

## GRANULAR-AGGREGATE MAPPING IN SOUTHEAST LABRADOR

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### ABSTRACT

Aggregate mapping in 2004 took place along the southeast part of the Labrador Highway (from the southeast part of NTS map area 13A/14 to the north end of the road at Cartwright). This is the second year of a two-year project to complete aggregate mapping along the recently constructed road. The first phase of mapping in 2003 included the southern part of the road from Red Bay (NTS map area 12P/9) to the northwest end of NTS map area 13A/15, including the branch roads to St. Lewis and Charlottetown.

In 2004, sand and gravel deposits were identified near the north end of NTS map area 13A/14, at several locations along the road in NTS map areas 13H/3, 4, and 5, near the southwest and central part of NTS map area 13H/6, and 11 km south of Cartwright in NTS map area 13H/11. These deposits vary from fine sands and silt to sandy gravel and gravel, and range in quantity from 50 000 m<sup>3</sup> to many millions of cubic metres of aggregate. Most deposits are within 1 km of the road and have potential for use in future road upgrading, for winter ice control, or for local community use.

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### INTRODUCTION

The recently constructed gravel road (the Labrador Highway (LH)), which runs along the southeast coast of Labrador (Figure 1), between Red Bay and Cartwright, covers a distance of 325 km, and includes branch roads to St. Lewis and Charlottetown–Pensons Arm. The objectives of the aggregate-mapping program in this area are to locate, map and sample sand, gravel and till, in support of road upgrading and construction activities in nearby communities, and to reserve deposits for future development. The mapping of aggregate deposits and provision of data on quantity and quality will help road builders, contractors and consultants determine sources and quality of material in a given area, and evaluate the distance required to transport these materials to a specific job site, a factor that can greatly affect construction cost.

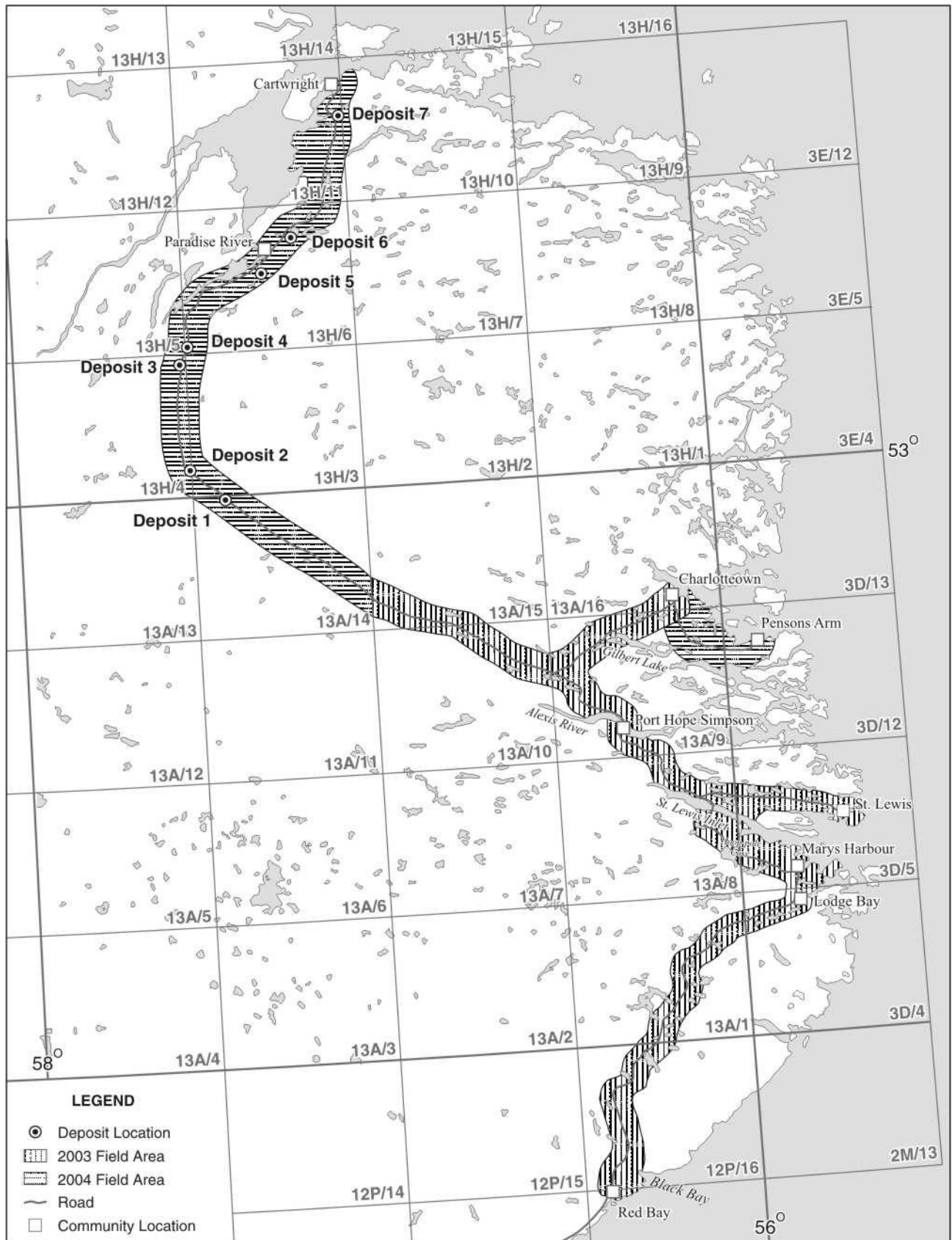
The demand for aggregate is closely associated with construction activity. Road construction and maintenance is by far the most important use of mineral aggregates. Aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market as well as its quality and size (Vanderveer, 1982). Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in areas experiencing rapid development. Such strategies must be based on a sound

