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Saskatchewan Stone

Preliminary Investigations

by G. Pearce and P. Guliov

1996



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Cover: Polished slab of Mystic Lake "Verde Antique" stone from the Creighton-Amisk Lake area (photo by K. Jones, Visual Memories).

Title page: Porphyritic-textured Phantom Lake granite, Creighton-Amisk Lake area (photo by G. Pearce).

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Foreword

Funding for the preparation of this report was provided by Natural Resources Canada under the Canada-Saskatchewan Partnership Agreement on Mineral Development.

It brings together all work done to date on Saskatchewan building stone resources and its purpose is to provide a sampling of the wide variety of attractive stone types to be found in the Province and to stimulate its investigation and, hopefully, development.

It should be noted that work done on the deposits described in this report is in no way adequate to establish the commercial viability of any particular deposit.

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Acknowledgments

This report is the culmination of the efforts of individuals from the private sector and the Saskatchewan and Federal Governments. Data were collected during the course of projects funded severally by Natural Resources Canada (formerly Energy, Mines, and Resources) and Saskatchewan Energy and Mines.

The concept of grassroots regional exploration for stone was conceived by Paul Guliov of Saskatchewan Energy and Mines. Mr. Guliov selected promising accessible areas, managed the various projects, and authored the first information report entitled "Stone in Saskatchewan".

Other officers of Saskatchewan Energy and Mines gave freely of their time and expertise both to Mr. Guliov and to consulting firms engaged in the identification and evaluation of stone resources. Most notably, D.J. Thomas and J. Pearson deserve mention.

This report has been compiled by Gary H.K. Pearse of Geo-Agricola Inc. from data, figures, and photos extracted from the studies credited below.

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- Natural Resources Canada: La Ronge area granites
- National Testing Laboratory Ltd.: Limestone Lake dolomite
- John D. Patterson and Associates Ltd.: Creighton-Amisk Lake and Johnson Lake-Pelican Narrows areas granites, marbles, and ornamental stones.
- Close-up stone photos: K.G. Jones (Visual Memories), R. Bredin, and production editors P. Guliov and G.H.K. Pearse
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- W. and B. Kent Fieldstone Masonry, Saskatoon: dolomite and bulk samples
- Geo-Agricola Inc., Ottawa: Granite, marble, and ornamental stone bulk sampling, sample preparation for Creighton-Amisk Lake and Johnson Lake-Pelican Narrows

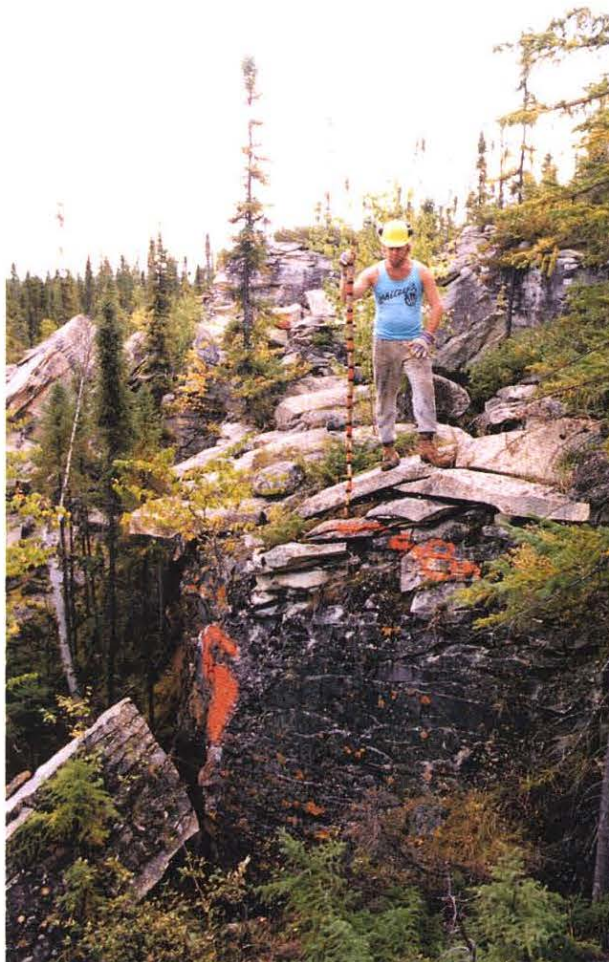
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- G.H.K. Pearse of Geo-Agricola Inc., Ottawa

Introduction

Humankind's intimate relationship with stone goes back to the misty beginnings of the race itself, appropriately termed the Stone Age. Indeed, tools, weapons, and other artifacts crafted from stone are frequently the only surviving clues to prehistoric human culture and activity.

Quarrying and stone shaping skills for architecture and art on a large scale were already well advanced by the third millennium B.C. In Egypt, and in the ensuing ages, human achievements were gauged in large part by the grandeur of their creations in stone.



Field examination of a prospective stone resource.

During the 20th century, science and technology created a variety of alternative materials for construction - concrete, glass, steel, aluminium, and plastics - that relegated stone to a minor decorative role and all but closed the stone industry in Canada and elsewhere.

In recent years, major cost-cutting advances in stone quarrying and processing technology and the incomparable beauty of this medium have brought stone once again to the forefront of interest for architects and the general public. Growth in stone production around the world has been phenomenal during the 1980s and resumption in these trends can be expected with full recovery from the present economic recession. It could be said that a new Stone Age is in the making.

The resurgence of stone has spawned interest in new resources around the world and with it



Outcrop quarried by lake ice offers a preliminary quarriability assessment.

new departures. The classics (white and black marbles; pink, grey, and black granites; grey and buff limestones and sandstones) remain popular to be sure. However, introduction of shimmering blue anorthosites (Blue Pearl), banded gneisses, highly coloured banded marbles, porphyritic granites, and other exotic stones has awakened builders and architects

to the hitherto unsuspected variety and beauty to be had in this venerable material.

Perhaps least expected of all is that Saskatchewan has promising resources of not only several of the classics but also of exotic stone varieties to rival the best from anywhere.

Overview and Scope

An earlier report, "Stone in Saskatchewan", published in 1989, was based on investigations funded under the former Canada-Saskatchewan Mineral Development Agreement. Since that time, other attractive stone prospects have been identified by regional exploration projects funded by Saskatchewan Energy and Mines.

Work to date has identified a wide variety of accessible stone types that show excellent promise in terms of aesthetics, quarriability, engineering properties, and reserves. Colourful marbles rival the famous red, buff, and yellowish marbles of Verona, Italy, which they resemble. Granites of vivid colours including a jade-green stone and an assortment of unique ornamental stones have been identified. A dark greenish to black stone with white and red veining, surpasses in beauty and engineering properties the well-known Verde Antique type of Italy and Vermont. Some of these stones have been displayed at Canadian and United States expositions where they received an enthusiastic response from the international stone industry.

Although much development work remains to be done, the two main objectives of the study are well on their way to being met:

- a) Preliminary fieldwork, quarry tests, cutting and polishing trials, and engineering tests indicate that Saskatchewan is endowed with a rich variety of stone resources of superb potential.
- b) A stone industry based on these resources has begun in a small way. Graham Construction Ltd. has started to develop dolomite at Deschambault Lake and the stone was used in the construction of the new Agriculture building at the University of Saskatchewan. As well, Eagle Stone is test quarrying Sahli granite in the Pelican Narrows area.

This report is a compilation of all significant work done to date on Saskatchewan stone resources. Information is organized by region rather than by stone type reflecting the regional nature of the investigations. Accordingly, resource data are presented under the following headings:

- a) Lac La Ronge Area,
- b) Johnson Lake–Pelican Narrows Area, and
- c) Creighton–Amisk Lake Area.

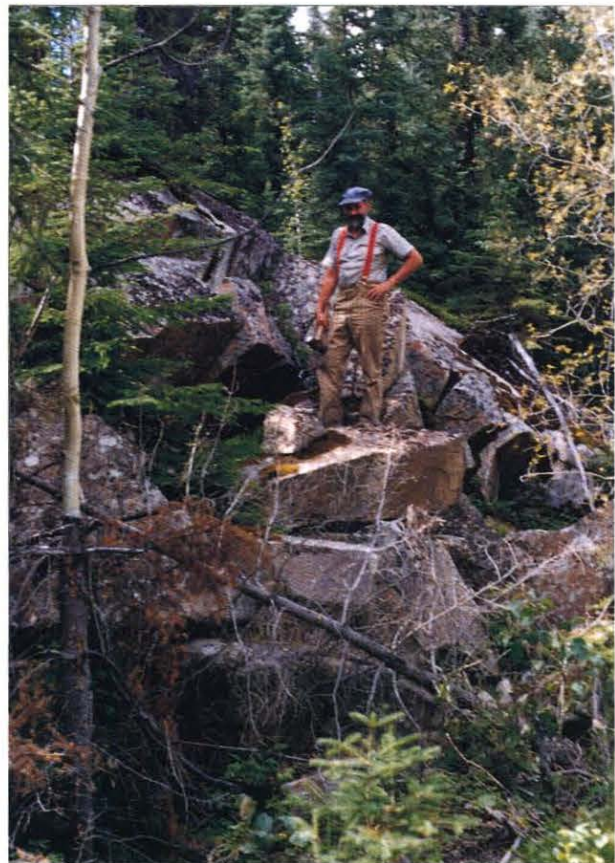
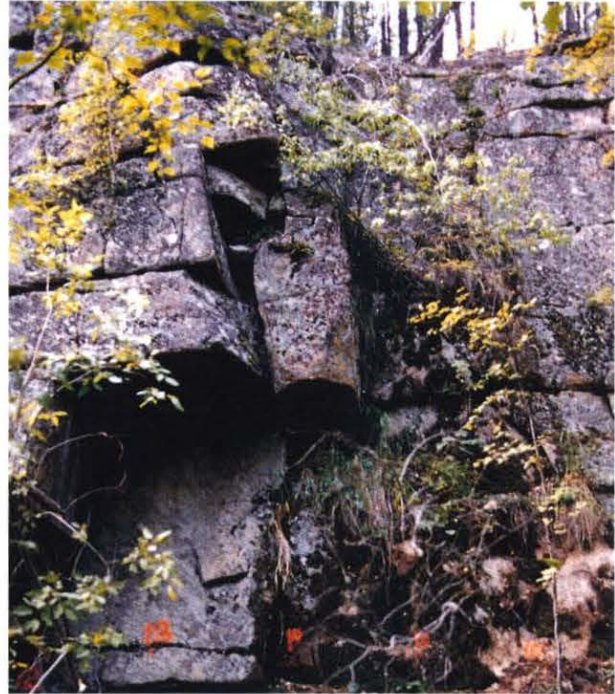
The work reported is preliminary and indicative only. Although considerable optimism for the best of Saskatchewan stone resources is justified on the basis of work to date, no decision should be taken to put a given resource into production without doing rigorous, site specific, technical, and economic feasibility evaluation. Such work may well disqualify a prospect that showed excellent characteristics in a preliminary study. Nor can it be claimed that the surveys have identified all or the best of accessible resources to be found. Only resources within a few kilometres of good roads have been examined and, given the vast area covered, some good prospects have been undoubtedly overlooked. Also, a good stone 10 to 20 kilometres away from the roads would pay the cost of construction of access to it. The resources selected for this report should, therefore, be interpreted only as a sampling of what is to be found in Saskatchewan. For those who wish to explore further, excellent geological maps are available to serve as a guide.

