80	7.06	2.97	4.13	11.75	1.33	1.31	0.39	0.08	0.08	0.07	13.22
Blow Me Down Brook	12G/1	47.03	4.39	8.11	26.44	1.81	0.76	0.39	0.22	12.50	0.06	0.04	10.51
Nicholsville	12H/3	65.29	16.45	3.51	1.86	4.15	3.58	1.69	0.46	0.06	0.10	-	2.70
Rocky Brook	12H/3	70.60	10.38	3.53	1.74	3.04	2.11	2.58	0.59	0.08	0.08	-	4.82
Reidville	12H/3	74.00	10.75	2.59	1.78	0.77	2.06	3.23	0.29	0.08	0.08	-	3.46
Junction Brook													
Zone 1	12H/3	78.08	10.33	2.26	0.77	0.81	2.92	2.59	0.25	0.06	0.09	-	1.41
Zone 2	12H/3	79.45	8.93	2.51	1.02	1.03	2.28	2.27	0.36	0.07	0.07	-	2.14
Zone 3	12H/3	81.10	8.49	2.38	0.72	0.76	2.26	2.20	0.37	0.07	0.06	-	1.43
Deer Lake Airport	12H/3	72.60	11.00	3.52	2.01	0.92	1.92	3.13	0.46	0.07	0.09	0.04	3.73
Little Harbour	12H/3	67.85	13.95	6.05	1.63	0.65	2.14	2.58	0.64	0.12	0.16	-	3.18
North side of Deer Lake	12H/4	71.46	10.89	3.51	2.43	1.86	1.81	2.51	0.42	0.08	0.06	0.03	4.76
Trans-Canada Highway	12H/4	75.83	10.00	3.56	2.12	0.74	2.45	1.70	0.41	0.10	0.09	-	2.60
Pasadena	12H/4	80.40	8.77	2.35	0.95	0.41	1.98	1.72	0.38	0.08	0.09	0.03	2.30
Hughes Brook (North)													
Deposit 1	12H/4	74.22	10.22	3.42	1.30	2.10	2.22	1.92	0.64	0.09	0.09	0.08	2.53
Deposit 2	12H/4	72.3	9.67	3.09	0.91	4.32	2.27	1.74	0.53	0.08	0.14	0.03	4.37
Deposit 3	12H/4	78.3	9.9	3.04	0.91	0.69	2.35	1.89	0.55	0.09	0.12	0.03	1.52
Deposit 4	12H/4	61.48	8.36	2.98	2.82	10.28	1.75	1.51	0.38	0.09	0.06	0.03	8.42
Hughes Brook (South)	12H/4	41.35	5.59	2.37	7.58	17.87	1.05	1.22	0.32	0.07	0.06	0.07	22.08

Note: Percentages are based on a compilation of undivided samples from each deposit. In many areas only one sample was collected.

Table 3. Aggregate summary of silica-rich sand deposits in western Newfoundland

Deposit	Cubic metres	Number of samples collected	Percent gravel (+5 mm)	Percent sand (+0.078 mm to -2 mm)	Percent silt–clay (-0.074 mm)
Humber River	3,850,000	4	34.96	63.48	1.36
Matthews Brook	367,500	2	7.15	89.75	3.15
Little Rapids	56,000	2	22.76	76.21	1.03
North Harbour - Grand Lake	6,000	1	49.6	49.5	0.9
Trout Creek	18,900	1	51.6	47.8	0.6
Dancing Point	400,000	2	19.98	76.18	3.84
Reidville	3,920,000	4	12.85	85.30	1.88
Rocky Brook	12,240,000	1	5.10	83.43	11.48
Junction Brook					
Zone 1	3,060,000	7	23.93	75.11	0.97
Zone 2	2,500,000	6	34.30	65.30	0.40
Zone 3	450,000	5	25.3	60.04	8.42
Pasadena	880,000	1	5.65	47.9	0.50
Hughes Brook					
Deposit 1	1,080,000	4	20.53	71.13	8.38
Deposit 2	1,350	1	0	36.7	63.3
Deposit 3	108,000	1	0	80.4	19.6
Deposit 4	175,000	3	22.77	70.47	6.47

Note: Estimated quantities given in table are based on airphoto analysis and field investigation conducted by site observation and backhoe test pitting. Percentages are based on a compilation of individual samples and do not take into account extent and depth of deposits at any one locality.

bridge over the Humber River. The deposit is overlain by farmland, dense tree growth and a residential area. Geochemical analyses of five samples collected in this area indicate this deposit is fairly homogenous and best used as a mixture with shale in cement production. The 34.96 percent gravel content shown in Table 3 is composed predominently of material between 5 mm and 8 mm.

