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BEDROCK AGGREGATE SURVEYS IN THE BULL ARM–MOSQUITO COVE AREAS, TRINITY BAY, AND CENTRAL NEWFOUNDLAND

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ABSTRACT

The 1990 field program consisted of two field surveys; a detailed investigation of the Bull Arm–Mosquito Cove areas, Trinity Bay and a reconnaissance survey in central Newfoundland. The first was an assessment survey, done to determine the quality and quantity of bedrock for use as aggregate in the construction of the concrete, gravity-based structures, and associated site infrastructure. Fifty-seven sites were examined in this region, and 52 samples collected. Based on preliminary physical property results, (hardness, freshness and rock type), 20 samples are considered to be of high quality, 18 samples are considered to be of marginal quality and 14 samples are considered to be of low quality.

The second survey was a reconnaissance investigation, which was done to determine the quality and quantity of bedrock aggregate for local industrial use in central Newfoundlnad. A total of 509 sites were examined and 270 samples collected. Based on preliminary physical property results (hardness, freshness and rock type), 122 samples are considered to be of high quality, 90 samples are considered to be of marginal quality and 58 samples are considered to be low quality.

Analyses of geotechnical properties of bedrock, including geological structures, presence of deleterious substances, petrographic analysis and number, abrasion, and soundness are presently under study, whereas alkali–reactivity tests have been performed on selected samples.

INTRODUCTION

The announcement in August 1990 that Mosquito Cove was to be the construction site of the offshore concrete gravity-based structure (GBS), initiated a detailed study for potential bedrock-aggregate sites in the Bull Arm–Mosquito Cove areas (Figure 1).

Granular material (sand and gravel) would be ideal for this project, however, it is not available on or near the proposed site (F.T. Kirby, personal communication, 1990), and therefore the bedrock-aggregate potential in the adjacent region was examined; this is the object of this report.

The second half of the field season was located in central Newfoundland (Grand Falls–Baie Verte Peninsula) (Figure 2). This was a reconnaissance investigation, which examined all the roadcuts, quarries and natural bedrock outcrops along highways and side roads, looking for sites of potential bedrock aggregate. The project is a continuation of a province-wide survey to identify potential high-quality bedrock and granular aggregate sites for local use (see Ricketts and McGrath, 1990).

GENERAL GEOLOGY

The geology of the Bull Arm–Mosquito Cove area consists of Cambrian volcanic and sedimentary rocks of the Musgravetown Group (King, 1988). The volcanic rocks consist of basalt, andesite, rhyolite and pyroclasts (mafic and felsic tuffs) of the Bull Arm Formation (King, 1988). The sedimentary rocks consist of sandstones, silstones and conglomerates of the Big Head, Maturin Point and Trinny Cove formations (King, 1988).

The general geology of central Newfoundland (Figure 2) consists of felsic to mafic volcanic rocks and minor occurrences of sedimentary rocks of the Robert's Arm, Springdale, Betts Cove, Buchans, Lush's Bight, Mic Mac Lake, Flatwater Pond, Goldson, Pacquet Harbour, Cape St. John and Snooks Arm groups and Lawrenceton, Sansom and New Bay formations (Kean *et al.*, 1981, Hibbard, 1983). Medium- to coarse-grained igneous rocks are characteristic of the Topsails, Dunamagon, Burlington, Cape Brule Porphyry, Halls Bay and Loon Bay intrusions and metamorphic rocks of the Birchy Complex, Rattling Brook, Old House and White Bay groups, the Garden Cove and Pigeon Island formations, the East Pond Metamorphic suite and the Dunnage Melange (Kean *et al.*, 1981; Hibbard, 1983).

FIELD WORK

Field work consisted of boat and foot-traverses along the shores of Bull Arm, Trinity Bay; and in central Newfoundland, mainly highway traverses along the Trans-Canada Highway and various side roads, including visits to all rock quarries in the area between Grand Falls and the Baie Verte Peninsula.