knowledge of the total mineral-aggregate resource base at both local and regional levels.

Definition of aggregate depends on the producer, location and use of the material (Smith and Collis, 1993). Aggregate, as used in the context of this report, is defined as any hard, inert material such as gravel, sand, crushed stone or other mineral material that is used in the construction industry (Carter, 1981; Rutka, 1976). Aggregates are used extensively in all types of construction activities, of which road construction is a major consumer. Water and sewer systems, driveways, building foundations, backfill and landscaping all require aggregate.

Aggregate materials can be, i) processed and used as Class A gravel (aggregate having a diameter of less than 19 mm, having a specified proportion of finer grain sizes and 3 to 6 percent silt-clay; Department of Transportation, 1999) or Class B gravel (aggregate having a diameter of less than 102 mm, having a specified proportion of finer grain sizes and 3 to 6 percent silt-clay; (Department of Transportation, 1999), ii) processed to mix with a cementing agent to form concrete, asphalt and mortar or iii) used as unprocessed, out of pit material.

Not all quarry materials are suitable as aggregate. Vanderveer (1983) defined the quality of mineral aggregate by its composition. The silt-clay quantity is important; high



**Figure 1.** Location map of deposits found along the Labrador Highway and examined in this survey.

silt-clay volumes can cause instability, such as flowage; low silt-clay volumes can result in loss of compaction. Too much silt-clay in concrete (> 2 percent) can interfere with the bonding process between the aggregate and the cementing agent. High silt-clay aggregate (greater than 15 percent) can be used for earth-filled dams, fill and subgrade road material. The presence of deleterious substances (such as silt-clay coatings, iron-oxide staining on the surface of the aggregate, or of blade-shaped fragments), can cause bonding problems with the cementing agent, or the breakdown of aggregate with time.

Aggregate resources use in the construction of the LH came primarily from blasted bedrock; normally, blasting increases cost of production. However, in this area large, roadcuts were required through rock ridges to provide suitable driving conditions, and thereby supplying crushed rock at the same time. Aggregate used in road repairs, upgrading or in winter ice control will be more cheaply acquired if known granular deposits are available. Therefore, information gained from aggregate-resource mapping can provide valuable information to future work in the area.

## STUDY AREA

The study area is a 6-km-wide corridor following the LH, along river systems near the highway, and around communities in coastal Labrador. It is located north from the southeast end of NTS area map 13A/14, to Cartwright in NTS map area 13H/11 (Figure 1). The area has moderate to low relief and shows the rounded geomorphology typical of glaciated terrain. Work was done by truck along the LH, by boat to potential deposits near ponds and lakes, and by foot traverse to deposits within the 6-km-wide mapping corridor.

## PREVIOUS WORK

The geographic outline of the region is discussed by Hare (1959), who completed a photo-reconnaissance survey of Labrador-Ungava, primarily to determine vegetation type; drift cover and physiographic type were noted as a secondary objective.

Surficial geological mapping at 1:50 000 scale (Fulton *et al.*, 1975), based largely on aerial photographic interpretation, is completed for the field area. This work was part of a much larger program, covering over 95 000 km<sup>2</sup> of southern and eastern Labrador. Compilation of these maps at 1:250 000 scale (Fulton *et al.*, 1979) and 1:500 000 scale (Fulton, 1986) shows glacial flow features having a dominant southeast to east orientation.

Aggregate-resource reconnaissance mapping (Ricketts, 1987) in parts of coastal Labrador concentrated on aggregate

resources in community areas. This project resulted in the release of 1:50 000-scale landform classification maps and aggregate-resource maps for all coastal communities from Lodge Bay in the south to Nain in the north. McCuaig (2002a, b) conducted a study of the Quaternary geology and the glacial history of the Alexis River area and Blanc-Sablon to Mary's Harbour road corridor. She identified the erosional effects of glaciation, and landform types resulting from glacial, glaciomarine and glaciofluvial deposition.

