Current Research (1988) Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 367-372

AGGREGATE POTENTIAL OF BEDROCK ON THE AVALON PENINSULA

Dan Bragg and Glenn Norman[1]
Quaternary Geology Section

ABSTRACT

Aggregates (sand, gravel, crushed stone) are nonrenewable mineral commodities that are being continuously depleted by the rapid increase in demand by the construction industry for aggregate use in cement, concrete, asphalt, railway ballast, armour stone, gravel roads and as fill material.

Due to the scarcity of granular aggregate deposits on the Avalon Peninsula, a reconnaissance study of bedrock aggregate potential for industrial use was initiated in 1985 and completed in 1987. The study involved investigation of all quarries and roadcuts; 537 samples were collected during the two years of the project for geotechnical analyses.

INTRODUCTION

During the 1985 and 1987 field seasons, an evaluation of bedrock aggregate potential on the Avalon Peninsula in eastern Newfoundland was undertaken by an examination of bedrock quarries and road-cuts. This assessment was conducted to determine the quality and quantity of bedrock aggregate for industrial uses, and to eliminate the use of poor-quality rock for aggregate purposes.

The field area covers twenty-two, 1:50,000 map sheets (Figure 1), therefore only road traverses were carried out because of time and manpower limitations.

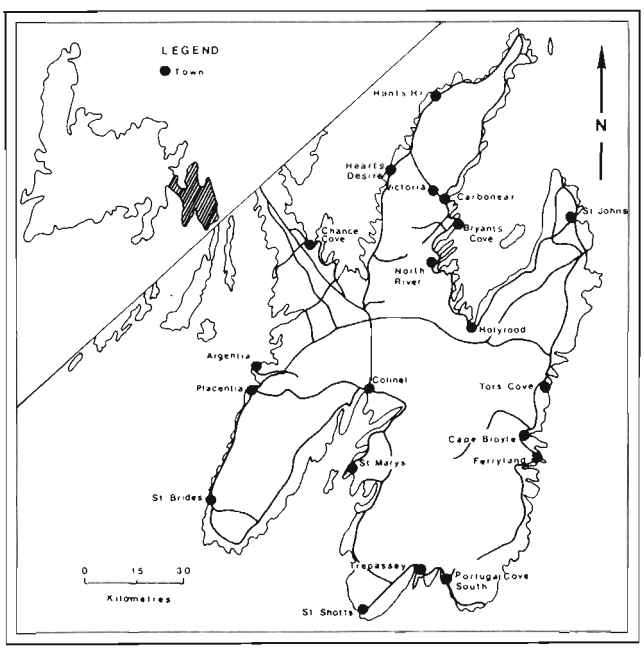

Figure 1. *Location of study area.*

Field Work

Field work consisted of road traverses along all numbered highways and all side roads, and the examination of all rock quarries and roadcuts in the area.

Field investigations at each quarry or site consisted of rock identification, representative sampling, determining (where possible) land ownership and present use, recording overburden type and thickness and describing any geological feature that may be present.

Rock Identification

Rocks were identified according to their genetic origin as either sedimentary (which result from deposition of sediment at the earth's surface by water, wind, ice, or natural chemical processes), igneous (rocks that solidify from molton rock, on or in, the earth's crust), and metamorphic (rocks that have been changed or deformed by high temperature and pressure within the earth's crust). Identification was usually made on site with the aid of a hand lens, but a later, more detailed examination using a petrographic microscope was carried out.

Representative Sampling

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 or site were large (greater than 300 m by 300 m), if there were a number of different rock types present, if the degree of weathering varied, or if veining and alteration zones were observed. Much larger samples (about 50 kg) were taken at random for more extensive laboratory analyses.

[1] Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland, A1B 3X5

Ownership and Use

The ownership of each quarry, whether operated by the Provincial Government (Department of Transportation) or privately owned, was recorded where possible. Most rock quarries (80 percent) are currently controlled by the Department of Transportation, although a significant number of these (15 to 20 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.

Overburden Type and Thickness

The main type of overburden observed in the area was a thin (less then 1 m) veneer of till (observed at 70 percent of sites), however, locally, thicknesses range from 0.8 m to 3 m. Sites with no overburden (10 percent of the sites) are completely barren; other sites (20 percent) are thinly vegetated with shrubs and trees.

Geological Features

The main geological features or structures that were considered during the field investigation include faults (Plate 1), fractures (Plate 2), joints (Plate 3), dykes (Plate 4) and cleavage (Plate 5). These affect the breakage pattern of the bedrock and the cost of quarrying, by determining the amounts of explosives required and the amount of waste product, such as excessively oversized or undersized blast material. Microfractures from thin section investigation were also recorded when observed because they affect the compressive strength of the rock.