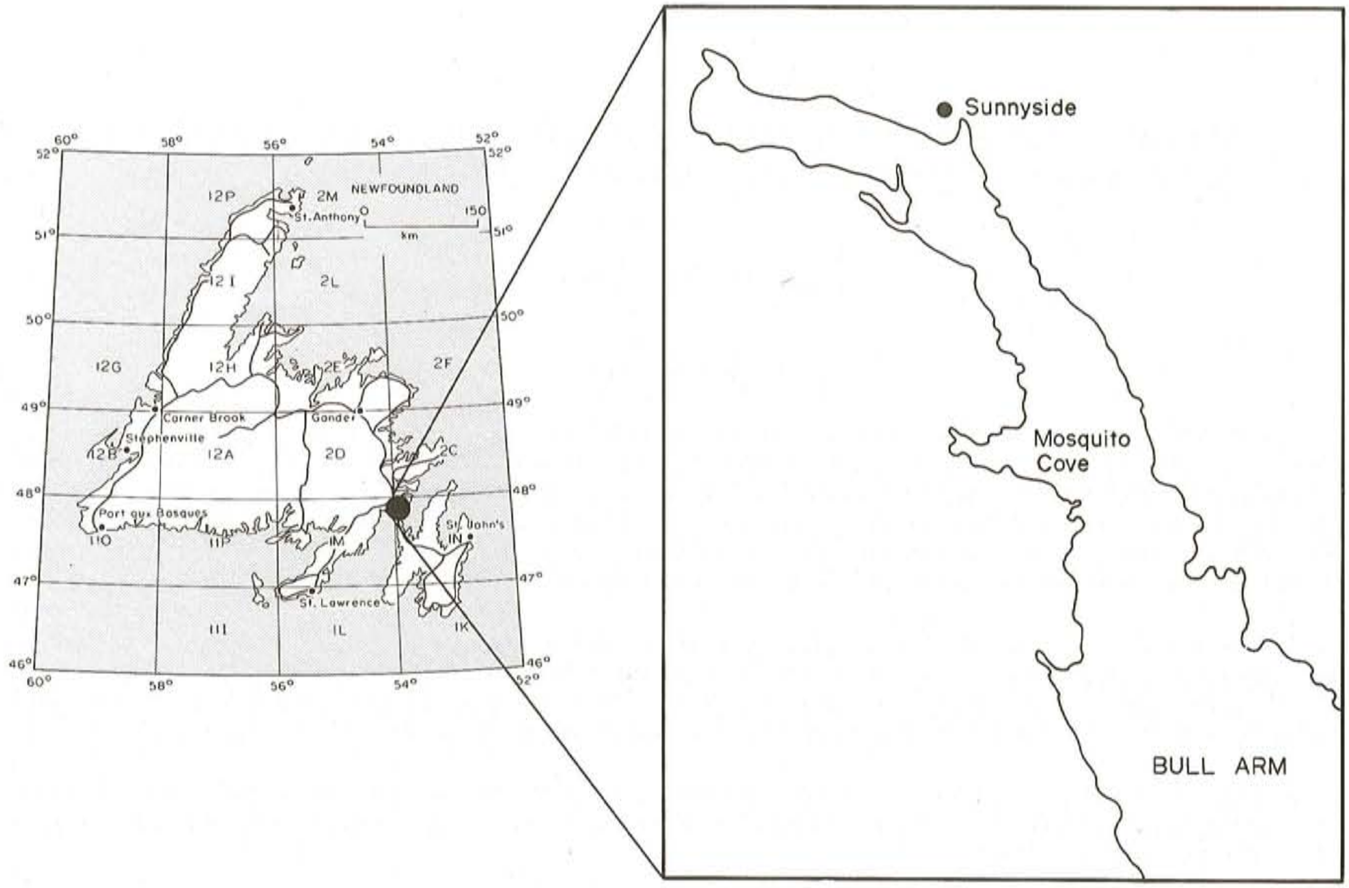

Figure 1. *Location map of study area in Bull Arm, Trinity Bay.*

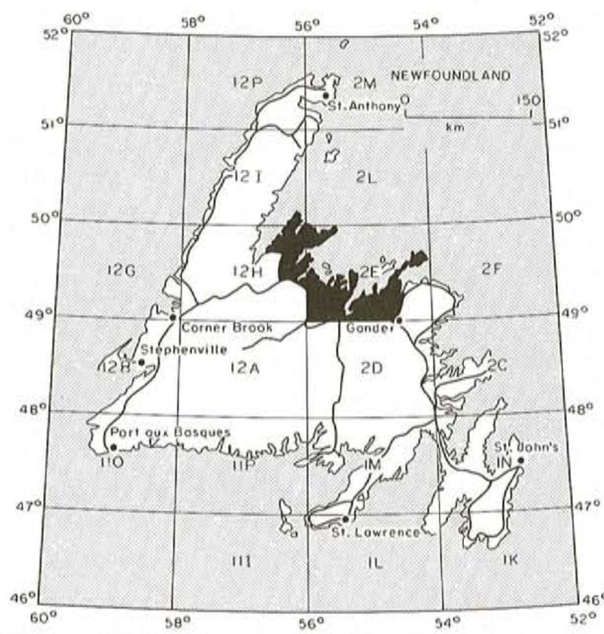

Figure 2. *Location map of study area in central Newfoundland.*

Field investigations at each site may include rock identification, representative sampling, and the description of geological features. The site investigations methodology is reported in Bragg (1986, 1989) and Bragg and Norman (1988).

Once site investigations were completed, an initial quality reference (petrographic number) is given to each sample based on deleterious substances present and petrographic factors. Deleterious substances are materials that occur within or on the rock surface, and which are capable of producing adverse effects (e.g., chemical reactions with other minerals), resulting in a deterioration of the rock or cement binder when used in concrete or asphalt. Common deleterious substances include clay minerals, organic matter, mica, iron and manganese oxide staining, and cherty or fine-grained siliceous material. Alteration zones, encrustations and weathering are also factors that are considered to be deleterious to the quality of the rock aggregate (American Society for Testing and Materials (ASTM), 1985, 1986, 1987b; Bragg, 1989).

A petrographic number (P.N.) is calculated for each site and this is a preliminary measure of the quality of material for aggregate purposes. The petrographic number is calculated by sampling 100 clasts/fragments and assigning a petrographic factor to each clast/fragment. The petrographic factor (P.F.) ranges from 1 (best) to 10 (worst) depending on rock type, freshness, hardness and deleterious substances present (Canadian Standards Association (CSA), 1973; Table 1), and