## MAPPING AND ANALYTICAL METHODS

The assessment of granular aggregates can be complex because of the great variety of materials, and because available information is commonly insufficient to determine quality of material in localized areas for pit and quarry operations. Much interpretation is involved and the degree of error in tonnage estimates can be high. Interpretation of aerial photographs (1:50 000 scale and 1:12 500 scale) is the first stage in locating potential deposits. Air-photo interpretation is used to produce preliminary landform classification maps that show the distribution and nature of the various deposits found within an area. They usually show a variety of tills, and sand and gravel deposits. Till is a sediment deposited by a glacier, commonly containing a wide variety of grain sizes. Sand and gravel is commonly formed by fluvial action, either by glacial meltwater or present-day streams. The landform classification is used to identify potential granular deposits that may be used in the construction industry. Granular aggregate maps are a derivative of landform classification maps supplemented by ground truthing and sampling; they subdivide potential aggregate deposits into high, moderate, or low potential for aggregate production. The size of the deposit can be determined if its areal extent and average thickness are known or can be estimated. Thickness values are approximations, based on the face heights of pits developed in the deposit, in roadside exposures or using features of the general landscape such as the height of ridges and terraces above the surrounding terrain. Individual deposits are then assigned one of four zones on the granular aggregate-resource maps, with Zone 1 being the area of highest potential (Kirby *et al.*, 1983, 1990). Detailed investigation of deposits using ground-penetrating radar (McCuaig and Ricketts, 2004), or backhoe test-pitting, could improve the accuracy of such thickness estimations.

In addition to the data collected from aerial photographs, information on the various sediment types was obtained in the field by examining natural exposures (e.g., such as stream-cuts, shorelines, and gullies) or man-made exposures (e.g., roadcuts, and pit and quarry excavations). Where exposures were not available, samples were collected from 1-m-deep hand-dug pits. In some places, hand-dug pits were not practical due to the presence of boulders or a

thick, cemented B soil-horizon, which made it difficult to see the undisturbed parent material. Lack of exposures in this study area meant that deposit thickness often was difficult to assess. The scarcity of vertical sections, combined with the presence of a concealing surface mat of organic material in many places, made positive interpretation of the nature and extent of the glacial sediments heavily dependent upon evaluation of local geomorphology. Thus, in most instances, geomorphic expression was an important aspect in recognition of the unit mapped. Obvious landform boundaries on air photographs were the basis of many delineations. Other features recorded in the field were sediment thickness, stoniness, presence of compact layers and the presence of vegetation.

Sampling provided material for petrographic and grain-size analyses. Approximately 15 kg of material was collected for sieving at each site. Field sieving and petrographic analysis were performed on samples containing >8mm size material. A split of the sand-silt-clay fraction (<8 mm) was retained for laboratory sieve analysis, which involved drying and splitting the sample to a manageable size (70 to 140 g) and wet and/or dry sieving each sample following the procedures outlined by Ricketts (1987). This data was used to describe deposits based on texture. Cobble and boulder content (aggregate too coarse for sieving) was estimated in the field.

The suitability of aggregate depends on physical properties and the capability of the rock to withstand stresses placed upon it when used as a construction material. The lithology of the pebble fraction (16 to 32 mm) was evaluated to define the petrographic characteristics (Bragg, 1995; Ontario Ministry of Transportation 1994; Canadian Standards Association, 1973). The petrographic number, which can range from 100 to 1000, is derived by taking the sum of the percentage of each rock type present in the pebble fraction (in a sample of approximately 100 pebbles) multiplied by a petrographic factor (based on soundness and durability) assigned to that rock type (Ricketts, 1996). The petrographic factor is determined mostly by rock type and grain size of the rock in a given sample. Weathering, staining and fracturing are also considered. The lower the petrographic number, the better the quality of aggregate material. For example, clean, hard, fresh granite would normally have a petrographic number of 100, whereas friable, soft shale would be 1000. Most deposits contain a combination of different rock types with different petrographic factors. The proportion of each of these components determines the petrographic number. For most purposes, aggregate material used in concrete requires a petrographic number of 135 or less, whereas road asphalt and Class A and B gravels can tolerate a petrographic number up to 150 (Department of

Transportation, 1999). The rounding of pebbles, the number of fracture faces and their sphericity are important considerations in using an aggregate for concrete.

## AGGREGATE POTENTIAL

Surficial sediments consist of glacial till, glaciofluvial sand and gravel, marine sand-silt-clay, and organic deposits. Sand and gravel have the greatest economic potential. These types of deposits were sampled at several locations within the 6-km-wide corridor along the road in NTS map areas 13A/14, 13H/3, 4, 5, 6 and 11 (Figure 1, Table 1). Textures ranged from fine sands and silts to cobble and boulder gravels. These deposits are expressed in terms of their grain-size composition as shown in table 2. Deposits size ranges from 50 000 m<sup>3</sup> to 50 000 000 m<sup>3</sup>.