The investigations varied in their degree of identification of the resources studied. In the Lac La Ronge area, six granite deposits were chosen from the 23 known and a single traverse was done on each. Selection was based in large part on proximity to Highway 102. Small samples were taken for cutting and polishing and general observations on the terrain and fracture spacing were noted. This work

was done as a first look to see if the Precambrian in Saskatchewan might yield acceptable building stone resources. The investigations did not rule out the remaining 17 granite bodies in the area. Indeed, the larger bodies may provide the best possibilities for large uniform stone reserves.

Work done in the Creighton–Amisk Lake and the Johnson Lake–Pelican Narrows areas involved more detailed traverse coverage, fracture analysis, and quarry block sampling. Detailed stratigraphy of the marble formation (Red River Dolomite) was measured and described from the base to the 18.5 m level near McNally Lake. This is about two-thirds of the total thickness of the formation in the area. Diamond drilling was done at one locality only. This was part of the development work at Deschambault Lake.

In keeping with the purpose to familiarize the stone industry and others with the variety and beauty of the stone resources potentially available in Saskatchewan, the text is well illustrated with maps and photographs. Representative stone samples are available for viewing at Saskatchewan Energy and Mines in Regina.



Nature's quarry provided a good first appraisal.

Regional Exploration for Stone

Building stone development has traditionally been the domain of the quarryman, whose range of skills does not commonly include a knowledge of geology. Similarly, the stone craftsman's skills are largely unfamiliar to much of the geological fraternity. Because of this, development of the world's stone resources has been incidental in nature. Only the more obvious, near-at-hand occurrences or special ones that have come to the craftsman's notice during some other activity, have been developed.

The dominating factor in stone development is, therefore, the presence of stone craftsmen in an area, rather than the abundance of resources *per se*. For example, it is a long tradition in stone production and use that makes Italy the world's largest producer. Closer to home, it explains why there are 83 granite quarries in eastern Canada (65 in Quebec alone) and why of the 10 in Ontario, three are owned by Quebec producers, and one by a New Brunswick company. Clearly, Saskatchewan can't rely on the incidental development model to avail itself of the opportunities associated with world-scale building stone development. A program of resource identification and promotion is necessary. In the author's experience, such an approach can be most fruitful. A recent re-evaluation of quarries long-closed in Newfoundland and Labrador, coupled with a production demonstration project, resulted in this province once again becoming a granite producer with six quarries. Similarly, an evaluation and promotional project in Manitoba resulted in the opening of several quarries.

The difference in Saskatchewan is that, with no stone production experience, it was necessary to start from scratch with grassroots exploration projects - a new concept in building stone resource development.



Fractures should be evaluated for "healing" or attenuation with depth.



Lack of uniformity disqualifies this otherwise sound stone.

The technique involved several stages:

- 1) selection of promising accessible areas from geological maps;
- 2) reconnaissance along roads, lakeshores, and rivers;
- 3) compass traverses over selected deposits;
- 4) fracture analysis at selected sites;
- 5) quarrying small sample blocks for processing trials and ASTM testing; and
- 6) diamond drilling for information on fracture spacing, uniformity, and reserves.

The general criteria for field evaluation of a given prospect were:

- 1) Aesthetics; is the stone attractive?
- 2) Uniformity of colour and texture. Uniformity generally implies that the same colour and texture can be observed from one small sample to another (e.g. 30 cm floor tiles). However, for banded, veined and brecciated varieties, and volcanics exhibiting grosser structures (pillows, agglomerates, etc.), uniformity must be judged in terms of broader patterns. Such a stone may require one or more square metres of material to encompass a "unit of uniformity". To distinguish between the two types of uniformity the author uses the terms 'granular' uniformity and 'pattern' uniformity.
- 3) Adequate reserves for 10 plus years of production.

- 4) The presence of an orthogonal and/or widely spaced fracture system. Ideally, standard blocks of 1.5 m x 1.5 m x 2.7 m are sought, with minimum waste (generally below 50 per cent).
- 5) Freedom from unstable metallic minerals. Many ore minerals and pyrite will 'bleed' on exposure to weathering and stain stone-work. Magnetite tends to be stable and is acceptable in small amounts.
- 6) Other criteria include: adequate topographic relief to permit low-cost quarry development; reasonable access to a road network; availability of fill for access construction; etc.

It should be noted that the importance of any particular criterion varies with the character of the stone being considered. Where a stone was considered ordinary in an aesthetic sense, it was examined more intensely only if other factors were favourable. The rationale here is that, since such a stone would not fetch a high price, it should be cheap to quarry and be amenable to production of large blocks with minimal waste. Conversely, where a stone was judged to be aesthetically distinctive, lower standards for fracture pattern, waste factors, accessibility, etc. were deemed acceptable.

Sample blocks taken from promising deposits were slabbed and polished to evaluate potential finished products and samples were cut for engineering testing.

