Appendix 4.

Important Characteristics to Consider When Evaluating Granitic Rocks in Glaciated Terrain

There are numerous geological features typical of granites in the region, which may have implications for the sampling procedure and the conclusions drawn in this report. These characteristics are also important because they can have an impact on the quarrying process and issues pertaining to the environment. They may also have legal and financial ramifications for a company that has not applied due diligence at the site before opening the quarry. A schematic cross-section of the granitic bedrock in the South Mountain Batholith (Fig. 10) has been constructed (Prime and White, 2004) to assist in the discussion. The reader is cautioned that this composite sketch of the granites does not contain all characteristics which would affect aggregate potential. It is also unlikely that any granite deposit would contain all of the features shown here, although one should expect to find at least some of them within the dimensions of a typical granitic aggregate deposit.

The discussion will begin with a look at outcrop typical of the South Mountain Batholith. Features 1 and 2 are fairly characteristic of bedrock exposures observed in the study area. Although they can be quite large in road cuts or along streams and lake shores, exposures are typically only a few square metres of surface area and widely scattered. The area between the outcrops is generally hidden by surficial deposits of till and forest cover. Geological maps of the South Mountain Batholith show that the total bedrock exposure is only a small fraction of the land surface in most areas. Thus the field observations, samples collected, and conclusions drawn in this study are based on limited outcrop information.

The cross-section also illustrates how relying on outcrop can lead to erroneous interpretations about the geology and resource potential of the area. Although exposures 1 and 2 are typical of the majority of the bedrock in the diagram, there are a variety of features that could influence aggregate potential. One important characteristic that can affect aggregate quality is weathering associated with joint spacing in the granites. Because the joint fractures are pathways for water entry, there is a narrow zone next to each fracture face where the mineralogy has been affected by migrating fluids. The fluids can cause physical changes through the breakdown and leaching of minerals, and through chemical changes that transform some of the minerals to others (e.g. feldspar to kaolin). These processes tend to make the rock near the fractures less durable and more subject to water absorption. The degree of alteration along fractures appears to be related to factors such as the mineralogy of the rock, grain size and microfracturing. Altered zones adjacent to joints typically vary from a veneer to a few millimetres in thickness. In extreme examples the weathering can be centimetres in thickness. The effects of this fracture-related weathering on aggregate quality would depend on the frequency of the joints and the intensity of the weathering. It generally appears to be most common in near-surface bedrock of some of the coarse grained granites.

Surface samples taken from exposures 1 and 2 would also be affected to some degree by surface weathering. From deglaciation to the present a host of physical and chemical processes have influenced the bedrock near the surface, causing alteration, leaching and fracturing, and leading to a reduced durability in the rock. The agents responsible include seasonal freeze-thaw cycles, frost action, runoff, fluctuations in groundwater, acid rain and physical and chemical changes associated with vegetation. The effects are most noticeable in outcrops where recently exposed bedrock is continuous with natural exposure. The natural bedrock surface, which has been exposed for more than 10 000 years, is commonly textured and pitted. The recently exposed portion of the outcrop, typically unearthed during the construction of an