### Deposit 1

The largest sand and gravel resource along the LH consists of large glaciofluvial outwash and terrace deposits (Figure 3, Plate 1) located in the northeast part of NTS map area 13A/14. These deposits are greater than 40 m thick in some areas. The deposit extends several kilometres beyond the 6-km-road corridor (McQuaig, 2002b). The deposit within the corridor is estimated to contain 50 000 000 m<sup>3</sup> of material. Analyses of 20 samples indicate variable textures from predominantly sand, to silty sand, very gravelly sand and very sandy gravel. Grain-size analyses show an average of 22.7 percent gravel, 73.4 percent sand and 3.9 percent silt-clay (Table 1, Figure 2). Pebbles consist of fresh to highly weathered granite (54 percent), fresh to intensely weathered gneiss (43 percent) and minor amphibolite and quartz (3 percent). Petrographic numbers of eight samples analyzed range from 141 to 277 with an average of 192.

### Deposit 2

Glaciofluvial deposits (Figure 4, Plate 2) along the southern, east-west boundary between NTS map areas 13H/3 and 13H/4 contain an estimated 10 000 000 m<sup>3</sup> of sand and gravel. These deposits can be classified into sandy gravel, very sandy gravel and sand based on analyses of 13 samples. Silt-clay content is generally less than 5 percent in most samples, and sand ranges from 28.1 to 97.8 percent. The area along the LH (Zone 1) has coarser aggregate, containing an average of 28.5 percent gravel, whereas along the river valley (Zone 2), gravel content was less than 5 percent with the exception of one sample from six samples collected (Table 1, Figure 2). Petrographic characteristics of both deposits are similar. Pebbles consist mostly of fresh granite (38 percent) and fresh to moderately weathered gneiss (47 percent), and lower amounts (15 percent) of fresh granodi-

**Table 1.** Summary results of aggregate deposits in NTS map areas 13A/14, 13H/3, 4, 5, 6 and 11

Deposits	m <sup>3</sup>	Gravel	Sand	S1-Cl	No. of Samples Analyzed	PN Range	PN Average	Notes
1	50 000 000	22.7	73.4	3.9	20	141-277	192	Fine sand to very sandy gravel
2 (Zone 1)	3 000 000	28.5	67.9	3.6	7	108-117	113	Sandy gravel, very sandy gravel and sand
(Zone 2)	7 000 000	7.4	87.7	4.9	6	110	110	
3	600 000	58.7	41.2	0.1	7	---	---	Boulder gravel to sandy gravel and sand
4 (Zone 1)	12 000 000	65.0	33.4	1.5	8	114-168	132	Sandy gravel to silty sand
(Zone 2)	3 000 000	5.0	83.6	11.4	9			
5	500 000	0.1	90.6	9.3	2	---	---	Sand and silty sand
6	50 000	80.0	19.6	0.4	2	119-182	150	Esker gravel
7	300 000	4.5	80.4	15.0	4	---	---	Sand and silty sand

Note: Estimated quantities in table are based on airphoto interpretation and observations at field sample locations. Grain-size percentages are based on a compilation of sample data for each deposit.

--- No data available

**Table 2.** Description of sand and gravel aggregate based on grain-size composition

Description	Composition
Silty sand	5 to 20 % silt
Sand	> 95 % sand
Gravelly sand	5 to 20 % gravel
Very gravelly sand	>20 % gravel
Sand - gravel	About equal
Very sandy gravel	> 20 % sand
Sandy gravel	5 to 20 % sand
Gravel	>95 % gravel

orite, quartz pebbles, quartzite, anorthosite, quartzite and volcanics. Petrographic numbers of four samples analysed are 108, 110, 115 and 117.