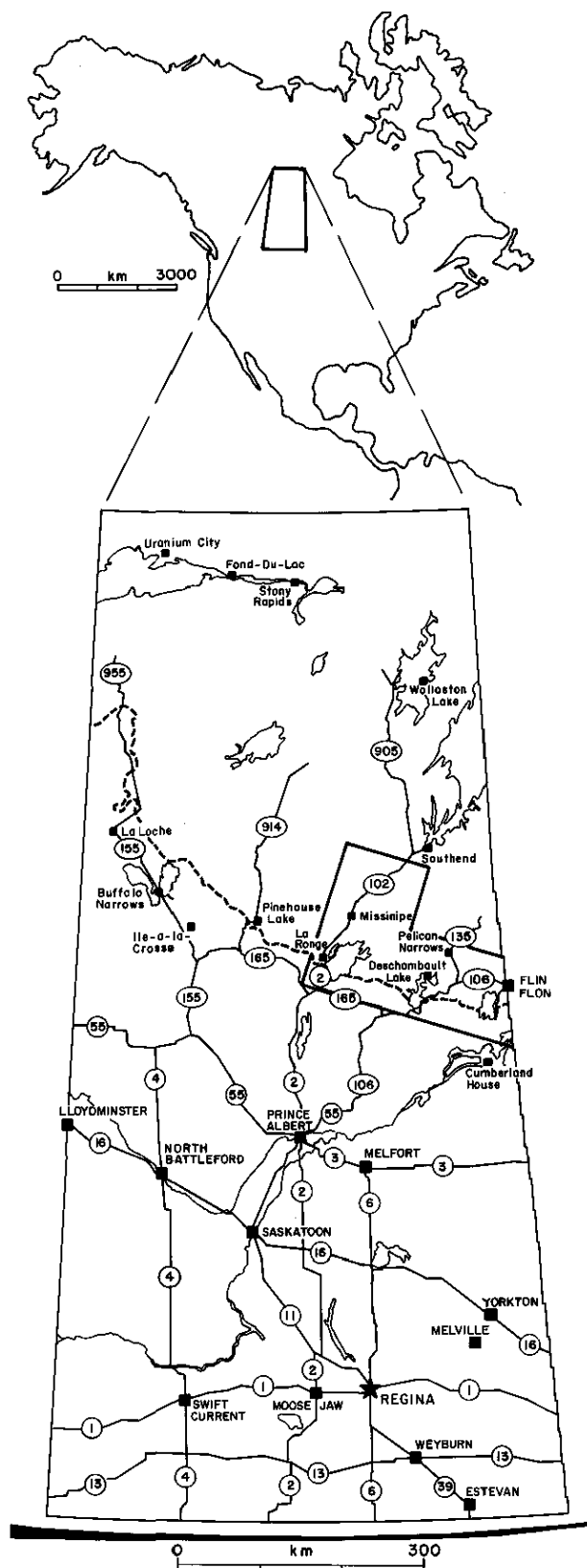
Location and Access

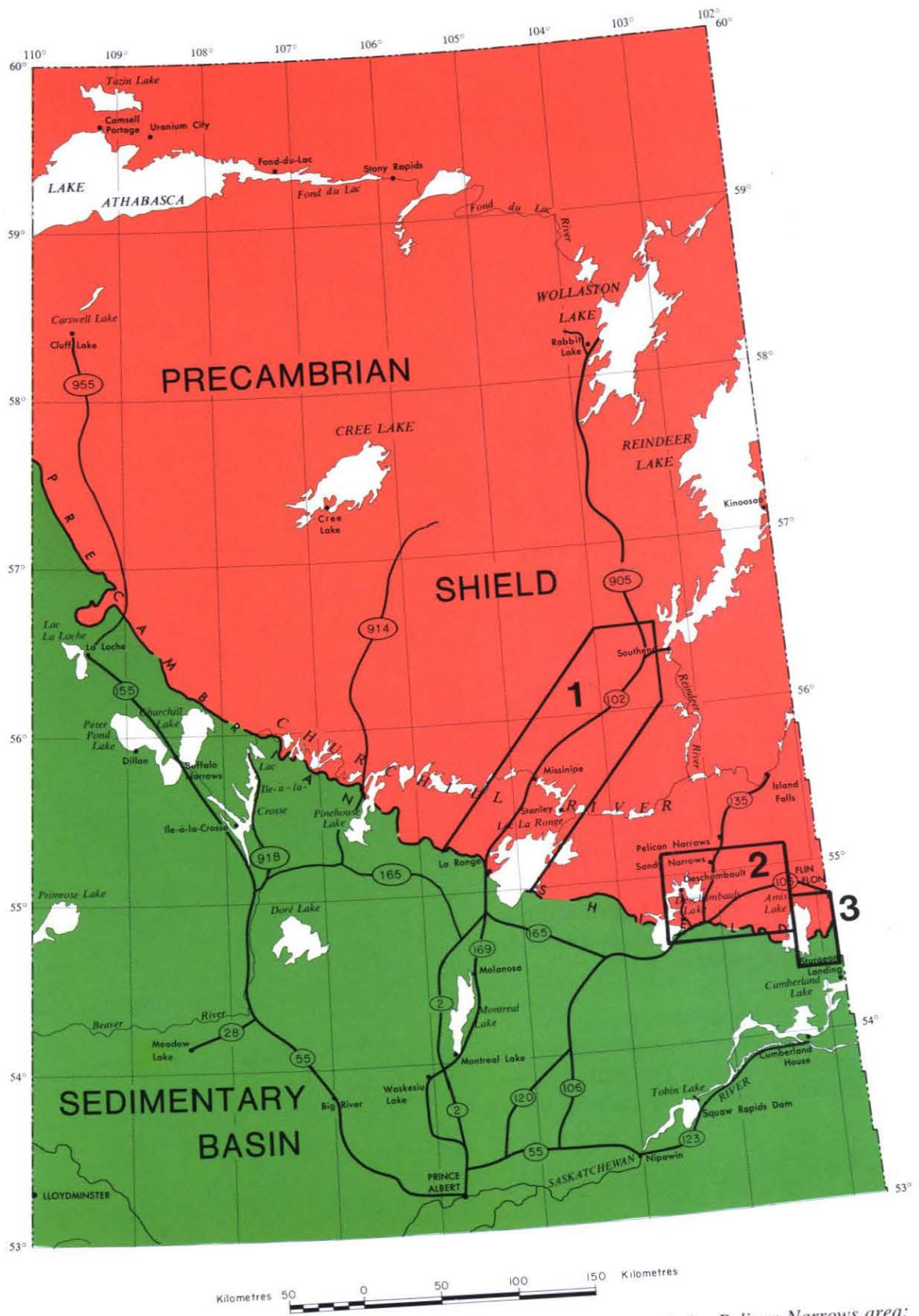
The premier hunting ground for granites of all varieties in Canada is the Precambrian Shield. Of some 100 quarries, about three-quarters are in the Shield with the balance being in younger crystalline rocks, mainly in the Atlantic Provinces and British Columbia.

In Saskatchewan, granites occur only in the Precambrian terrain of the northern third of the Province. Although road access is limited, four all-weather roads penetrate from 100 to 400 km into the Precambrian of Saskatchewan. Information in this report has been gathered from the areas transected by Highways 167 (Creighton–Denare Beach), 106, 135, and 102 as well as secondary roads issuing from these. Areas along Highway 905 to Wollaston Lake (which is an extension of Highway 102 from La Ronge), Highway 914 in the central region, and Highway 955 to Cluff Lake in the west, have not yet been examined for stone.

A series of connecting roads near and parallel to the Paleozoic-Precambrian contact (namely the westward extension of Highway 106, and Highways 165 and 155) provide access to the aforementioned roads and also to vast potential resources of marble (dolomite) along the Paleozoic escarpment. Highway 2 through Prince Albert or Manitoba Highway 10 to Flin Flon–Creighton provides access to the region from major centres.

For further regional prospecting, areas not served by road can be reached by float plane, boat or canoe utilizing the myriad of lakes and rivers which occur in all parts of this region.





Location map of building stone investigations. 1, Lac La Ronge area; 2, Johnson Lake–Pelican Narrows area; and 3, Creighton–Amisk Lake area.

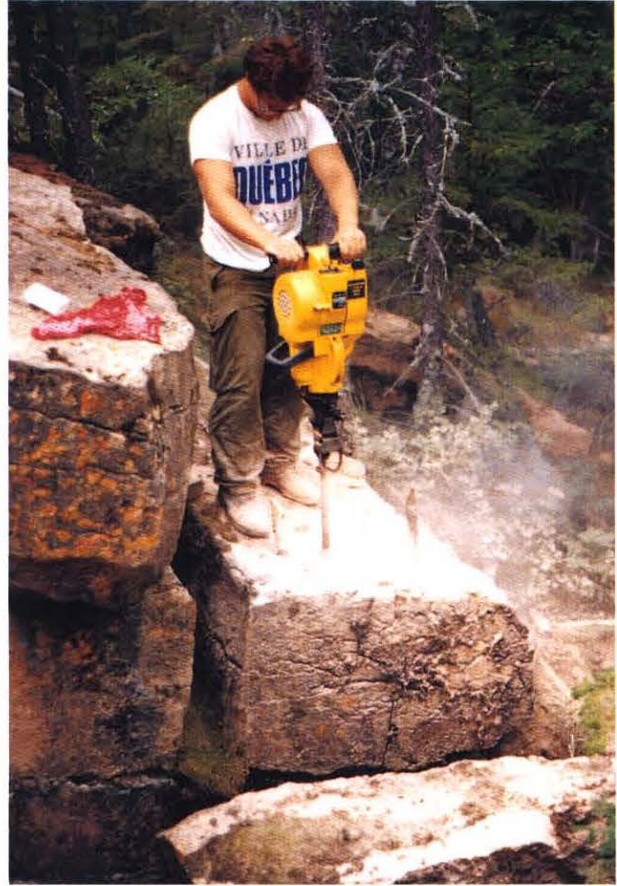
A Note on Stone Terminology

A glossary is provided in this report but a few words are appropriate for the benefit of the geologist whose understanding of shared terms differs from that of the stone craftsmen. For the stone specialist, igneous and metamorphic rocks that have a fine to coarse granular texture and take a high polish are termed granites. A dark gabbro, anorthosite, pyroxenite, amphibolite, etc. with a “granitic” or granular texture is called a black granite. Similarly, distinctions between true granites, granodiorites, diorites, monzonites or recrystallized metasedimentary rocks are made only on the basis of colour - they are all granites to the stone craftsman.

A similar heresy is to be found in the term marble. Marble includes the true recrystallized carbonates but also serpentinites and other rock types that show marble-like textures and patterns and take a high polish. Dense, indurated carbonate rocks like the Red River Formation dolomites, volcanic rocks, fine-grained dark metasediments with *lit-par-lit* bands, feldspar augen, etc. may be termed marbles.

“Rock” is used by the stone craftsmen to describe a finish on a stone product. Specifically, “rock-face” is the result of breaking a stone to produce a natural rough surface. For example, the top and sides of a polished grave stone may be “rock faced”.

Given that this report is based on evaluation of resources selected from the known geology of the region and the exploration-style approach, it is a hybrid of the two disciplines. Because of this, both stone and geological terms do appear in the report, but their distinctions are generally clear from the context of their use.



Compact dolomite (top) and metadiorite (bottom) are termed “marble” in the trade.

Selected Deposits

Lac La Ronge Area

The La Ronge Domain is the name given to a belt of metamorphic rocks intruded by granites (stone nomenclature) which extends north-easterly from La Ronge into the Reindeer Lake area. The belt is some 50 km wide by 300 km long and 23 major granite bodies are known between La Ronge and the south end of Reindeer Lake. This area is conveniently traversed along its length by Highway 102 from La Ronge. The granites range in area from a few to hundreds of square kilometres and most are within 12 km of the highway. Considerable variety occurs, ranging from light-coloured granite, monzonite, and granodiorite compositions to medium and dark coloured diorite and gabbro.

DIORITIC & GABBROIC PLUTONS



- 5. Basset Lake — greyish green-greenish black
- 17. Neyrinck Lake — light blue grey-greenish black

