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RECONNAISSANCE STUDY OF BEDROCK AGGREGATE POTENTIAL FOR OFFSHORE AND INDUSTRIAL USE

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ABSTRACT

In 1985 a reconnaissance study of bedrock quarries for offshore aggregate potential and industrial use was initiated on the Burin and Avalon peninsulas. On the Burin Peninsula special emphasis was placed on the Marystown - Spanish Room and Swift Current areas, where a total of 119 sites were visited and 156 samples taken. On the Avalon Peninsula special emphasis was placed on the Come-By-Chance - Adams Head area, the proposed construction site of concrete platforms to be used in the Hibernia offshore oil development. A total of 138 sites were visited and 131 samples taken. Geotechnical properties of the bedrock, such as geological features, deleterious substances, abrasion, soundness, alkali-reactivity and petrographic factors, are under study.

INTRODUCTION

The announcement of the use of concrete gravity-based structures (GBS) as platforms for the development of offshore oil at Hibernia, coupled with the fact that there is already a shortage of unconsolidated aggregate material on the Avalon and Burin peninsulas, is creating the need for alternate sources of aggregate material. Bedrock is a suitable alternative due to its quantity and usually homogeneous characteristics.

During the 1985 field season, an evaluation of the aggregate potential of bedrock quarries on the Burin and Avalon peninsulas in eastern Newfoundland (Figure 1) was undertaken. This assessment is to determine the quality and quantity of bedrock aggregate available for offshore and industrial uses. Ricketts (*this volume*) has concentrated on the unconsolidated aggregate deposits in the same areas and his work complements this study.

FIELD WORK

Field work consisted of traverses along the Trans-Canada and Burin Peninsula highways, and various side roads, including visits to all rock quarries in the area. Road-cuts were also sampled where no rock quarries are present. Foot traverses were done in selected areas along the coastline.

During the first six weeks of the field season, work was centred on the Burin Peninsula, and for the last eight weeks, work was carried out on the Avalon Peninsula. The Marystown - Spanish Room and Swift Current areas on the Burin Peninsula, and the Come-By-Chance - Adams Head area on the Avalon Peninsula, because of their geographic location and deep, safe harbours, are potential sites for offshore supply bases and concrete platform construction.

Field investigations at each quarry consisted of representative sampling, determining (where possible) land ownership and present use, recording thickness of overburden, and making general geological observations. These are described below.

Representative Sample

At least one representative sample (1 kg) was collected from each quarry or site. However, 2 to 5 samples were commonly taken if the quarry were large, if there were a number of different rock types present, if the degree of weathering varied, or if veining and alteration zones were observed. At selected sites larger samples were taken for laboratory analyses.

Ownership and Use

The ownership of each quarry, whether operated by government, i.e., Department of Transportation, or privately owned, was recorded. Many rock quarries are currently controlled by the Department of Transportation although a significant number of these (30 to 55 percent) are depleted of reserves. Most of the quarries (greater than 95 percent) were opened to supply materials for use in road construction and the remainder are used in the production of ready-mix concrete.

Rock Types and Uses

The rocks types on the Burin Peninsula are mainly volcanic rocks (basalt, rhyolite, tuff, agglomerate and breccia) of the Love Cove Group (Jenness, 1957), Burin Group (Greene, 1973) and Marystown Group (Strong *et al.*, 1978). These rocks usually have a petrographic number of 1, and thus form excellent aggregate material. However, due to weathering in some areas, the petrographic number may range up to 6. Sporadic outcrops of sedimentary rocks (shale, sandstone, limestone) and intrusive rocks (granite, gabbro and diorite) were observed.

The western part of the Avalon Peninsula consists of Precambrian sedimentary rocks (siltstone, sandstone,