Table 1. Rock type and petrographic factors

Rock type	Classification	Factor
Carbonates (hard)	good	1
Carbonates (sandy, hard)	good	1
Sandstone (hard)	good	1
Gneiss (hard)	good	1
Quartzite (coarse grained)	good	1
Greywacke–arkose	good	1
Volcanic (slightly weathered)	good	1
Granite–diorite	good	1
Trap	good	1
Magnetite	good	1
Pyrite (disseminated in trap)	good	1
Iron-bearing quartzite	good	1
Sedimentary conglomerate (hard)	good	1
Carbonates (slightly weathered)	fair	3
Carbonates (sandy, medium hard)	fair	3
Sandstone (medium hard)	fair	3
Crystalline carbonates (hard)	fair	3
Crystalline carbonates (slightly weathered)	fair	3
Gneiss (soft)	fair	3
Chert and cherty carbonates	fair	3
Granite (friable)	fair	3
Volcanic (soft)	fair	3
Pyrite (pure)	fair	3
Flints and jaspers	fair	3
Carbonates (soft, slightly shaly)	poor	6
Carbonates (soft, sandy)	poor	6
Carbonates (deeply weathered)	poor	6
Carbonates (shaly clay)	poor	6
Carbonates (ochreous)	poor	6
Chert and cherty carbonates (weathered)	poor	6
Sandstone (soft, friable)	poor	6
Quartzite (fine grained)	poor	6
Crystalline carbonates (very soft, porous)	poor	6
Gneiss (friable)	poor	6
Granite (friable)	poor	6
Encrustations	poor	6
Cementations	poor	6
Schist (soft)	poor	6
Ochre	deleterious	10
Shale	deleterious	10
Clay	deleterious	10
Decomposed volcanics	deleterious	10
Slates	deleterious	10
Talc–gypsum	deleterious	10
Iron formations (very soft)	deleterious	10
Sibley formation	deleterious	10