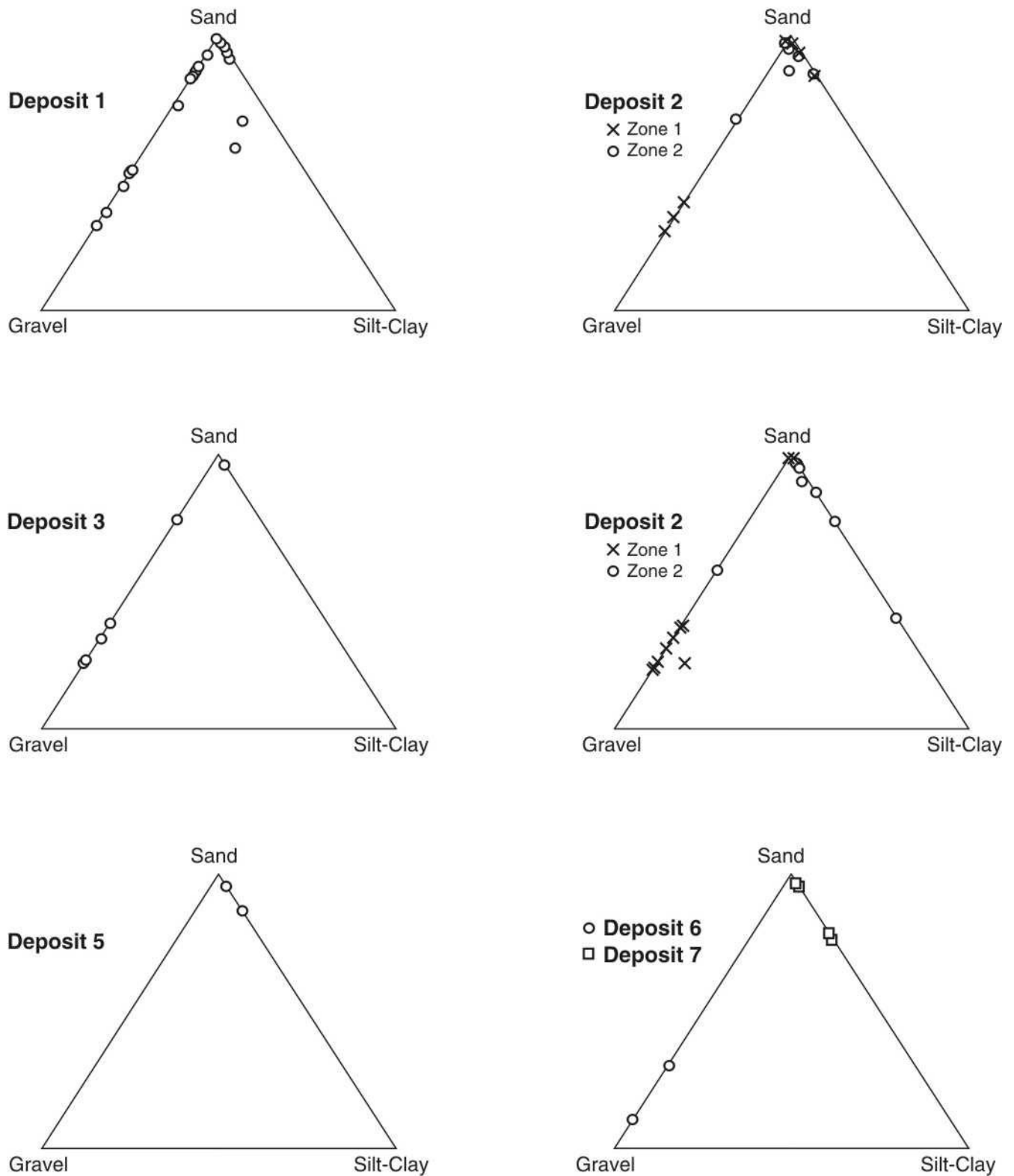
### Deposit 3

A small glaciofluvial deposit (Figure 5) is located along the LH, 7 km south of the northeast end of NTS map area 13H/4. This sandy gravel deposit is about 1200 m long, 60 to 300 m wide and 3 to 10 m high. It contains an estimated 600 000 m<sup>3</sup> of aggregate. Textures varied from boulder gravel (Plate 3) to sandy gravel and sand based on analyses of 7 samples (Table 1, Figures 2). Sampled material indicates an

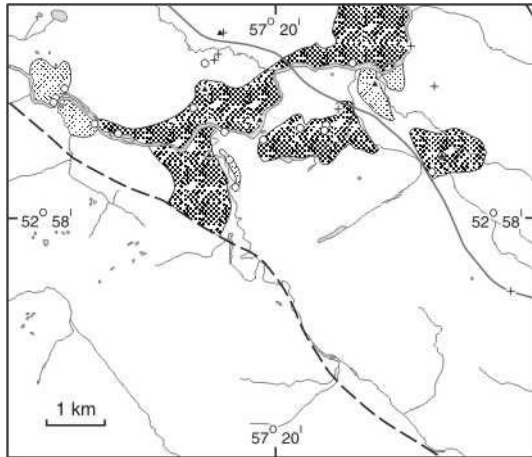
average of 58.7 percent gravel, 41.2 percent sand and 0.1 percent silt-clay. Pebbles are dominantly fresh to moderately weathered gneiss (53 percent) and fresh to slightly weathered granites (34 percent). Minor pebble types (13 percent) are quartz diorite, anorthosite, volcanics, quartzite, quartz pebbles, amphibolite and pelitic schist. Petrographic numbers of 6 samples range from 110 to 182, with an average of 131.