Matthews Brook. The North Star Cement Company presently obtains its silica-rich sand from this locality. It is a small deposit situated on the south side of the Trans-Canada Highway approximately 200 m east of Matthews Brook (Figure 2). The deposit consists of two sand units. The lower unit has the higher silica and lower alumia content, plus a higher concentration of sand-size material (95 percent versus 85 percent), and is more favorable for use in cement production. However, the upper unit can be used for cement production but requires more screening. The North Star Cement Company has conducted extensive geochemical analyses on samples collected in this deposit. However, because of depletion, another source of silica-rich sand is needed.

Little Rapids. This deposit is situated between the railway track and the Trans-Canada Highway in Little Rapids (Figure 2). It is the site of an abandoned quarry, which is partly overgrown by low bushes and trees. Houses are located in the vicinity, and may pose some restriction in excavation of material. One sample was collected from this deposit. It has suitable geochemical characteristics based on analyses of one sample. However, analyses by North Star Cement show an aluminum content of 13.27 percent, exceeding the desired limit. Screening will be required to remove the 22.76 percent gravel material.

North Harbour–Grand Lake. The North Harbour–Grand Lake deposit is situated approximately 13 km south of Pasadena (Figure 2) near the end of a dirt road used for logging operations. Its location, small size and high gravel content greatly reduce its potential for use in cement production.

Trout Creek. The Trout Creek deposit is located 3 km south of Pasadena along a dirt road leading to Grand Lake. The deposit is covered by dense tree growth. A 1-m layer of silty pebble gravel and 0.5 m of iron oxide and topsoil overlie the sand–gravel layer. One sample collected from this area has an excellent geochemical composition for use in cement production. However, analyses by North Star Cement indicate

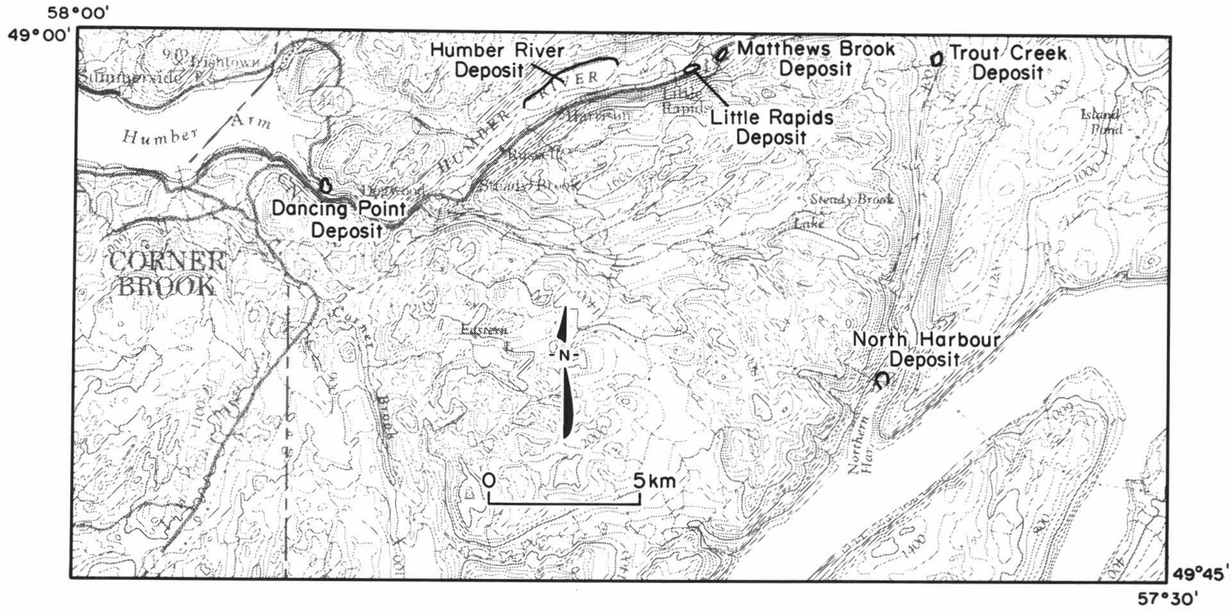

Figure 2: *A portion of NTS area 12A showing silica-rich sand deposits.*

a silica content of 88.2 percent. This may be too high if this material is to replace the shale component in cement production. Further sampling by backhoe test pitting and analyses of samples are required in this area to determine the extent of the deposit and geochemical variations.