MATRIX ROCKS

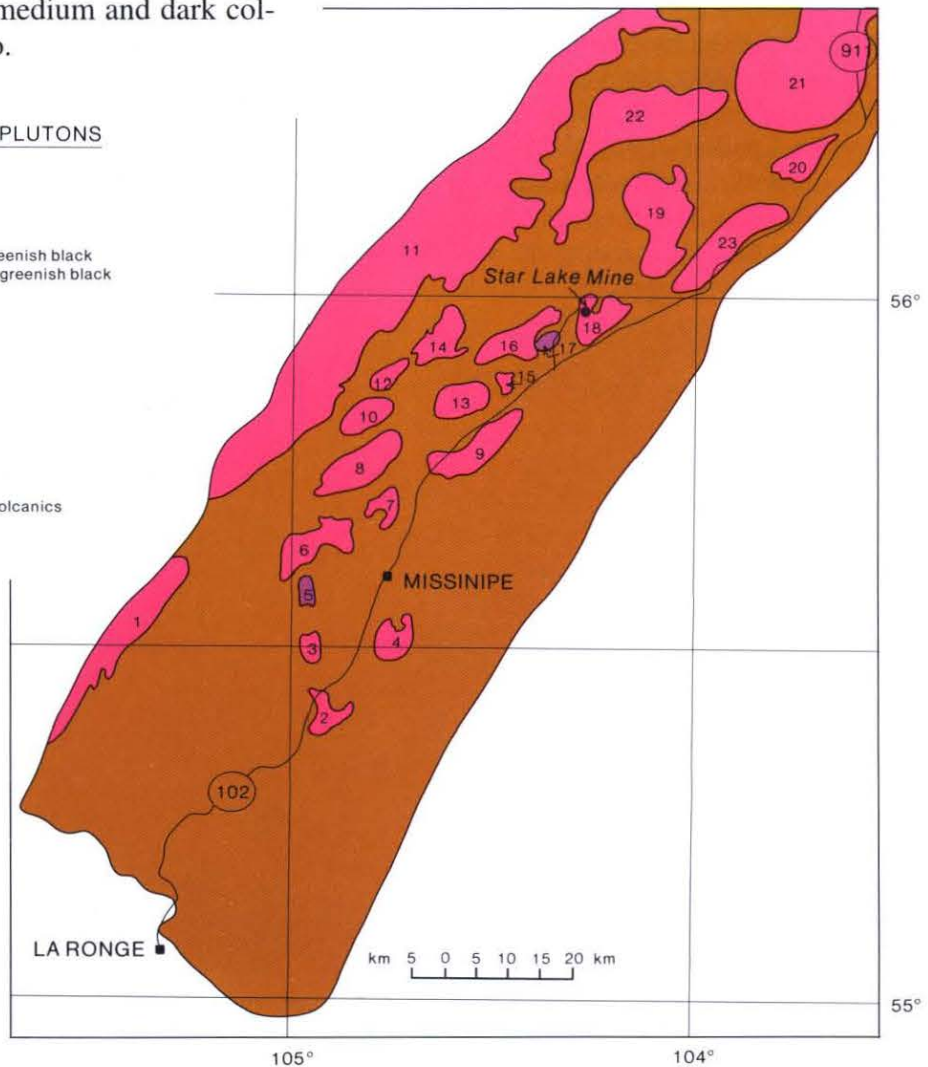


metasediments and metavolcanics

GRANITIC PLUTONS



- 1. Trout Lake — light-medium grey
- 2. Little Deer — orange pink-greyish pink-medium grey
- 3. Welk Lake — pinkish-yellowish grey
- 4. Bridgeman Lake — medium pink-orange pink
- 6. Onipooiwuk Lake — greyish-medium pink
- 7. Bernaski Bay — greyish-medium pink
- 8. Kruger Lake — yellowish grey-medium orange pink
- 9. Bervin Lake — yellowish grey-orange pink-pink
- 10. Moir Lake — very light grey-pinkish grey
- 11. Hickson Lake — grey-pink
- 12. Dreaver Lake — very light grey-yellowish grey
- 13. Ismond Lake — pinkish grey-orange pink
- 14. Brochu Lake — light-dark grey-pink
- 15. Wilson Lake — orange pink-light red
- 16. Gibbons Lake — very light grey-yellowish grey-pinkish grey
- 18. Star Lake, Island Lake — yellowish-pinkish grey
- 19. Brindson Lake — medium-light-pinkish grey
- 20. Contact Lake — pinkish grey-greyish pink
- 21. Nistoassini Lake — light-dark grey-pinkish grey
- 22. Kenwood Lake — medium-light yellowish grey
- 23. Payne Creek — medium-light-pinkish grey

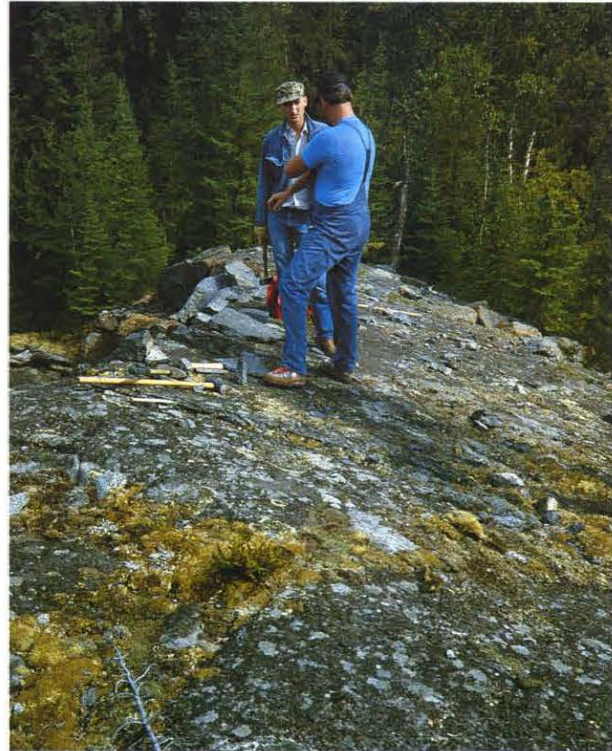


Neyrinck Lake Granite

Dark-coloured rocks of gabbroic to dioritic composition (commonly referred to as black granite in the stone industry) of the Neyrinck Lake pluton occur over an area of about 2.5 km by 2 km.

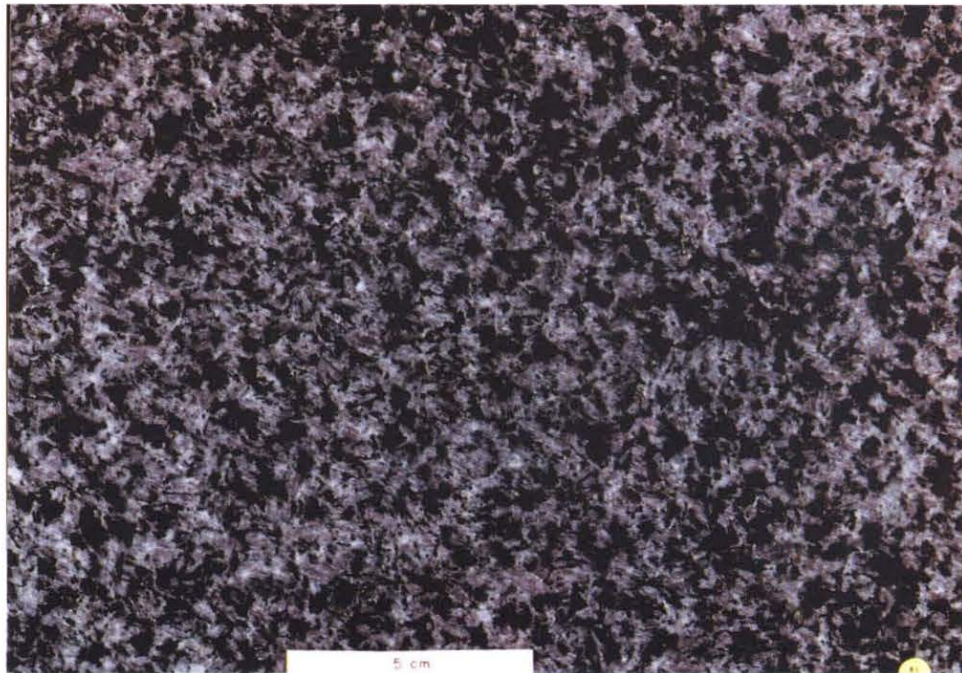
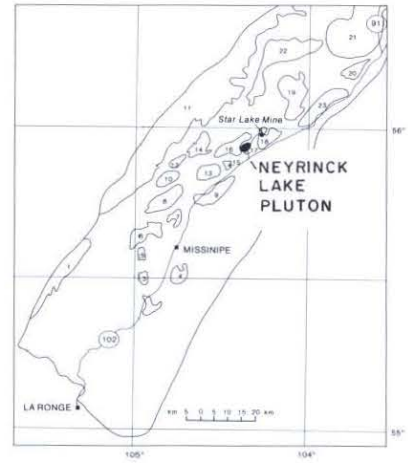
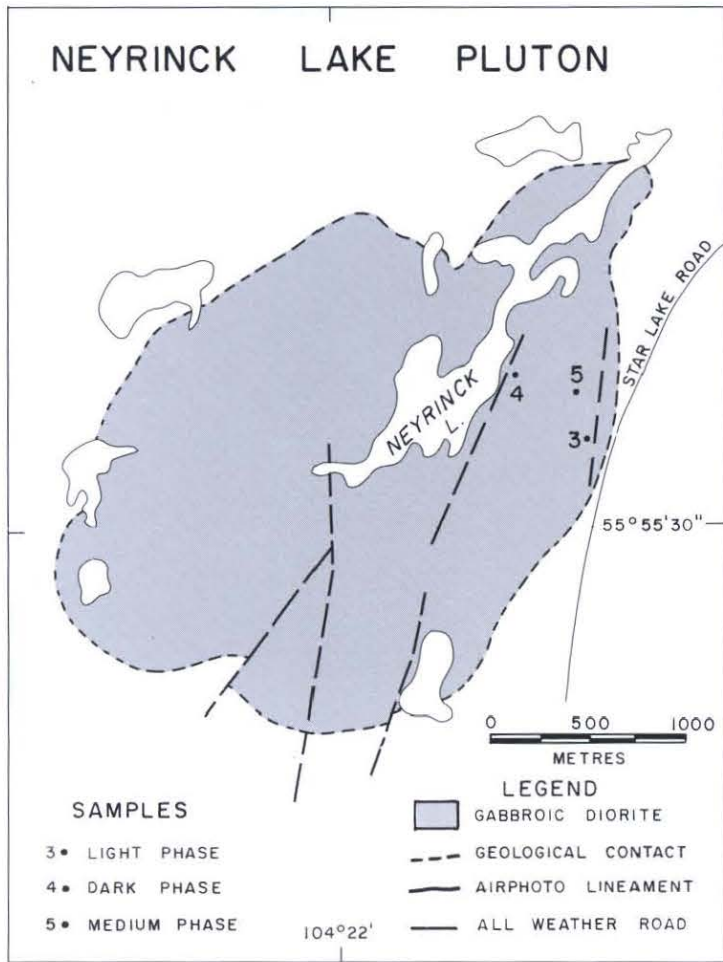
The eastern margin of the pluton is transected by the Star Lake Road about 3.5 km north of its junction with Highway 102. Ground cover is thin to absent and the rocks are exposed in many hummocks and broad ridges rising 20 to 30 m above Neyrinck Lake. The mineralogy comprises 15 to 50 per cent hornblende and 50 to 85 per cent plagioclase feldspar with traces of biotite mica, and rare pyrite, pyrrhotite, and magnetite. Hornblende clots up to 10 cm across and narrow dykes generally less than a metre wide are locally present. The range of hornblende and plagioclase composition yields three types of stone that appear to be separately quarriable: medium grey, bluish grey, and nearly black; they range from medium to coarse-grained. Locally centimetre-scale rhythmic layering is present. The rocks are commonly cut by two sets of steeply-dipping fractures: a dominant northwesterly set and a minor northeasterly set. These are commonly spaced greater than one metre apart. Horizontal fracturing results in a top sheet commonly 0.5 m thick and subsequent sheets of over a meter thick.