Other attributes are:

1) grain size—generally, the finer the grain size the harder the rock;

Plate 1. *Faulting in green and red shales in the Conception Group near Bay Roberts.*

Plate 2. *Fracturing in sandstone and siltstone of the Signal Hill Group near St. John's.*

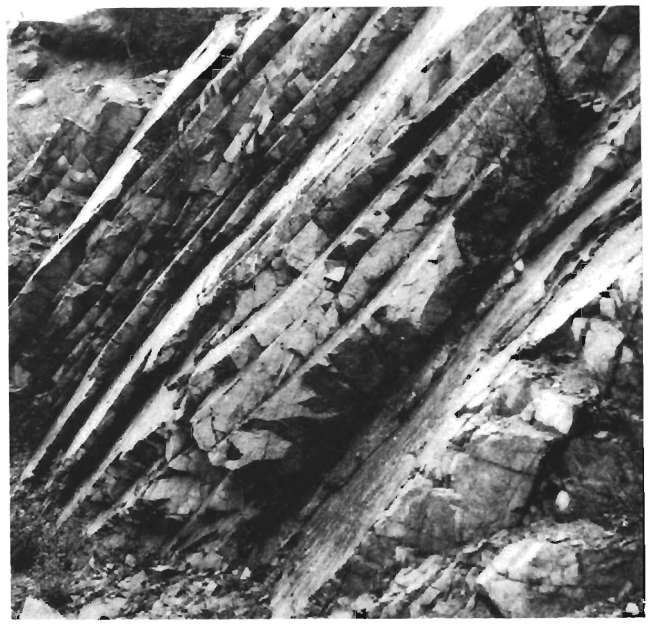

Plate 3. *Sheet jointing in granite of the Swift Current Granite near Swift Current.*

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 alignment—common in metamorphic rocks, these tend to be planes of weakness and thus important with regard to excessive rock breakage when blasting,

Plate 4. *Mafic dykes (dark colour) in granite near Swift Current.*

Plate 5. *Schistosity showing cleavages in mica schist near Trans-Canada Highway in Whitbourne area.*

crushing and during the blending of the crushed stone with cement or asphalt binders;

5) mineralization, veining and alteration zones were also noted becausing of their deleterious effect; and

6) weathering—the degree of weathering (fresh, slight, moderate and high).

GENERAL GEOLOGY

The western part of the Avalon Peninsula consists generally of Precambrian sedimentary rocks (siltstones, sandstones, graywackes, shales and conglomerates) of the Musgravetown (Hayes, 1948) and Connecting Point groups (Hayes, 1948). Felsic to mafic volcanic rocks of the Bull Arm Formation (McCartney, 1958) and Harbour Main Group (Rose, 1952) are also present. Usually the shale is locally altered, but any of the above rock types may be altered or deformed.

The eastern section of the Avalon Peninsula consists mainly of Precambrian sedimentary rocks (siltstones, sandstones, arkose, shales, argillites and conglomerates) of the Conception, St. John's and Signal Hill groups (Williams and King, 1979) with sporadic occurrences of volcanic rocks from the Harbour Main Group and granitic rocks of the Holyrood Plutonic Series. These rock types, like their western Avalon counterparts, are fairly fresh and unaltered except locally.

ROCK TYPES AND USES

Rock types in any given area that are being considered for aggregate use should be rated on the basis of the amount of deleterious substances and their petrographic number.

Deleterious substances are materials in the rock that are capable of producing adverse effects (such as chemical reactions with other minerals) that cause deterioration of the rock or the cement binder used in concrete or asphalt. Some common deleterious substances are: clays, organic matter, mica, iron- and manganese-oxide staining, and cherty or fine grained siliceous material. Alteration zones, incrustations, and weathering are also factors that are considered deleterious to the rock.

The petrographic number is the sum of the products of the petrographic factors. The petrographic factors 1, 3, 6 and 10 (CSA Standard A2312) (Table 1 of this report) and a revised version (Table 2; Bragg, 1986) are numbers given to different rock types which indicate the quality of the rock. A petrographic factor of 1 usually means good or best quality and 10 means worst or deleterious; thus the lower the petrographic number the more superior the rock quality, which is expressed in the range of 100 to 1000 i.e., a clean, hard, unweathered granite would normally have a petrographic number of 100, whereas a friable, soft shale would be 1000. The quality is usually affected by the presence or absence of deleterious substances and/or weathering (Table 3).