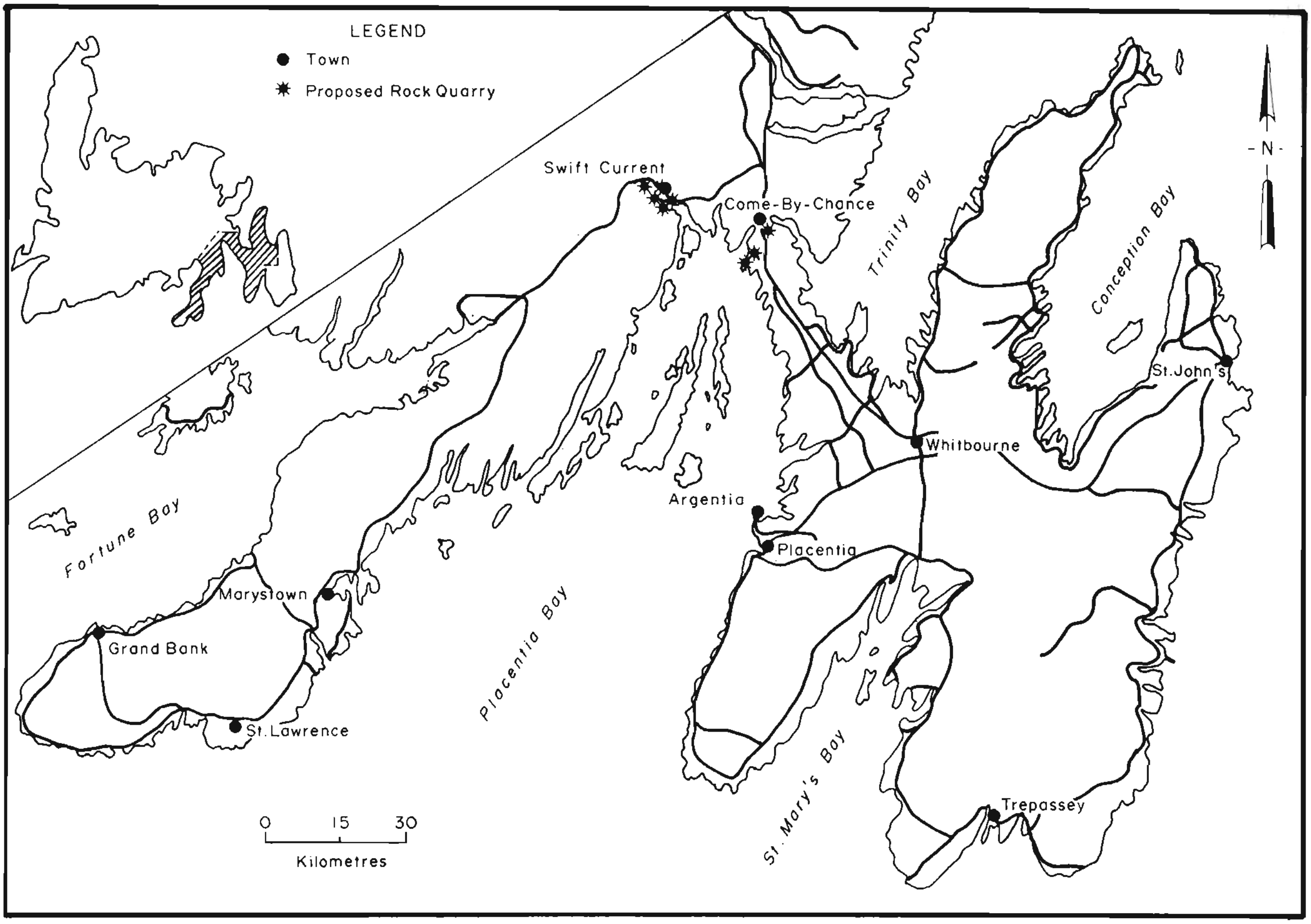

Figure 1: *Field area coverage for bedrock aggregate survey during the 1985 field season, showing proposed rock quarry sites.*

graywacke, chert, shale, conglomerate) of the Musgravetown (Hayes, 1948) and Connecting Point (Hayes, 1948) groups, and acidic to mafic volcanic rocks of the Bull Arm Formation (McCartney, 1958) and the Harbour Main Group (Rose, 1952). There are sporadic occurrences of intrusive rocks (granite and gabbro) throughout the sedimentary and volcanic rocks.

The volcanic rocks that occur on the Burin and Avalon peninsulas all have petrographic factors of 1 to 6; the factor is 1 where rocks are fresh. They may all be used for industrial purposes if they are fresh and free of deleterious substances. The sedimentary rocks (sandstone, siltstone, limestone, graywacke, and chert) have petrographic factors of 1 to 6; the factor is 1 where rocks are fresh.

Shale has a high petrographic factor of 10 due to its softness, friability and mineral content. It is normally used as a rare material in portland cement, and in some lightweight aggregates. Shale may also be used as a fill or ballast for road construction.

The conglomerates in the study area have petrographic factors of 1 to 10 and a usual factor of 6 where fresh. It is not normally used as concrete aggregate because of its weak internal bonding, which may cause breakdown during each handling of the rock. However, some well cemented homogeneous conglomerates, i.e., those composed mainly of volcanic or granitic clasts, may be used as aggregate material, such as armour stone.

Geological Features

The geological structures that were considered during the investigation are faults, fractures and joints. These affect the breakage pattern of the bedrock, and affects the cost of quarrying, i.e., amount of explosives required, and the amount of waste product, such as excessively oversized or undersized blast material. Microfractures are also important because they may affect the compressive strength of the rock. These will be examined by thin section analysis.