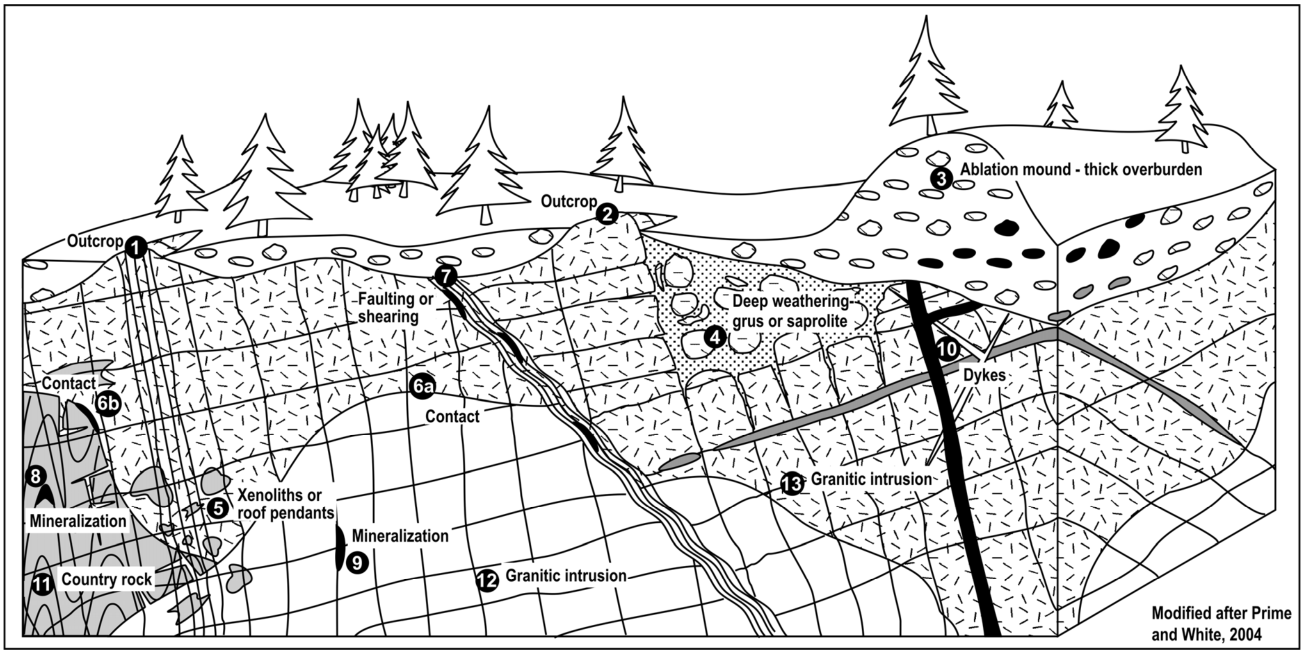

Figure 10. Schematic block diagram of the South Mountain Batholith illustrating features that may affect aggregate quarry development in these granitic rocks. Features: (1) and (2) outcrop; (3) ablation mound - thick overburden; (4) deep weathering - grus or saprolite; (5) xenoliths or roof pendants; (6a) contact between different phases of granitic intrusions, and (6b) contact between granitic phase and country rock; (7) faulting or shearing; (8) sulphides or other metallic minerals within the country rock that has been intruded by the granite; (9) sulphides or other metallic minerals within the granitic body; (10) dykes; (11) country rock; and (12), (13) various phases of granitic intrusions.

access road, is usually smooth and 'fresh' in appearance. As little as a few centimetres of till cover can provide significant protection to the surface of the rock. The effects of rain water and freeze-thaw cycles on granites are commonly observed on the upper side of partially to completely exposed glacial boulders where exposure to the weather for millennia has resulted in rough, irregular surfaces. Where the more protected underside of the boulders can be seen, because they have recently been overturned by excavating activity or are naturally 'perched' on other rocks, the weathering is usually significantly reduced and the surface is smoother. Severity of the weathering also depends on the rock type and other geological characteristics of the stone. It is particularly noticeable in coarse grained granites. The thickness of this surface 'rind' can vary from a couple of millimetres to centimetres in depth. In contrast, the comparably impermeable metamorphic sandstone in the Meguma Group in the region typically produces very minor surface weathering.

In general, rock at the surface usually exhibits a greater degree of weathering than at depth. The problem can be compounded by the presence of subhorizontal, near-surface fractures related to ice deloading associated with deglaciation. The release of load pressure when the ice melted commonly caused near-surface exfoliation cracks or sheet-jointing in some of the bedrock. The network of near-surface fractures would probably have been intensified by freeze-thaw cycles, particularly in the early stages following deglaciation when seasonal melting and freezing of the upper area of the permafrost zone was common. Collectively these characteristics can have negative implications for any surface samples that are retrieved for test purposes. Because the effects of surface-related fracturing and weathering are reduced with depth, samples should ideally be collected in the subsurface rock. This might vary from a few centimetres to a couple of metres depending on the history of postglacial weathering. At this depth the rock should be fresher in appearance and more representative of the rock body as a whole. Costly diamond drilling or test hole blasting using an air track drill would be necessary to obtain samples at this kind of depth.

Areas of faulting or shearing (Feature 7) are zones of weakness in the rock regardless of depth. These structurally or mechanically weakened areas in the rock create major networks of fractures which become pathways for fluid migration. The rock can be friable or contain soft minerals that negatively impact aggregate quality. Faults can also contain brecciated rock or fault gouge, which create weaknesses in the rock. Collectively the rocks in these zones would be mechanically weakened for aggregate purposes.

Faults, shear zones (Feature 7) and other lithological contacts (Features 6a and 6b) can also be areas of mineralization. Over time, they can create the physical and chemical conditions leading to the precipitation of a variety of metals and minerals from fluids migrating through the rocks. As a result, these zones have a higher probability of containing harmful mineralization or acid-generating sulphides.

Sulphides and other metallic minerals can also be present in locations unrelated to shearing or lithological contacts. For example, they can be found within a granitic body (Feature 9) or in the country rock (Feature 8) that the granites have intruded.