Sedimentary rocks, because of their variability, may or may not be suitable for aggregate use. The sedimentary rocks on the Avalon Peninsula that are suitable for aggregate use are sandstone, siltstone, arkose and graywacke, providing they are hard, dense, fresh and free of deleterious substances. Sandstone, siltstone, arkose and greywacke have a

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

petrographic factor range of 1 to 6 with a usual factor of 1 when fresh and hard. These rock types may all be used as crushed-stone aggregate for roads, concrete, breakwaters, asphalt, canals, dams, retaining wall construction and railway and road ballast. The sedimentary rocks on the Avalon Peninsula that are usually unsuitable for aggregate use are shale, conglomerate and argillite. Shale, which has a high petrographic factor of 10, because of its softness, friability and mineral content, is not usually used as an aggregate. However, it may be used extensively as a raw material in Portland cement and in some lightweight aggregates. It may also be used as a fill or ballast for road construction.

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

Conglomerate has a high petrographic factor range of 1 to 10 and a usual factor of 6 when fresh. It is not used normally as an aggregate, because of its weak internal cement, which may break down during handling of the rock. However, some cemented homogeneous conglomerates (i.e., those composed of mainly volcanic or granitic particles) may be used as armour stone for breakwater construction. Argillite has a petrographic range of 3 to 6 and a usual factor of 6 when fresh. Although it is not normally used for aggregate it may be used for road fill and as a raw material for the ceramic industry, brick manufacturing and refractory materials.

Igneous rocks of the Avalon Peninsula have been subdivided on the basis of coarseness. Medium- to coarse-grained rocks are generally plutonic (intrusive), and the fine grained rocks are volcanic (extrusive).

In this report, intrusive rocks are classified as granite, diorite, monzonite, gabbro and syenite and extrusive rocks are classified as rhyolite, andesite, basalt, dacite and pyroclastics (tuffs and breccias). The above igneous rocks have petrographic factors ranging from 1 to 6 and a usual factor of 1 when fresh.

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

The medium- to coarse-grained intrusive rocks mentioned above are all excellent sources of aggregate material, and can be used for industrial and architectural purposes. The industrial uses include crushed stone for road construction, dams, bridges, pavement, retaining walls, railway ballast and foundation blocks. Architectural uses include dimension stone for ornamental and structural use in monumental structures, private, residential, commercial and institutional building complexes.

Fine grained extrusive volcanic rocks are usually excellent aggregate materials, but care should be taken when they are used in concrete. Highly siliceous rocks may react chemically with the high-alkali cements, resulting in progressive deterioration of the material. The volcanic rocks that may react are rhyolites, dacites, and andesites. The extrusive rocks may be used for the same purposes as their intrusive counterparts.

Metamorphic rocks may be suitable or unsuitable for aggregate use depending on their mineralogical character. The only metamorphic rock noted on the Avalon Peninsula is slate. This rock is usually unsuitable for aggregate use because of its mineral content, distinct cleavage and softness. It is used extensively, however, as dimension stone for a number of purposes such as roofing and floor tiles. The petrographic factor of slate is 10.

LABORATORY INVESTIGATION

Petrographic examination (ASTM method C-295.65, 1973) and C.S.A. Standard A23.2 (1973)) is being carried out on all hand specimens and thin sections. Petrographic examination involves determining the quality of the rock sample by identification of microstructures (fractures in the

crystals) and altered minerals due to weathering or metamorphic factors.

The Magnesium Sulfate Soundness test ASTM (88-78), which is used to indicate the durability of a aggregate, was also carried out on random samples. This test involves placing a quantity of the sample (300 grams) 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 (110°C). 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 of loss.

The Los Angeles Abrasion Test (ASTM-C131-69) for small-size, coarse aggregate was also conducted on randomly selected samples. This test consists of placing a 5-kg sample in a horizontal steel drum, containing a number of steel balls. The drum is rotated for 15 minutes at 33 revolutions per minute. After the test, the sample is sieved and the percentage of loss is calculated.

SUMMARY

A total of 517 sites were visited and 537 samples collected during the two field seasons of the project. Thin sections were made of all the samples and petrographic analyses is presently underway.

A more comprehensive report is scheduled for publication in the spring of 1988, and will give detailed descriptions of each site and sample. This will eliminate certain sites for aggregate use and promote others. The report will provide a data base for the exploitation of bedrock for aggregate and architectural purposes on the Avalon Peninsula.

REFERENCES

American Society for Testing and Materials
1973: Annual ASTM standards, C88-73, C295-73.

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

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

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.

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

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

Williams, H. and King, A.F.
1979: Trepassey map area, Newfoundland. Geological Survey of Canada, Memoir 389, 24 pages.