### Deposit 4

Deposits located along the boundary between NTS map area 13H/5 and 13H/6 (Figure 6) contain over 12 000 000 m<sup>3</sup> of sand and gravel. These deposits are divided into different zones based on grain-size characteristics of 17 samples (Table 1, Figures 2). Zone 1 is characterized as very gravelly sand and very sandy gravel (Plate 4). Minor sand lenses were sampled within these areas. These deposits have an average of 65.0 percent gravel, 33.4 percent sand and 1.5 percent silt-clay. Zone 2 varies from very silty sand to sand, and minor gravelly sand. These Zone 2 deposits have an average of 5 percent gravel, 83.6 percent sand and 11.4 percent silt-clay. Petrographic characteristics of this area are similar for both zones. Pebbles consist mostly of fresh to moderately weathered gneiss (49 percent), quartz diorite (22 percent) and granite (18 percent). Minor amounts (11 per-



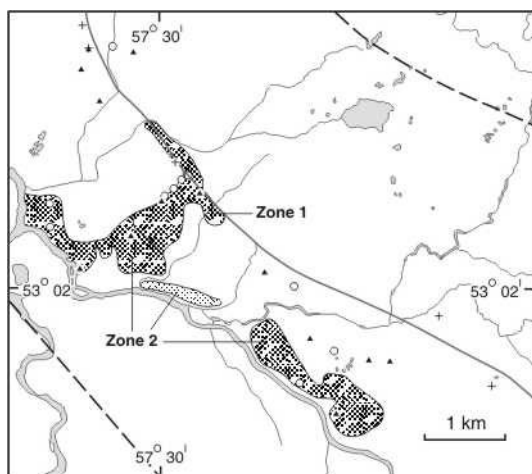
**Figure 2.** Ternary plots of aggregate samples collected from deposits in NTS map areas 13A/14, 13H/3, 4, 5, 6 and 11.



**Figure 3.** Deposit 1 is located in the north part of NTS map area 13A/14 (see Figure 5 for legend).



**Plate 1.** A 40-m-high glaciofluvial terrace in the northeast end of NTS map area 13A/14 (Deposit 1).



**Figure 4.** Deposit 2 is located along the southern east-west boundary of NTS map areas 13H/3 and 13H/4 (see Figure 5 for legend).



**Plate 2.** A 10-m-high gravelly sand exposure in abandoned quarry along the south boundary between NTS map areas 13H/3 and 13H/4 (Zone 1, Deposit 2).

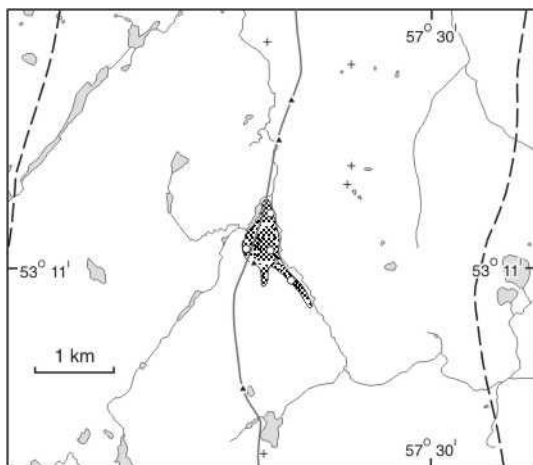


**Plate 3.** Cobble, boulder gravel in backhoe-dug pit in the northeast end of NTS map area 13H/4 (Deposit 3).

cent) of volcanics, gabbro, granodiorite, and quartz pebbles were also present. Petrographic numbers of samples range from 114 to 168 and average 132.

### Deposit 5

Deposits 1.5 km southeast of the LH in the central part of NTS map area 13H/6 (Figure 7) contain approximately 500 000 m<sup>3</sup> of predominantly sand and silty sand. Analyses of 2 samples show averages of 0.1 percent gravel, 90.6 percent sand and 9.3 silt-clay (Table 1, Figure 2). This deposit did not contain coarse material for petrographic analyses. The distance from the road and the fine-grained texture of these deposits may make them unsuitable for exploitation.