Although it must be emphasized that environmental problems associated with mineralization are quite rare in the granites, their presence could have serious consequences for site development. Finding unacceptably high concentrations of sulphides in a newly opened quarry could be costly for the environment and the producer. Discovering a harmful metal (e.g. uranium, arsenic or lead) several years into the development of a quarry site and distribution of its materials could have much broader implications for the producer and the community. Scrutinzing a potential aggregate deposit for mineralization by examining and sampling scattered outcrops would be ineffective. Ideally, a diamond-drilling program, trenching and possibly a geophysical survey should be conducted in order to determine the presence or absence of these materials. Although costly, these methods also provide the opportunity for a detailed evaluation of the aggregate reserves. However, because of the costs associated with this work and small likelihood of there being a problem in this geological setting, the operator may prefer to closely monitor the quarry for mineralization as it advances into the deposit. This should be done by a qualified geoscience professional.

Research by Prime and White (2004) suggested that areas adjacent to contacts between different phases of granitic rocks (Feature 6a) may produce inferior stone. Although the reasons are uncertain it may be caused by the presence of alteration minerals at some locations.

Xenoliths or roof pendants (Feature 5) may affect aggregate quality depending on the proportion of these rocks in the granitic deposit and their mineral composition. Small inclusions should not have a significant impact on the rock, but larger bodies, particularly if they are schistose and micaceous, could cause problems for an aggregate source. These platy fabrics can be soft, producing zones of weakness and are vulnerable to water entry and freeze-thaw cycles.

Feature 4 shows an area of the South Mountain Batholith with a deep weathering profile in granite. The grus or saprolite found here is, by definition, altered and highly fragmented. These loose, friable rocks are unacceptable for high quality aggregate and would have to be stripped away as overburden. The rock beneath this material gradually becomes more solid with depth, but it would also contain characteristics that would make it unsuitable for high quality aggregate. Narrow zones of saprolite in the deposit may be tolerable, but if the goal is to extract high quality aggregate these materials should be avoided. Weathering is common in the coarse grained rock of the South Mountain Batholith.

Depth of overburden is an important consideration because all surficial materials must be stripped away before quarrying can occur. Thick overburden is undesirable because it is costly to remove. Landforms such as ablation mounds (Feature 3) could result in a site being uneconomic for development. Ideally, a site should have minimal overburden for quarrying, but some surficial materials are preferable for reclamation of the site. Determining if a hill is primarily bedrock with thin overburden or a mound of thick till is often difficult to establish based on a field examination of the land surface. Commonly this can only be determined by drilling or trenching.

The presence of dykes (Feature 10) could have an impact on the quality of a deposit, depending on their lithological characteristics and abundance in the host rock. A fine grained durable rock such as aplite would probably enhance the aggregate potential of the deposit. The brittleness and coarse grained nature of the feldspar in a feldspathic pegmatite dyke, on the other hand, would most likely reduce the overall quality of the rock. Although dykes are not necessarily a problem, a high volumetric proportion of dyke rock could have significant implications for an aggregate deposit.

Although the location of outcrop in a glaciated terrain may appear to be random, there are geological factors which can influence where it is found and the quality of the rock observed. One of the most significant factors in terms of aggregate potential is the durability of the rock and its susceptibility to erosion. If the rock is particularly hard and resistant to erosion (a situation which may occur at Feature 2), there is a higher probability that it will be elevated above the surrounding, weaker bedrock and exposed in areas of thin glacial deposits. Conversely, a soft or friable rock such as grus (Feature 4) may be preferentially eroded by the glacial ice to create hollows in the bedrock surface. These low areas have a greater tendency to be infilled by till and hidden from view. Thus, there may be a bias in terms of which rock is exposed. If this preferential exposure of the bedrock is present, it might lead to the conclusion that the deposit has better aggregate potential than actually exists. A more detailed discussion of differential glacial erosion is presented by Prime (2001; p. 14 and Fig. 12).

In summary, the bedrock in the study area can contain a variety of characteristics that would make it unsuitable for quarrying. Examining and sampling scattered surface exposures with the goal of identifying aggregate potential has serious limitations. The outcrops are more or less, ‘random windows’ into the bedrock which may or may not be representative of the larger body of stone. In the absence of diamond drilling or trenching, one can only speculate on the overall composition of the granite body. On the positive side, the granitic bodies of the South Mountain Batholith tend to be homogeneous over large areas. Thus, many attributes such as grain size and mineralogy of the rock are quite predictable. The characteristics which are more difficult to foresee are shear zones, weathered areas and thick tills not detectable by the geomorphology of the landscape. The data presented in this report should only be seen as a first step in determining the location of a high quality aggregate deposit.