Tests were done on relatively small (surface) samples (not quarried) and results are therefore indicative only. All surpass ASTM standards and the absorption is outstanding.



Outcrop of massive gabbro, Neyrinck Lake Pluton.

	Dark Phase	Medium Phase	Light Phase
Compressive Strength (Mpa)			
Dry	246	217	249
Wet	247	178	178
ASTM V99: Modulus of Rupture (Mpa)			
Dry	15	16	13
Wet	15	15	10
ASTM C97: Specific Gravity			
	2.73	2.77	2.71
STM C97: Absorption %			
	0.03%	0.07%	0.17%

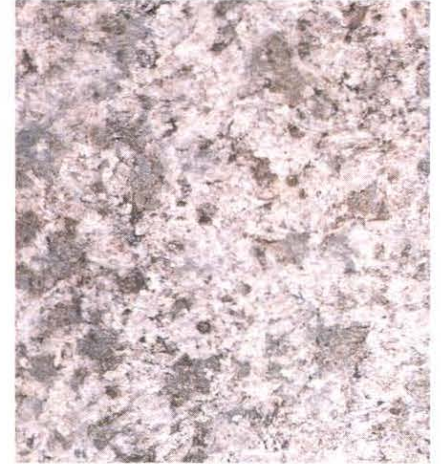


Neyrinck Lake Granite; polished.

*Neyrinck Lake gabbroic diorite
light phase*



*Neyrinck Lake gabbroic diorite
medium phase*



*Neyrinck Lake gabbroic diorite
dark phase*



polished

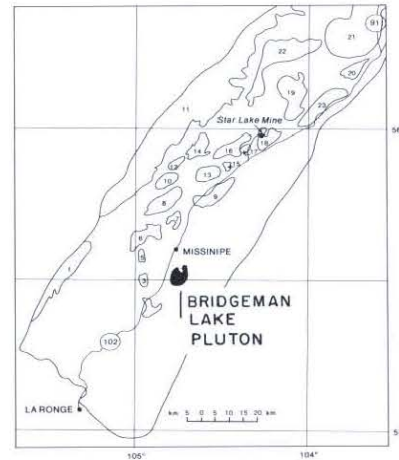
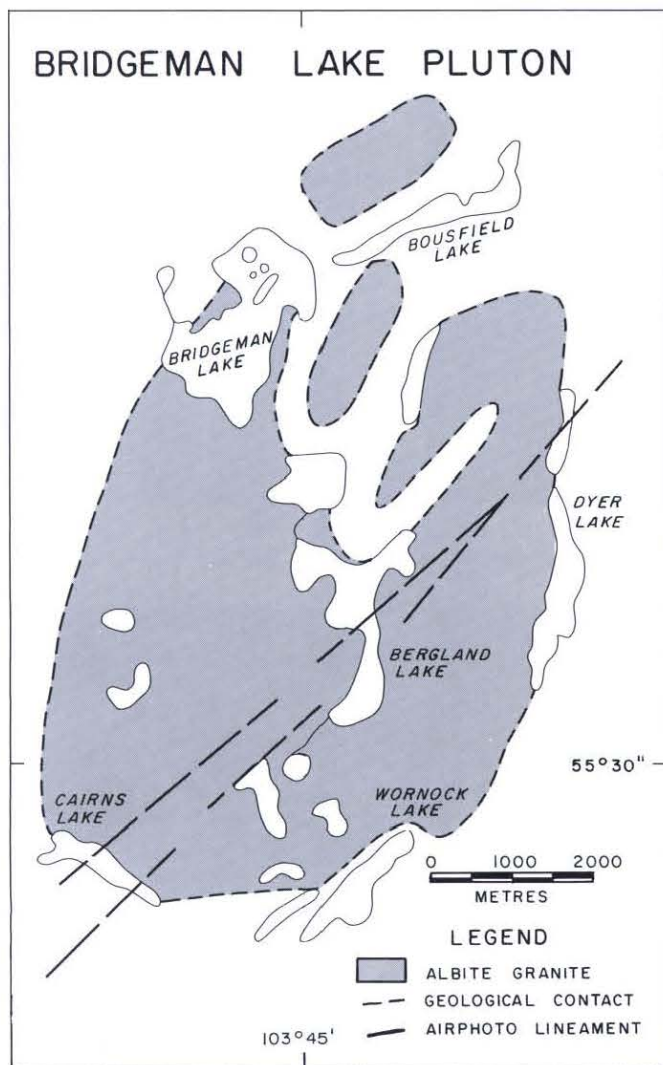
honed

flamed

Bridgeman Lake Granite

The Bridgeman Lake pluton is a biotite granite body extending over an area of about 8 km by 6 km and lying about 6 km south-southeast of Missinipe. The western margin of the pluton is about 1.5 km east of Highway 102. In the area west of Bergland Lake, the granite is well exposed in extensive bedrock uplands rising up to about 90 m above Bergland and Bridgeman lakes. It varies from

fine to coarse grained and contains scattered feldspar megacrysts throughout. The fine-grained phase is characteristically penetrated by deep pink, medium to coarse-grained feldspar-rich bands ranging from 2 to 20 cm thick. The coarse-grained phase is texturally more uniform. Nearly vertical joints are spaced from 20 cm to over 4 m while moderately dipping joints are less common and are spaced at 1 to 3 m. No quarry tests or engineering tests were done.

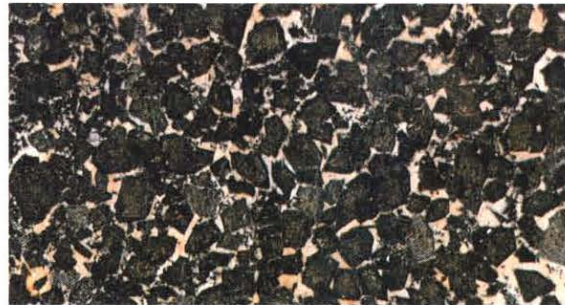


Bridgeman Lake Granite; polished.

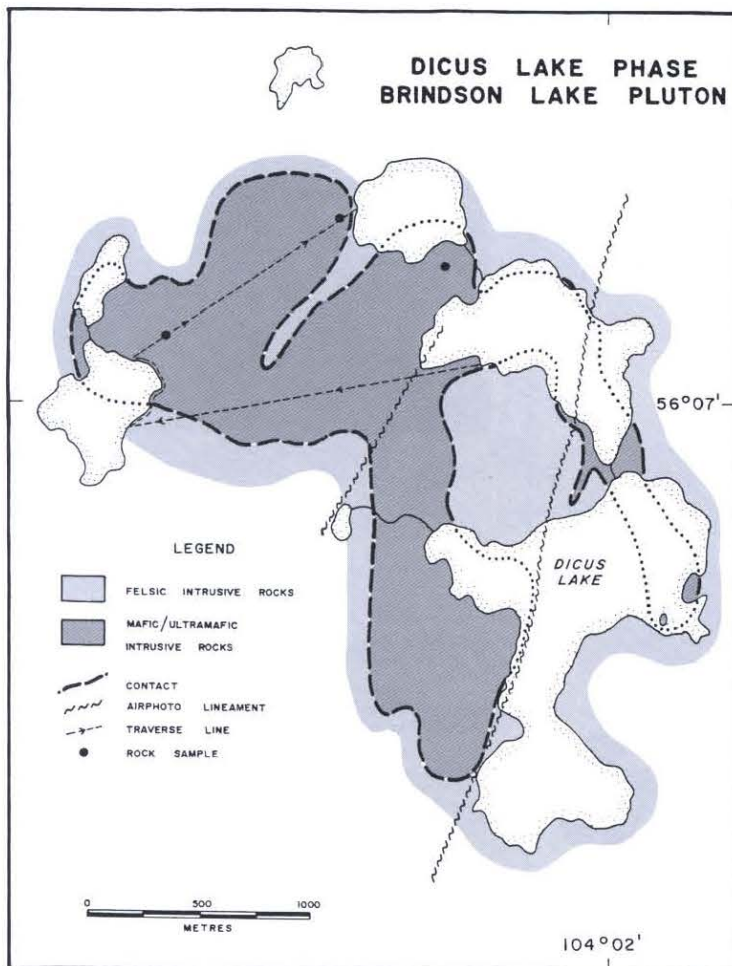
Dicus Lake Granite

The Dicus Lake body is a small (about 3 km²) gabbroic phase of a larger complex body known as the Brindson Lake pluton. The Dicus Lake body is located near the centre of the pluton about 9 km northwest of Highway 102 and is one of eight mappable phases. The physiography is characterized by high, round, steep-sided bedrock knobs and a total relief of about 40 m.

The most common rock type in the Dicus Lake body is a speckled black and white-weathering, medium-grained, equigranular, massive gabbro containing greater than 60 per cent hornblende and minor biotite. The lighter mineralogical component of the rock is light grey to pink feldspar varying from rounded to lath-shape. Magnetite and pyroxene are reported in the outer margin of the body. The



Dicus Lake gabbro; polished; polished.



rock contains a widely spaced, nearly vertical orthogonal joint pattern with little evidence of a horizontal joint set. Other phases of the intrusion were not evaluated but may yield other stone varieties.

On the basis of the dark colour index, which currently has a high market demand, and the widely spaced joint sets, the Dicus Lake gabbro is recommended for more detailed field investigations. No quarry testing or physical tests have been done.