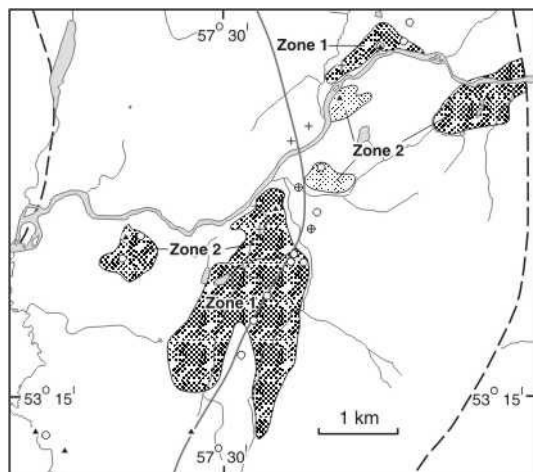
**LEGEND (for figures 3 through 9)**

-  Deposit location
-  Esker
-  Road
-  6-km-wide corridor boundary

**SAMPLES**

Sample Location	Silt-clay content
○	<5%
▲	≥5% and ≥ 15%
+	>15%

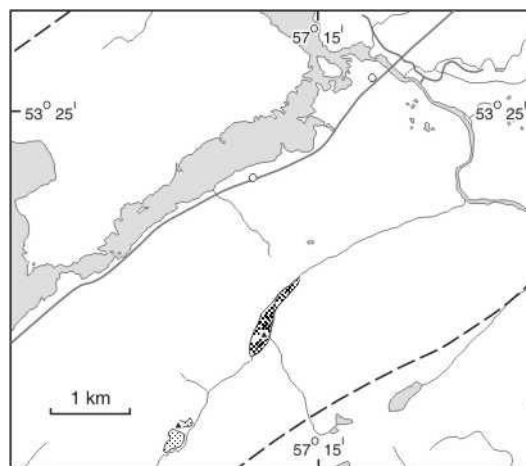
**Figure 5.** Deposit 3 is located near the northeast part of NTS map area 13H/6.



**Figure 6.** Deposit 4 is located along the southern east-west boundary between NTS map areas 13H/5 and 13H/6.



**Plate 4.** A 10-m-high sandy gravel exposure along roadcut in NTS map area 13H/6 (Zone 1, Deposit 4).



**Figure 7.** Sand deposits (5) near the central part of NTS map area 13H/6.

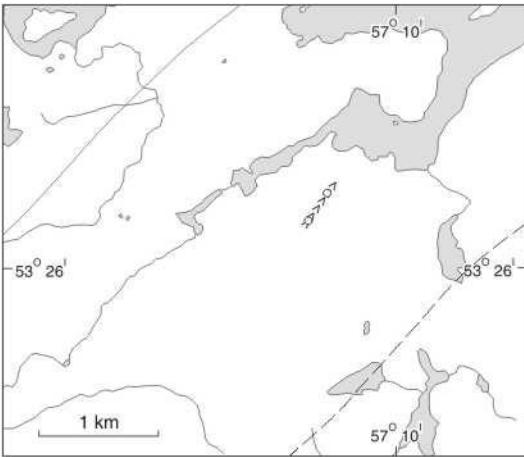
**Deposit 6**

A 350-m-long esker is located 1.6 km southeast of the LH in the central part NTS map area 13H/6 (Figure 8). This deposit contains approximately 50 000 m<sup>3</sup> of aggregate. Analyses of two samples show 80.0 percent gravel, 19.6 percent sand and 0.4 percent silt-clay (Table 1, Figures 2). Pebbles consist mostly of gneiss (47 percent), quartz diorite (27 percent) and granite (18 percent). Minor amounts of pelitic schist, granodiorite and arkose were also present (8 percent). Petrographic numbers of two samples are 119 and 182. The small size and distance from the road may make this deposit unsuitable for exploitation.

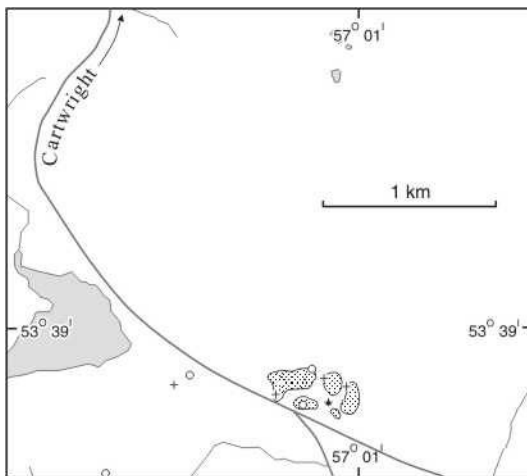
**Deposit 7**

A dissected marine terrace is located near the LH, 11 km southeast of Cartwright (Figure 9). The terrace contains





**Figure 8.** Esker deposit (6) in the north-central part of NTS map area 13H/6.



**Figure 9.** Sand and silty sand in dissected marine terrace (deposit 7), 11 km southeast of Cartwright.

approximately 300 000 m<sup>3</sup> of sand and silty sand (Plate 5). Deposits in this area have been quarried in the past. The high silt content results in lower quality and has restricted use. The larger and thicker deposits approximately 20 m from the road have not been quarried. If these 7- to 8-m-thick deposits are of acceptable quality for winter ice control or local community needs, it will be a valuable deposit, as in this area, good quality aggregates are not available in significant quantities. Analyses of 4 samples indicate an average of 4.5 percent gravel, 80.4 percent sand and 15.0 percent silt-clay (Table 1, Figures 2). This deposit does not contain coarse aggregate for petrographic analysis.