Dancing Point. The deposit is situated on the north side of the Humber River near its exit into Humber Arm (Figure 2), and is the nearest to the North Star Cement plant of any deposit located to date. The site consists of an abandoned quarry showing evidence of small-scale recent removal. A few houses are located near the eastern end of the deposit. Geochemical analyses of two samples indicate material from this deposit to be adequate for use in cement production. Screening will be required to remove the 19.98 percent gravel content. Geochemical analyses of two units of material from this deposit are quite similar; however, particle-size analyses show a much wider variation. The upper unit is coarser, containing 29.3 percent gravel and 70.2 percent sand, whereas the lower unit contains only 4.8 percent gravel and 87.7 percent sand.

Reidville. The Reidville deposit is located approximately 2 km northeast of Reidville along the north side of the Upper Humber River (Figure 3). This is an extensive deposit overlain by dense tree growth and abandoned farmland. Geochemical analyses are available for two samples from this deposit. The amount of K_2O may be unacceptably high in this deposit. However, analyses by North Star Cement show an acceptable level of K_2O (2.5 percent), but their analyses also show a slightly higher than desired amount of MgO (2.1 percent). Particle-size analyses of samples taken from a 3.2-m road exposure indicate sand-size material dominates. However, two backhoe pits located approximately 400 m northwest of the Humber River revealed only 0.9 m and 0.4 m of sand over an undetermined thickness of clay.

Rocky Brook. The Rocky Brook deposit is situated near the intersection of the Reidville highway and Rocky Brook (Figure 3). The geochemistry of this deposit is similar to that of the Reidville deposit although it contains less K_2O, making it a more favourable deposit. Analyses by North Star Cement show a higher MgO content, at 2.56 percent, which is 0.56 percent higher than the desired level. The deposit consists predominently of sand and minor coarser material in the 17-m-high exposure along the stream. Four samples gave an average content of 83.43 percent sand, and a silt–clay content of 1 to 23.9 percent.

Junction Brook. Junction Brook intersects the Trans-Canada Highway approximately 10 km northeast of Deer Lake (Figure 3). This is an extensive deposit composed of variable particle-size ranges and variable geochemistry. This deposit is divided into three zones based on grain-size distribution and chemistry.

Zone 1 constitutes the eastern section of the deposit between Junction Brook and the Trans-Canada Highway. An asphalt plant and a Newfoundland Department of Transportation depot are presently situated within this area. Geochemical analyses by the Newfoundland Department of Mines and Energy show higher than acceptable levels of Na_2O and K_2O. However, analyses provided by North Star Cement show only 1.8 percent K_2O. No results were available for Na_2O from the company. A desired content of less than three percent is preferred for each of these. SiO_2 is much higher (87 percent) in the North Star Cement results, indicating potential problems in crushing this material. It is probably the least important of the three at Junction Brook. Zone 1 has a high gravel content (23.93 percent), requiring added cost for extraction, and loss of material by screening.

Zone 2 is located on the north side of Junction Brook near its confluence with the Upper Humber River. The silica content ranges from 74.35 to 82.90 percent in four samples analyzed. Field sieving was only required on one of eight samples collected, indicating that most material is smaller than the +8-mm fraction. This deposit is substantial, which,