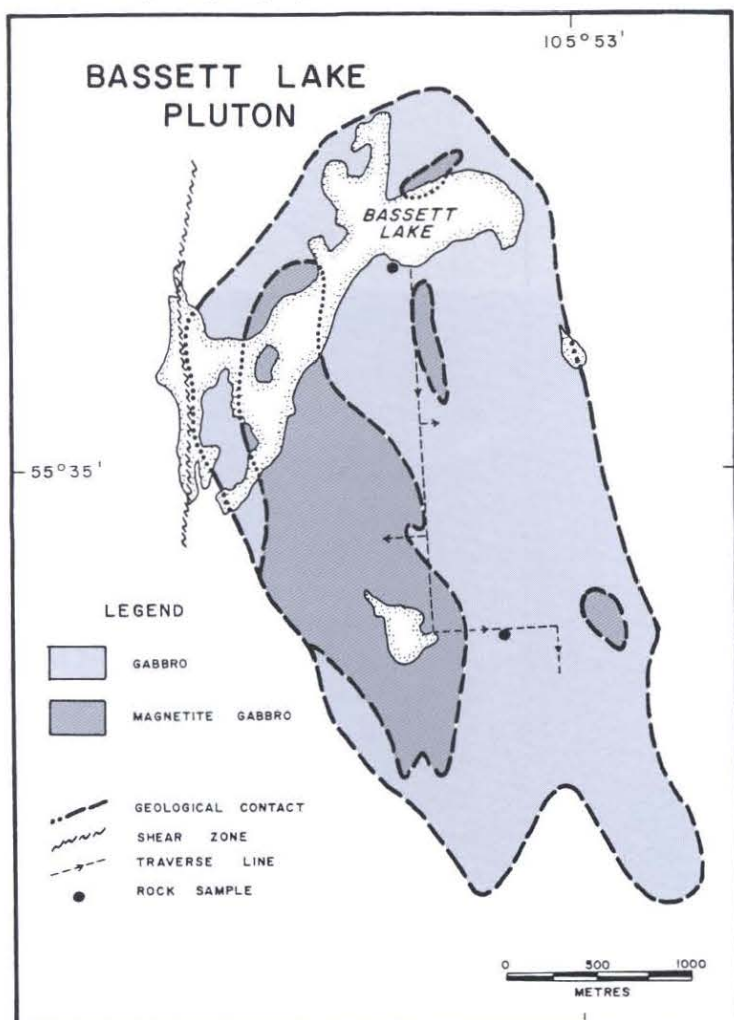
Bassett Lake Gabbro

The Bassett Lake Intrusion is a hook-shaped body underlying about 10 km². Its eastern margin is located about 10 km west of Missinipe. Except for its northeast quadrant, the pluton is characterized by extensive steep-sided uplands rising 50 m or more above Bassett Lake. Bedrock exposure is abundant in the uplands.

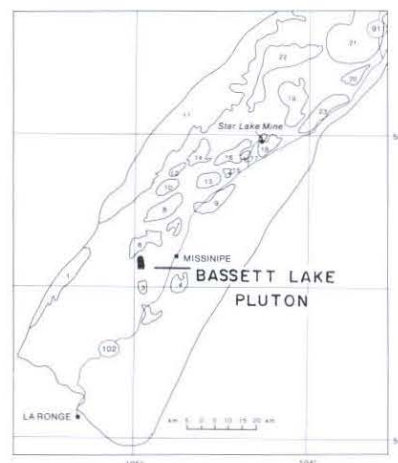
The pluton is a gabbro to diorite complex ranging from fine to coarse grained with a minor amount of anorthositic material. The principal minerals are plagioclase and hornblende with minor amounts of hypersthene and biotite. Magnetite (comprising up to 60 per cent of the rock), pyrrhotite, pyrite, and chalcopyrite are largely restricted to the western half of the body. Light grey to white, coarse-

grained leucogabbro commonly intrudes the darker gabbros. Anorthositic members display rhythmic layering locally.

The prominent joint set is nearly vertical and spaced at intervals of 4 m or greater. Horizontal fracturing results in sheet thicknesses generally greater than one metre. Despite the variability of rock types in the Bassett Lake Intrusion it is recommended for a closer examination due to the presence of the highly desirable "black-granite" variety. No quarry blocks were taken and physical tests were not done.



Bassett Lake gabbro; polished; polished.



Kruger Lake Granite

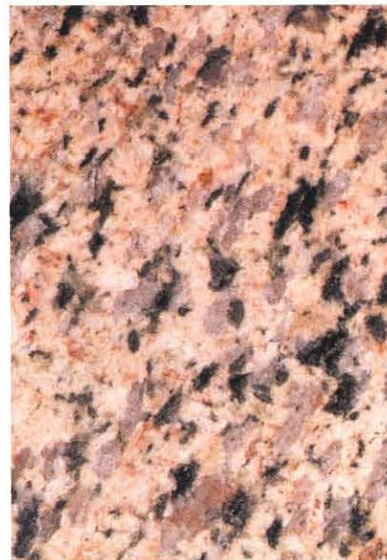
The Kruger Lake pluton underlies an area 17 km long and 6 km wide located about 6 km northwest of Highway 102 from a point about 18 km northeast of Missinipe. Bedrock is well exposed in northeasterly trending ridges rising 40 m or more above adjacent lake levels.

The central part of the Kruger Lake pluton is a medium- to coarse-grained, homogeneous, deep pink, feldspar-porphyrific biotite granite. The rock contains slightly elongated grey quartz grains and aggregates up to 1 cm long, deep pink, euhedral microcline phenocrysts ranging between 2 and 3 cm across, and about 5 to 10 per cent biotite. Alignment of the biotite and quartz knots results in a distinct gneissosity. Quartz veining, tension gashes, and other irregularities occur throughout the pluton. In the northwest part of the

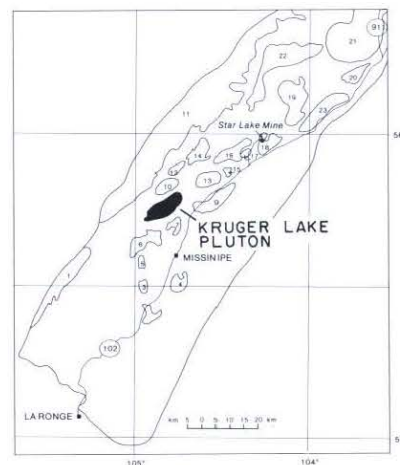
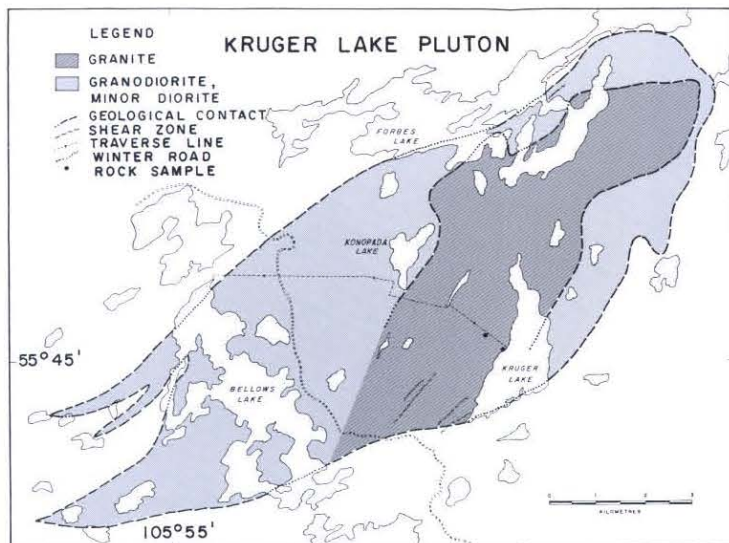
body, a contorted gneissic foliation is present locally.

North-northwesterly trending subvertical joints spaced at 0.5 m to greater than 5 m intervals are irregularly developed across the pluton. Moderately to shallow dipping joints, nearly perpendicular to the subvertical set, are common.

The Kruger Lake granite is an attractive stone and in light of the potential for suitable block size due to the favourable joint pattern this pluton warrants further investigation. No quarrying or engineering testing has been done.

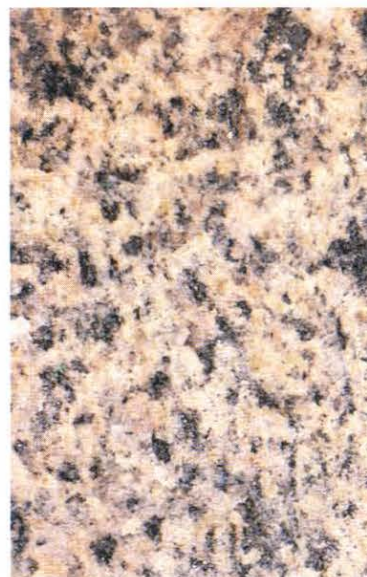


Kruger Lake granite; polished.