### SUMMARY

Although sand and gravel aggregates are plentiful, they are fixed location, non-renewable resources that can be exploited only in those areas where they are found. Sand and



**Plate 5.** A 5-m-high sand exposure along roadcut, 11 km southeast of Cartwright in NTS map area 13H/11 (Deposit 7).

gravel deposits were sampled at several locations along the LH. These deposits vary from silty sand and sand to sandy gravel and gravel, and range in quantity from 50 000 m<sup>3</sup> to several million cubic metres of aggregate. Most deposits are close to the road and can be quarried for road upgrading, or sand can be extracted and used for winter ice control. Although some deposits, such as marine sands near Cartwright, have a high silt-clay content that makes them less economical, they can be used if higher quality deposits such as gravel and sandy gravel are not found in the area. Deposits 1, 2 and 4 are the largest deposits. These have variable textures and excellent to moderate petrographic quality. These deposits can be used as a good aggregate source for nearly any aggregate construction project within trucking distance.

### ACKNOWLEDGMENTS

Daniel Downton was a reliable, enthusiastic and hard-working assistant for the duration of the field program. Logistical support from Gerry Hickey and Sid Parsons was greatly appreciated. The author wishes to thank Shirley McQuaig and Dave Liverman for reviewing this report.

## REFERENCES

- Bragg, D.J.  
1995: Petrographic examination of construction aggregate. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 95-1, pages 77-89.
- Canadian Standards Association  
1973: CSA standard A23.2.30, Rexdale, Ontario, pages 207-209.
- Carter, P.D.  
1981: The economics of mineral aggregate production and consumption in Newfoundland and Labrador. Newfoundland Department of Mines and Energy, St. John's, Newfoundland, 112 pages.
- Department of Transportation  
1999: Specifications Book (third edition). Government of Newfoundland and Labrador, Department of Works, Services, and Transportation, Highway Design Division, St. John's, 1299 pages.
- Fulton, R.J.  
1986: Glacial flow features, and organic cover of southwest Labrador; Battle Harbour - Cartwright (1:500 000 scale). Department of Energy, Mines and Resources, Geological Survey of Canada, Ottawa.
- Fulton, R.J., Hodgson, D.A. and Minning, G.V.  
1975: Inventory of Quaternary geology, southern Labrador - terrain studies in undeveloped areas. Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa, Paper 74-46, 14 pages.
- Fulton, R.J., Minning, G.V. and Hodgson, G.V.  
1979: Surficial materials, Battle Harbour, Labrador, Newfoundland. Department of Energy, Mines and Resources, Geological Survey of Canada, Ottawa, Map 19 (1:250 000 scale).
- Hare, F.K.  
1959: A photo-reconnaissance survey of Labrador-Ungava. Department of Mines and Technical Surveys, Geographical Branch, Memoir 6, 85 pages.
- Kirby, F.T.  
1990: Detailed aggregate-resource assessment project, Newfoundland and Labrador. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 90-1, pages 19-26.
- Kirby, F.T., Ricketts, R.J. and Vanderveer, D.G.  
1983: Inventory of aggregate resources of Newfoundland and Labrador. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-2, 36 pages.
- McCuaig, S.J.  
2002a: Quaternary geology of the Alexis River area, and the Blanc-Sablon to Mary's Harbour road corridor, southern Labrador. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 02-1, pages 1-20.  
2002b: Landforms and surficial geology of the NTS map sheet 13A/14. Newfoundland Department of Mines and Energy, Geological Survey, Map 2002-10.
- McCuaig, S.J. and Ricketts, M.J.  
2004: Ground-penetrating radar: A tool for delineating aggregate-resource deposits. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey, Report 04-1, pages 107-115.
- Ontario Ministry of Transportation  
1994: Procedures for petrographic analysis of coarse aggregate. Ministry of Transportation, Ontario, Laboratory Testing Manual, Volume 2, LS-609, 18 pages.
- Ricketts, M.J.  
1996: Granular aggregate-resource mapping in the Roddickton-Main Brook area, Great Northern Peninsula, Newfoundland. *In* Current Research. Newfoundland Department of Natural Resources, Geological Survey, Report 96-1, pages 41-53.  
1987: Coastal Labrador aggregate resources. Newfoundland Department of Mines and Energy, Mineral Development Division, St. John's, Mineral Resource Report 5, 50 pages.
- Rutka, A.  
1976: Economic use of mineral aggregate in road construction (Draft Report). Ontario Ministry of Transportation and Communications. Prepared for Presentation to the Mineral Aggregate Working Party, March 17, 1976.
- Smith, M.R. and Collis, L.  
1993: Aggregates: Sand, gravel and crushed rock aggregate for construction purposes (2nd edition). Geological Society of London, Geological Society Engineering Geology Special Publication No. 9, 339 pages.

Vanderveer, D.G.

1983: Aggregates-the often maligned and often forgotten mineral. *In* 19th Forum on the Geology of Industrial Minerals. Proceedings. *Edited by* S.E. Yudt. Ontario Geological Survey, Miscellaneous Paper 114, pages 65-78.

1982: Municipal planning and aggregate resources-a brief synopsis. Newfoundland Department of Mines and Energy, Mineral Development Division, Unpublished Report, 2 pages.