a revised version (Table 2; Bragg, 1986). The P.N. is the sum of the factors for each clast and can range between 100 and 1000. The lower the P.N. the higher the rock quality (e.g., a clean, hard unweathered granite would normally have a P.F. of 1, and a P.N. of 100, whereas a friable, soft shale would normally have a P.F. of 10 and a P.N. of 1000). The petrographic factor/number is usually affected by the degree of weathering (Table 3).

Table 2. Revised petrographic factors for some rock types

Rock type	Petrographic factor range	Usual factor
1. Sandstone	1-6	1
2. Shale	10	10
3. Mudstone	3-6	6
4. Siltstone	1-6	1
5. Conglomerate	1-10	6
6. Arkose	1-6	1
7. Argillite	3-6	6
8. Greywacke	1-6	1
9. Chert	1-3	1
10. Limestone	1-6	1
11. Dolomite	1-6	1
12. Quartzite	1-6	1
13. Granite	1-6	1
14. Gabbro	1-6	1
15. Diorite	1-6	1
16. Granite–diorite series	1-6	1
17. Felsic volcanics	1-6	1
18. Mafic volcanics	1-6	1
19. Intermediate volcanics	1-6	1
20. Felsic–mafic volcanics	1-6	1
21. Pyroclastics	3-6	3
22. Metavolcanics	3-6	3
23. Gneiss	1-6	3
24. Schist	3-10	6
25. Phyllite	6-10	6
26. Marble	1-6	1
27. Slate	10	10
28. Amphibolite	6-10	6
29. Ultramafic	6-10	6
30. Metasediments	1-6	3
31. Iron formation	6-10	6
32. Drift deposits	Any or all of the above	Any or all of the above

Table 3. Effect of weathering on petrographic factors

Petrographic factor	Weathering grade	Final petrographic factors
1	1, 2	1,2
	3	3,4,5
	4, 5	6,7,8,9
	6	10
3	1, 2	3,4,5
	3, 4	6,7,8,9
	5, 6	10
6	1, 2	6,7,8,9
	3, 4, 5, 6	10
10	1, 2, 3, 4, 5, 6	10

LABORATORY INVESTIGATION

During the on-site field investigation, selected rock samples, ranging from 14 to 45 kg, were taken for laboratory

Table 4. Petrographic number ranges of different rock units found in the Mosquito Cove area

Group/Formation	Number of samples	Petrographic number range	Petrographic number <160	Petrographic number >160	Average petrographic number
Musgravetown	16	130-180	10	6	150
Bull Arm Formation	36	110-180	34	2	135

testing. The proposed test program includes the $MgSO_2$ soundness test (ASTM, 1983), which is used to indicate the durability of an aggregate in relation to weathering agents. The Los Angeles Abrasion test for small-size coarse aggregate (ASTM, 1989) and for large-size coarse aggregate (ASTM, 1989b), is used to measure the durability of an aggregate in relation to wear, impact and abrasion from other agents.

If the results of these tests are favourable, the sample will be tested for alkali-reactivity (ASTM, 1987b). This is a quick chemical test used to measure the percentage of dissolved silica after the sample has been immersed in a solution of 1 N sodium hydroxide for 24 hours at 80°C. The advandage of this test is that results are obtained rather quickly (1 day), however, the disadvandage is that the test is not completely reliable. The more reliable tests are the Motor Bar (ASTM, 1987a) and the Concrete Prism (CSA, 1977). However, the optiumum test which is being used is the NBRI test (Oberholser and Davies, 1986), which is a 14-day accelerated motar bar test.