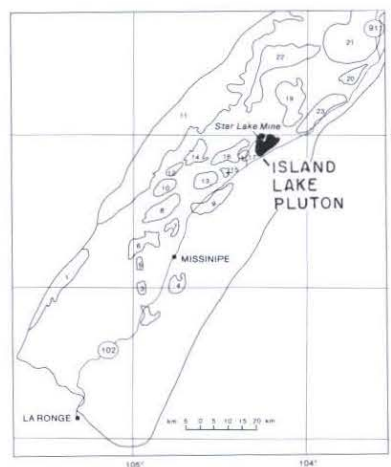
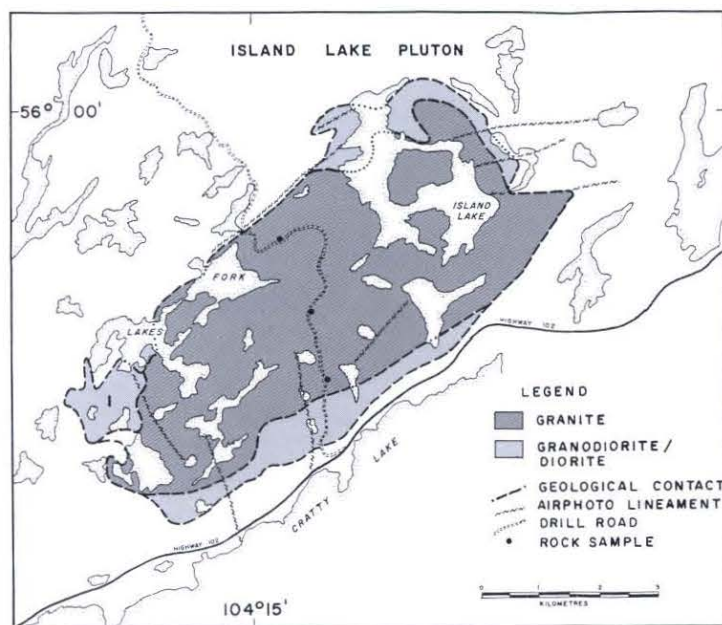


Island Lake Granite

The Island Lake pluton extends over about 23 km² with its southeastern margin less than one kilometre from Highway 102. An all-weather service road extends across the pluton and provides good access to its south-central part. Outcrop exposure is particularly abundant in uplands in the central portion of the pluton and is composed of homogeneous, light grey to light pinkish grey, massive to moderately foliated biotite granite. Subvertical jointing is arranged in an orthogonal manner with spacing commonly greater than 3 m. Horizontal fracturing appears to be poorly developed. The potential for large reserves and suitable block sizes is considered high, therefore a more comprehensive evaluation of the Island Lake granite is appropriate. No quarry or physical tests have been conducted.

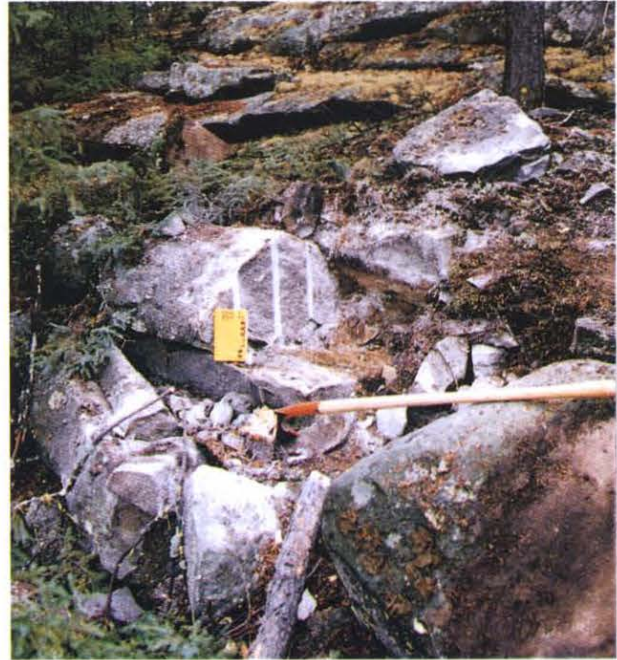


Island Lake Granite; polished.

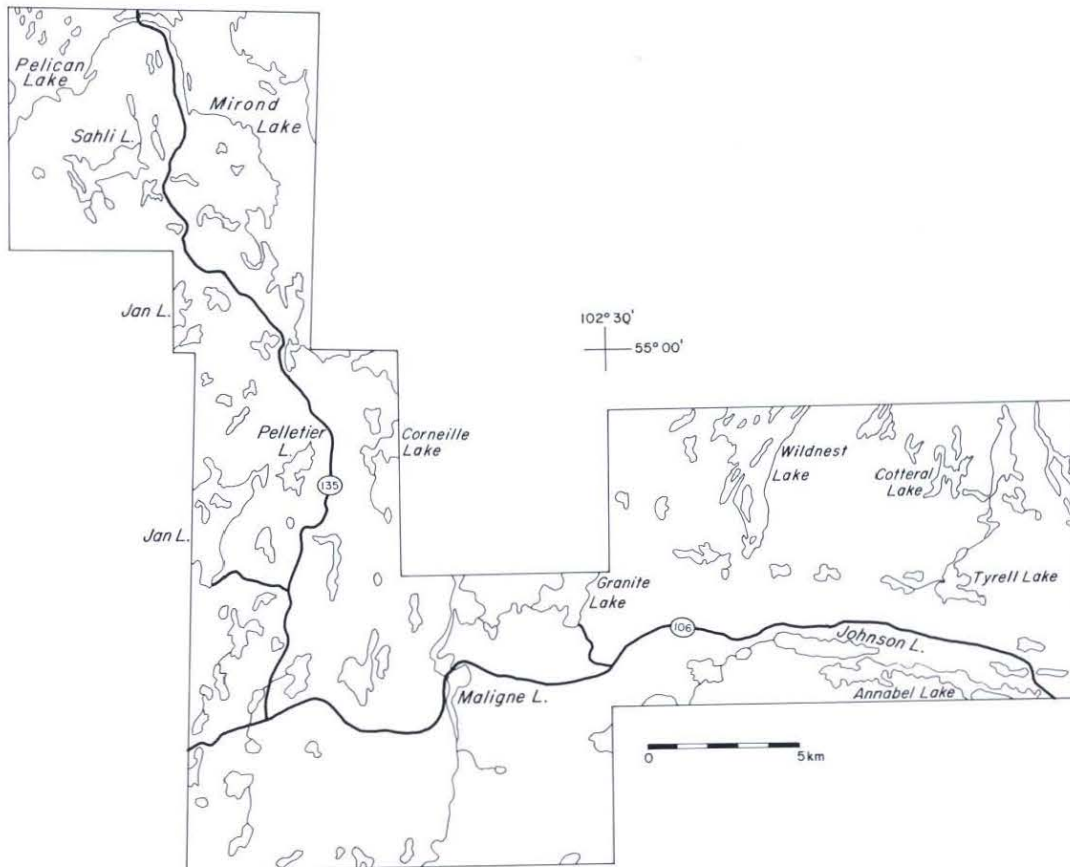


Johnson Lake–Pelican Narrows Area

The Johnson Lake–Pelican Narrows area consists of resources along Highway 106 between Creighton and Deschambault Lake and along Highway 135 to Pelican Narrows. Secondary roads are few, but portages, boat access to nearby lakes and rivers, and foot traverses two kilometres or so from the highways served to reveal a variety of interesting stone resources. Specifically, ornamental green, red, and grey granite, hosted in a meta-volcano-sedimentary belt and a mottled dolomite marble were identified.



Generally higher weathering rates of grey granites (higher porosity and feldspar solubility) results in low topographic relief and few clear outcrops (Johnson Lake Grey Granite).



Johnson Lake Grey Granite

Johnson Lake Grey Granite is an east-west belt of foliated grey hornblende granodiorite which crosses the central part of the Annabel Lake map sheet to the north of Johnson and Annabel lakes. The body is about 20 km long and 2 to 3 km wide. It separates the Amisk Group rocks to the south and the Kisseynew Group to the north and is in concordant contact with them everywhere.

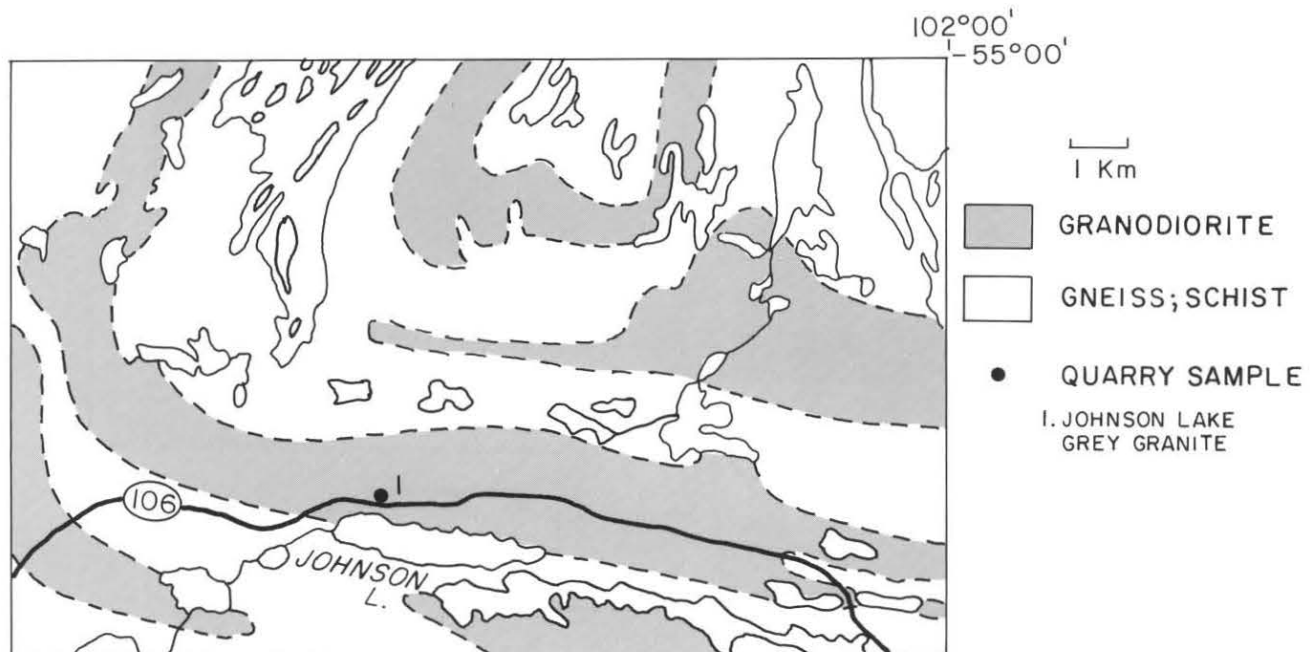
Johnson Lake Grey Granite is remarkably uniform along and across strike. It is a medium- to coarse-grained (0.5 to 2 mm), medium grey, hornblende granodiorite composed of 25 per cent quartz, 50 per cent white-grey feldspar, and 25 per cent hornblende (minor biotite occurs). Highly stretched black amphibolitic lenses, commonly 10 to 30 cm by 1 cm or less, occur scattered throughout the granite and serve to accentuate the generally strong foliation. The stone is also characterized by a marked flattening and alignment of mineral grains in the foliation plane.