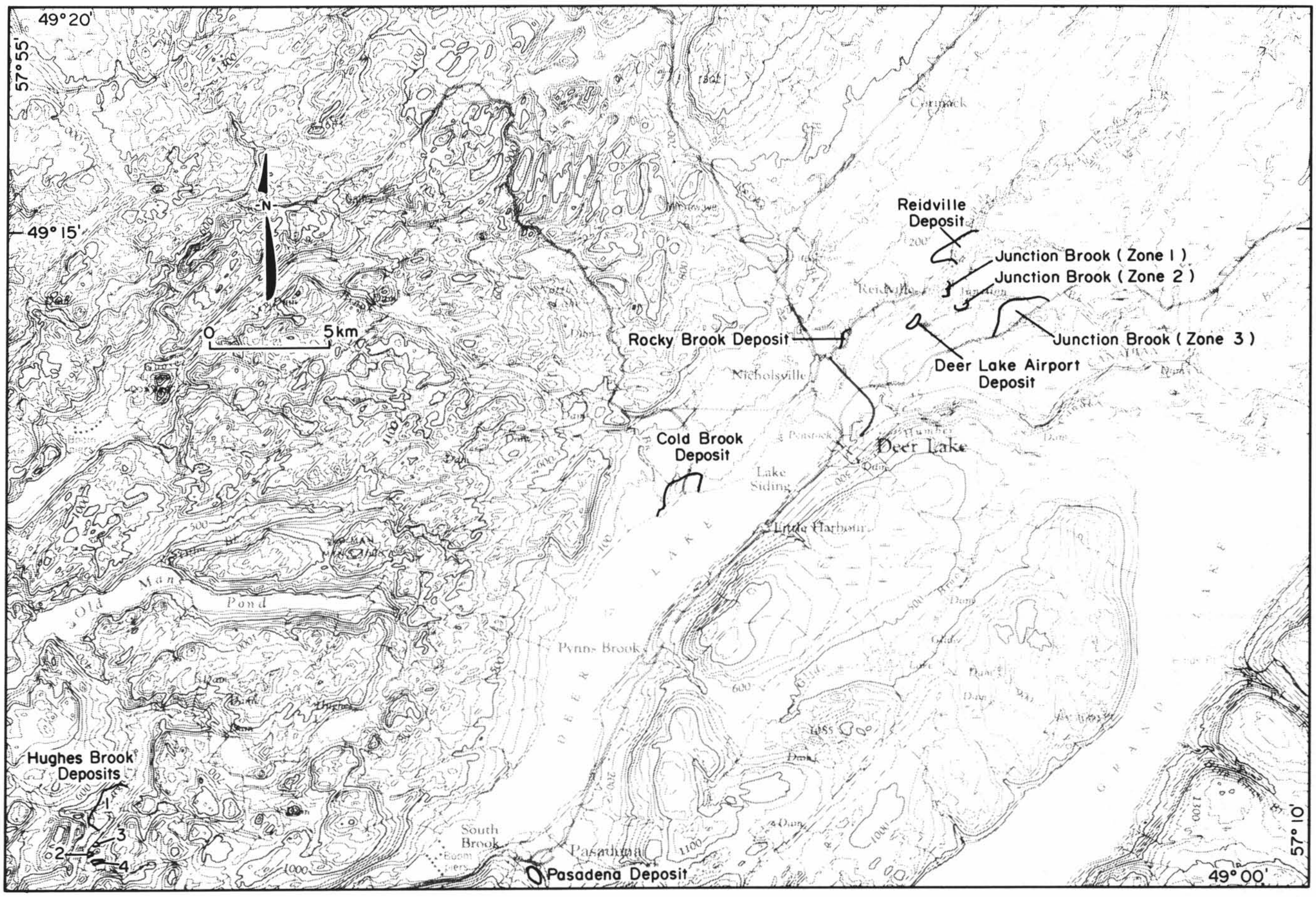

Figure 3: *A portion of NTS area 12H showing silica-rich sand deposits.*

along with its high sand content of 85.7 percent, greatly increases its value for use in cement production, providing the silica content is not too great.

Zone 3 is an area located on the south side of Junction Brook approximately 1 km west of the Deer Lake municipal dump. The geochemistry of samples from this zone is similar to Zone 2. However, analyses of one sample by North Star Cement show 89.12 percent SiO_2. The greatest difference between this deposit and Zones 1 and 2 is the increased gravel content, averaging 25.3 percent.

Pasadena. The Pasadena deposit is located in Pasadena along the southwest bank of Blue Gulch Brook (Figure 3). Only one sample was collected from a small burrow pit showing a maximun exposure of 1 m. Geochemical results indicate this deposit to be of high quality for use in cement production; however, grain-size analyses indicate a high gravel content (51.65 percent). More sampling, backhoe test pitting and analyses will be required to determine the extent and potential of this deposit.