The following factors are equally important when quarrying bedrock:

1) Grain size - generally, the finer the grain size the harder the rock.
2) Bedding structures - important because rocks tend to break more easily along bedding planes and laminae.
3) Flow structures - in igneous rocks these tend to be planes of weakness.
4) Mineral alignments - common in metamorphic rocks, these tend to be planes of weakness and thus important

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
Graywacke—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

with regard to excessive rock breakage when blasting, crushing, and during the blending of the crushed stone with cement or asphalt binders.

5) Mineralization, veining and alterations - noted because of their deleterious effect.

LABORATORY INVESTIGATION

During the on-site field investigation, rock samples ranging from 14 to 45 kg were taken for laboratory testing. Testing proposed will include the $MgSO_2$ Soundness test (ASTM-C88-73, which is used to indicate the durability of an aggregate derived from a rock sample, in relation to weathering agents. The test is done by placing a quantity of the sample in a wire mesh basket and submerging it in a solution of magnesium sulfate for 16 to 18 hours. Then the sample is dried for 8 hours at 230°F. This process is repeated a number of times and the sample sieved again. Any loss of the aggregate or crushed stone through the sieve is calculated as a percentage. The Los Angeles Abrasion tests,ASTM-C131-69 (for small size coarse aggregate) and ASTM-C535-69 (for large size coarse aggregate) are also conducted. This test consists of placing a sample of about 5,000 grams in a horizontal steel drum containing a number of steel balls. The drum is then rotated for approximately 15 minutes at 33 revolutions per minute. After the test, the sample is sieved and the percentage loss is calculated.

If the results of these tests are favorable, the sample will be further tested for alkali-reactivity (ASTM-C289-71). This test determines the potential reactivity of an aggregate with alkalies in portland cement concrete, determined by the amount of reaction during 24 hours at 80° C in 1N sodium hydroxide.

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. Graywacke	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

In house petrographic examination (ASTM Method C-295-65(1973) and CSA standard A23.2, 1973) will be done be using hand specimens and thin sections. This test involves determining the petrographic number by using the sum of the products of the petrographic factors. The petrographic factors 1, 3, 6, and 10 (CSA Standard A23.2, 1973) are an indication of the quality of the rock (Tables 1 and 2). The quality is usually affected by the presence or absence of deleterious substances and/or weathering (Table 3). The lower the petrographic number the more superior the rock quality, which is expressed in the range of 100 to 1000, e.g., a clean, hard, unweathered granite would normally have a petrographic number of 100, whereas a friable, soft shale would be 1000.

Table 3. Affect 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

SUMMARY

A total of 256 sites were visited during the field season and 286 samples collected. Thin sections will be made of all samples and petrographic analyses completed. However, only samples with fresh hard surfaces from areas which have the potential of becoming construction or supply sites for offshore development will be subjected to detailed analyses. Data on these and other sites should be available by the end of 1985 or early 1986.

A selected number of samples will be forwarded to a contract consultant to carry out the following testing: Soundness Test - ASTM C88; Resistance to Abrasion - ASTM C535 and C131; Petrographic Examination - ASTM C295; Potential Reactivity (Chemical Method) - ASTM C289; Potential Reactivity (Mortar-Bar Method) - ASTM C227; Potential Reactivity (Rock Cyclinder Method) - ASTM C586; Potential Reactivity (Concrete Prism Expansion) - CSA 23.2-14A.

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REFERENCES

American Society for Testing and Materials
1969, 1971, 1973: Annual ASTM standards, C131-69, C535-69, C289-71, C88-73, C295-73.

Canadian Standards Association
1973: Canadian Standards Association Standards, A23.2.30.

Greene, B.A.
1973: Geology of the Marystown and St. Lawrence map areas, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, 30 pages.

Hayes, A.O.
1948: Geology of the area between Bonavista and Trinity Bays, eastern Newfoundland. Geological Survey of Newfoundland, Bulletin 32, Part 1, 49 pages.

Jenness, S.E.
1957: Gander Lake (east half), Newfoundland. Geological Survey of Canada, Map 3.

McCartney, W.D.
1958: Geology of Sunnyside Map Area, Newfoundland. Geological Survey of Canada, Report and Map 18-1958, 21 pages.

Rickets, M.J.
This volume: Detailed aggregate mapping related to concrete platform construction.

Rose, E.R.
1952: Torbay map area, Newfoundland. Geological Survey of Canada, Memoir 265, 58 pages.

Strong, D.F., O'Brien, S.J., Taylor, S.W., Strong, P.G. and Wilton, D.H.
1978: Geology of Marystown (1M/3) and St. Lawrence (1L/14) map areas, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-8, 81 pages.