DISCUSSION AND RESULTS

A total of 566 sites were visited and 322 samples collected. Of these, 142 samples are considered to be of potentially high-quality bedrock aggregate, 108 samples are of potentially marginal quality and 72 samples were considered to be of poor quality.

In the Bull Arm—Mosquito Cove areas, where 57 sites were visited and 52 samples collected (Table 4), the mafic volcanic rocks and flow-banded rhyolite of the Bull Arm Formation are considered to be of high quality (fresh, hard and competent) for concrete construction; and the acidic and mafic tuffs of the Bull Arm Formation and sandstones and siltstones of the Musgravetown Group are considered to be of marginal and poor quality for concrete construction, but may be of sufficent quality for asphalt and road construction. Of the 52 samples collected, 20 samples are considered to be of high quality (P.N. less than 150); these are mainly mafic and acidic volcanic rocks from the Bull Arm Formation, 18 samples are considerd to be of marginal quality (P.N. range from >150 to 350); these are mainly acidic and mafic tuffs from the Bull Arm Formation and sediments from the Musgravetown Group, 14 samples are considered to be of poor quality (P.N. greater than 350); these are mainly altered versions of the above rock types from the Bull Arm Formation and Musgravetown Group.

In central Newfoundland, 509 sites were visited and 270 samples were collected (Table 5). Of the 270 samples collected, 122 samples are considered to be of high quality (P.N.< 150) for use in concrete and asphalt. These are mainly igneous rocks (granites, diorites, gabbros, acidic and mafic volcanics) of the Topsails, Burlington, Dunamagon, Loon Bay, Halls Bay and Cape Brule Porphyry intrusives, the Robert's Arm, Springdale, Buchans, Mic Mac Lake, Flatwater Pond, Pacquet Harbour, Lushs Bight, Cape St. John and Snooks Arm groups and of the Betts Cove Complex and Lawrenceton Formation. Ninety samples are considered to be of marginal quality (P.N.>150 to 350), these are mainly found in the Sansom, Golden and Point Leamington greywackes and the New Bay Formation and from metmorphosed and moderatly weathered versions of the igneous rocks, which are listed above in the high-quality category. Fifty-eight samples are considered to be of low quality (P.N.>350), these are all metamorphic rocks (schists, pelites, psammites) of the Birchy Complex, East Pond Metamorphic suite, Dunnage Melange, Rattling Brook, Old House and White Bay groups, and of the Garden Cove and Pigeon Island formations.

CONCLUSIONS

The bedrock aggregate potential of the Bull Arm—Mosquito areas is high for road construction material (asphalt aggregate, Class A and B material), because of the physical properties (hardness, freshness and competencey) of the rock. However, when examining bedrock aggregate for concrete use, the chemical properties (alkali-aggregate reactivity) of the rock has also to be taken into consideration. Five samples from the area were taken for alkali-reactivity testing and the results are shown in Table 6. The results show that the basalts and rhyolite from the area are considered to be non-reactive, whereas the sandstone and tuffs in the area are considered to be reactive.

In central Newfoundland, bedrock-aggregate potential is high, especially among the igneous rocks, when they are fresh and hard. The sedimentary and metamorphic rocks of the area are considered to range from marginal to poor quality. It must be stressed that the above are only preliminary results and that further sampling and testing is essential to substantiate the quantity and quality of bedrock in both areas.

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Table 5. Petrographic number ranges of different rock units found in the central Newfoundland field area