Hughes Brook. Hughes Brook intersects the Northshore highway approximately 7 km north of Corner Brook (Figure 3). There are several sand deposits located along the Hughes Brook valley on the east side of the Northshore highway. These deposits, located along the valley floor and at the base of rock slopes along the valley walls, are overlain by dense tree growth, cut-overs and farmland. The deposits have variable geochemistry and variable textures.

Geochemical analyses of three samples show 74.22 percent silica and 9.36 percent alumina in Deposit 1. Grain-size analyses of two samples taken from a stream exposure (3.5 m by 4 m) show an average sand content of 82.7 percent. The sand layer, visible along stream exposures, is overlain by a pebbly gravel layer ranging in thickness from 0.2 m to 1.3 m. Two backhoe pits (reaching depths of 3.3 m) approximately 150 m west of Hughes Brook show sand exposures (0.6 and 1.9 m thick) overlying an undetermined thickness of silt and fine sand. Grain-size analyses of these silt–sand samples are not complete, but visual observations indicate there may be unacceptably high percentages of silt.

Deposit 2 is a small area that has favorable geochemical characteristics, but it is small and has a high silt–clay content (63.3 percent). It is unlikely this deposit will be used for cement production.

Deposit 3 is a small deposit that is geochemically favorable. However, its small size and high silt–clay content (19.6 percent) reduce its potential.

Deposit 4 is a small deposit, and contains much less silt and clay than deposits 1, 2 and 3. The geochemistry of this zone is less favorable; silica values range from 50.2 to 73.15

percent in four samples collected. Magnesium values are also higher than desired in two of these samples (4.0 and 4.34 percent).

Other deposits showing marginal geochemical potential may have some usefulness if blended with higher quality materials. One of these deposits is located near the Deer Lake airport, and another near North Brook on the north side of Deer Lake (Figure 3). The deposit near Deer Lake airport has a lower K_2O value (1.93 percent) and a higher MgO value (2.07 percent) in North Star Cement analyses. The North Brook deposit also has marginal potential. Some MgO values are higher then the maximum 2 percent recommended, although three of the seven samples tested showed values of less than 2 percent. This is a substantial deposit composed mostly of sand. It is easily accessible by woods roads leading into the area. All six samples collected in this deposit were taken from shoreline exposures. Backhoe test pitting will be needed to determine the extent of this deposit, and to provide samples for further geochemical analysis.

SUMMARY

Thirty-seven sand and gravel deposits were sampled in western Newfoundland to test their potential use in cement production. Only twelve deposits show suitable or marginally acceptable geochemical results. Some of these deposits have a coarse gravel content and thus require screening. Long-distance transportation may also be a negative factor for some of the deposits, especially the North Harbour deposit. Private-land ownership of some of the deposits may result in sterilization of this material, and others may not be utilized because of proximity to houses.

Deposits that show only marginal geochemical suitability, but have few analyses, will need further investigation to determine deposit quality and/or quantity.

Despite the above limitations, there are a number of potential deposits to meet the requirements of the North Star Cement Company. These would include the following:

1) The Dancing Point deposit has suitable geochemical characteristics, but it will require screening to remove the 20 percent gravel content. Its proximity (1.5 km) to the North Star Cement plant will also make this deposit favorable for development.

2) Deposit 1 at Hughes Brook is possibly of high potential. Although all grain-size analyses have not been completed, this deposit has suitable geochemical characteristics, and is within a moderate distance of Corner Brook.

3) The deposit that shows the greatest potential, although located a greater distance from Corner Brook than the Dancing Point and Hughes Brook deposits, is Zone 1 at Junction Brook. It has a high-silica content and Zones 2 and 3 are within the allowable geochemical range. This deposit has considerable quantity and can supply material for many years at maximum production capacity.

In reviewing Tables 2 and 3 it is apparent that the many deposits sampled vary greatly in geochemistry and texture. Some deposits fall within the recommended range for geochemical composition, whereas many fall slightly outside this range and others show no suitability at all. Besides the high-potential deposits noted above, it may also be possible to combine (blend) some of the unfavorable deposits so that negative elements in one may be counter-balanced by the positive attributes of another. Blending of sand deposits will result in extra time and workload, but if access to high-quality deposits is denied, the increased cost of blending may be acceptable.

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