Group/Formation	Number of samples	Petrographic number range	Petrographic number <160	Petrographic number >160	Average petrographic number
Lawrenceton Formation	8	130-210	3	5	168
Robert's Arm Group	22	120-230	11	11	175
Topsails Granite	3	110	3	0	110
Springdale Group	9	125-210	3	6	165
Flatwater Pond Group	7	135-310	3	4	185
Betts Cove Complex	8	110-155	8	0	125
Birchy Complex	4	210-330	0	4	250
Rattling Brook Group	32	115-450	5	27	290
Old House Group	17	230-310	0	17	260
Garden Cove Formation	3	220	0	3	220
Pigeon Island Formation	3	210-270	0	3	240
White Bay Group	6	255	0	6	255
Pacquet Harbour	15	110-310	10	5	121
Dunamagon Granite	4	110	4	0	110
Cape Brule Porphyry	16	110-120	16	0	115
Cape St. John Group	29	110-135	29	0	120
Burlington Granodiorite	16	110-215	13	3	130
Loon Bay Batholith	6	115-125	6	0	120
Snook's Arm Group	3	125-155	3	0	135
East Pond Metamorphic Suite	9	215-350	0	9	265
Buchans Group	13	110-120	13	0	117
Golden Conglomerate	6	175	0	6	175
Sansom Greywacke	7	110-130	7	0	120
Dunnage Melange	9	110-350	2	7	260
Halls Bay Pluton	4	115	4	0	115
New Bay Formation	11	115-190	5	6	161
Point Leamington Greywacke	9	115-600	3	6	210
Lush's Bight Group	21	110-375	11	10	185

Table 6. Results of alkali-aggregate reactivity tests on representative rock samples in the Bull Arm area

Rock Type	% expansion in 14 days*	Comments
Tuff	0.365	Reactive
Basalt	0.020	Non-reactive
Basalt	0.029	Non-reactive
Rhyolite	0.078	Non-reactive
Sandstone	0.405	Reactive

*Note: Expansion > 0.15 percent at 14 days is considered deleterious and thus alkali-reactive.

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REFERENCES

American Society for Testing and Materials (ASTM)
1983: Standard test method for soundness of aggregates by use of sodium sulfate or magnesium sulfate. Annual ASTM standards, C88-83.

1985: Standard practice for petrographic examination of aggregate for concrete.

1986: Standard descriptive nomenclature for constituents of natural mineral aggregates.

1987a: Standard test method for potential alkali reactivity of cement-aggregate combinations (mortar-bar method). Annual ASTM standards, C227-87.

1987b: Standard test method for potential reactivity of aggregates (chemical method). Annual ASTM standards, C289-87.

1989a: Standard test method for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles machine. Annual ASTM standards, C131-89.

1989b: Standard test method for resistance to degradation of large-size coarse aggregate by abrasion and impact in the Los Angeles machine. Annual ASTM standards, C535-89.

Bragg, D.J.
1986: Reconnaissance study of bedrock aggregate for offshore and industrial use. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 86-1, pages 297-301.

1989: Reconnaissance assessment of potential bedrock aggregate. *In* Current Research. Newfoundland Department of Mines, Geological Survey of Newfoundland, Report 89-1, pages 221-227.

Bragg, D.J. and Norman, G.
1988: Aggregate potential of bedrock on the Avalon Peninsula. *In* Current Research. Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 367-372.

Canadian Standards Association
1977: Test method for alkali-aggregate reaction. National Standard of Canada CAN 3-A23.2-M77, Canadian Standards Association, A23.2-14A.

Hibbard, J.
1983: Geology of the Baie Verte Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Memoir 2, 279 pages.

King, A.F.
1988: Geology of the Avalon Peninsula, Newfoundland (parts of 1K, 1L, 1M, 1N and 2C). Newfoundland Department of Mines, Mineral Development Division, Map 88-01.

Kean, B.F., Dean, P.L. and Strong, D.F.
1981: Regional geology of the Central Volcanic Belt of Newfoundland. *In* The Buchans Ore Bodies: Fifty Years of Geology and Mining. *Edited by* E.A. Swanson, D.F. Strong and J.G. Thurlow. Geological Association of Canada, Special Paper 22, pages 65-78.

Oberholster, R.E. and Davies, G.
1986: An accelerated method for testing the potential alkali-reactivity of siliceous aggregates. *In* Cement and Concrete Research, Volume 16, pages 181-189.

Ricketts, M.J. and McGrath, J.
1990: Granular aggregate-resource mapping of the Gander Lake (NTS 2D/15), Gander River (NTS 2E/2) and Comfort Cove—Newstead (NTS 2E/7) map areas. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 65-75.