Topographic relief is very low and the stone is largely obscured by sand and gravel. This geomorphology appears to be due to mass

wasting proceeding from a system of fractures. One component of sheet fracture generation in the stone is in the form of foliation partings that are closely spaced at the surface and then disappear within a few metres down dip. A second set of sheet fractures, which are shallow-dipping to horizontal, transect the foliation parting. This system breaks up the surface and permits deeper weathering than is usual in granitic rocks. The higher porosity and solubility of feldspars generally noted in grey granites also augments this affect.

Minor hummocks appear to reflect local areas where the stone displays greater erosional resistance. This material seems to be somewhat darker in colour, but it is possible that differences are due to varying intensities of fracturing and weathering. Where construction excavation, blasting, and gravel pit development have exposed the granite, the unweathered stone is similarly darker.

Given the excellent fracture pattern and spacing virtually throughout the formation, a detailed fracture study at a given site was not considered necessary. Broader-based analysis from data gathered on traverses made across the granite is fully adequate for production ap-



praisal purposes. Foliation partings that trend from 090° to 100° and dip 30° to 50°N are observed to have shallow penetration. They range in spacing from a few tens of centimetres to 2 m, with the spacing increasing with depth. A fracture set at 000° to 030°, dipping steeply, exhibits spacing from 1 to 10 m apart and averages about 3 m. A complementary set trending 090° to 110° dipping 70°N to 65°S ranges from 1 to over 10 m apart and averages 3 m plus. It would be necessary to cap off the unusually thick weathered zone (2 to 3 m) before production could begin. After capping the stone, large blocks (4 m³ plus) can be produced at numerous localities with a waste factor below 50 per cent. A sample block was taken at UTM 672900E, 6083500N.

The polished surface was poor to fair, likely reflecting the deeper weathering of this stone and consequent higher porosity. The broken surfaces of the quarried sample exhibited separation around grain boundaries rather than breakage through grains suggesting the possibility that grains would pluck out during polishing.

Dry Crushing Strength* (MPa - avg)	Absorption %
101.4	0.60

*Tests were done on surface stone; better results can be expected from fresh stone.

As a general rule, the polished surfaces of grey granites tend to deteriorate much more rapidly than those of red, pink, and black granites. Examples abound on buildings of about 50 years of age where the polish is gone. In contrast, pink granites commonly still display glacial polish after more than 10,000 years. Given the dominant place of feldspar in the composition of granite, it would appear to be due to the higher solubility of certain feldspars (soda feldspars?). This aspect deserves study.



Johnson Lake Grey Granite exhibits widely spaced fractures. Outcrops clear of vegetation are uncommon in this stone.



Johnson Lake Grey Granite; polished.

Injection Gneisses

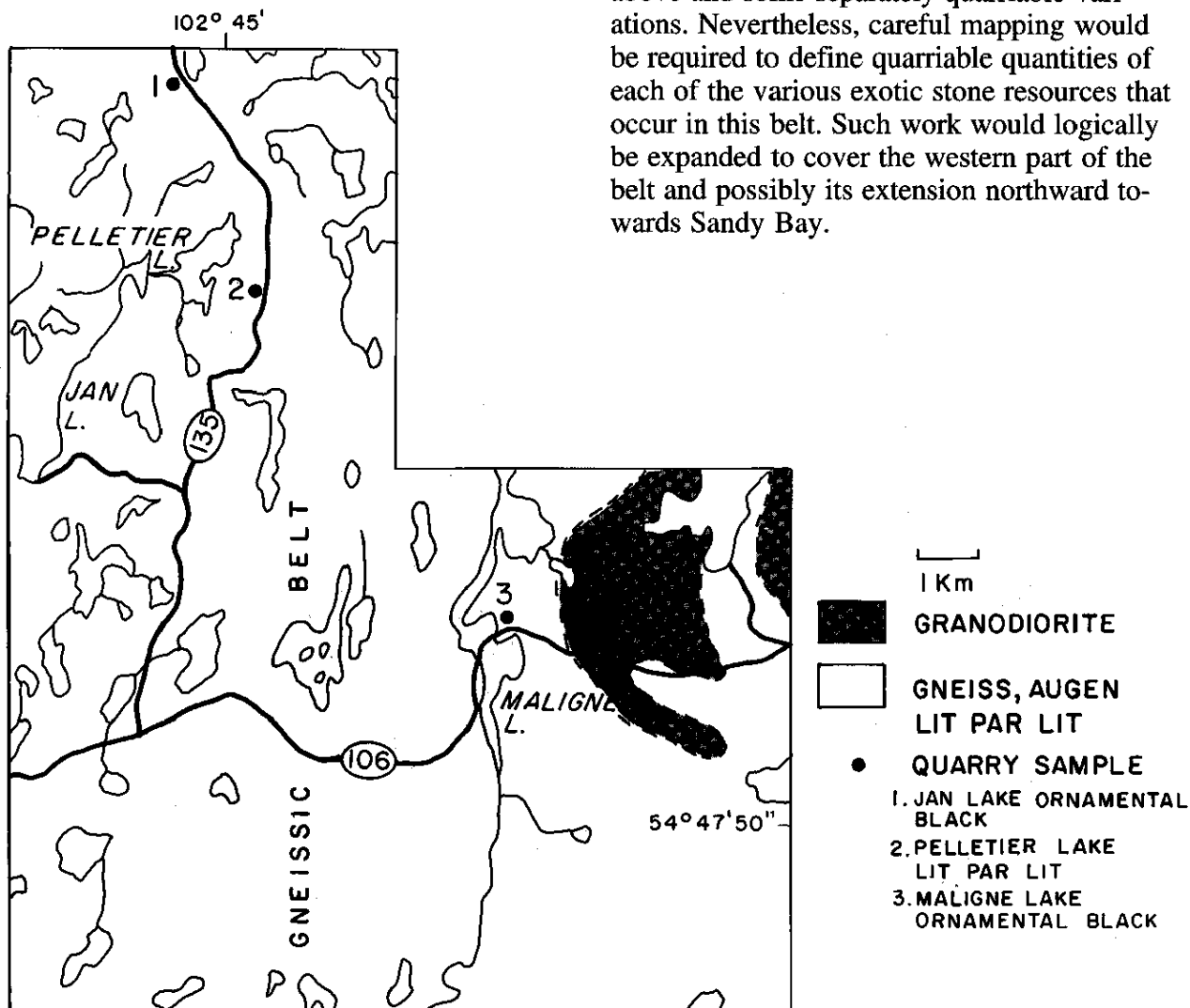
A northerly trending complex of amphibolitic injection gneisses occurs between Granite and Jan lakes. The belt is composed of a variety of attractive stones injected with abundant pegmatitic veinlets. The main types are:

- a) *lit-par-lit*, a regularly banded, metavolcano-sedimentary unit with concordant, thin, granitic and pegmatitic layers;
- b) a black ornamental stone having concordant, boudinaged, pegmatite veinlets and chains of pink and white, pegmatitic feldspar augen; and

- c) a grey and pink veined gneiss showing both concordant and cross-cutting granitic veins and seams.

Highway 106 cuts across the strike and, although not examined west of the junction with the Pelican Narrows Road, the gneissic belt appears to extend for many more miles westward. The northward extension was explored along Highway 135 to the Sahli Granite complex.

Topographic relief over the belt is up to 65 m and the terrain is fairly well-drained. Glacial outwash gravel obscures the bedrock in many areas, especially along Highway 135, but exposure is adequate to indicate the presence of abundant resources of the main types noted above and some separately quarriable variations. Nevertheless, careful mapping would be required to define quarriable quantities of each of the various exotic stone resources that occur in this belt. Such work would logically be expanded to cover the western part of the belt and possibly its extension northward towards Sandy Bay.



Three stone samples were selected for testing from the variety available:

- 1) Maligne Lake Ornamental Black, which is characterized by feldspar augen and stretched pegmatitic patches in a wavy foliation at UTM 652500E, 6080500N;
- 2) Jan Lake Ornamental Black, which has “ghostly” feldspar augen in a planar foliation at UTM 643000E, 6095400N, and

- 3) a dark grey and pink, *lit-par-lit*, regularly banded stone at UTM 645100E, 6089900N.

Detailed fracture pattern mapping was not done for these poorly exposed resources; however, a more general descriptive fracture analysis is provided in the section below.



Grey granodiorite gneiss is one of a variety of attractive stones to be found in the Maligne Lake–Pelican Lake gneissic belt. Note fracture direction cuts across foliation indicating strength of the foliation plane.

a) Maligne Lake Ornamental Black

Maligne Lake Ornamental Black trends 045°, dips 30°S, and shows some parting in this direction. The prominent fractures strike 165° and 110° with vertical dips. Fracture spacing averages only 0.5 m, but is discontinuous in nature, indicating better spacing with depth. Given the beauty of this stone, smaller blocks (1 m³ or less) may be produced at a profit. Similar stone was observed 3 km west along the highway from Maligne Lake, but at this locality, pegmatitic injections were thicker and more abundant. Where pegmatitic veinlets are much more than 5 cm wide, fracturing, especially within the pegmatitic material itself, appears to be extensive. In a given deposit, therefore, the presence of such zones may result in a higher waste factor. This stone takes a good polish and exhibits good closure (see glossary). The contrast of pink feldspar augen chains in a jet black matrix produces an attractive ornamental stone.

Dry Crushing Strength* (MPa - avg)	Absorption %
114.2	0.40

*Tests were done on surface stone; better results can be expected from fresh stone.



Maligne Lake Ornamental Black exhibits non-orthogonal closely spaced fracturing at surface.



Maligne Lake Ornamental Black; polished.

b) Jan Lake Ornamental Black

Jan Lake Ornamental Black trends 100°, dips 70°S, and shows a foliation parting with an average 3 m spacing. A prominent fracture set, with an average 1 m plus spacing and up to 3 m locally, trends 020° and dips vertically. The first and second sheets are 30 cm and 1 m thick respectively. The areal extent of this stone was not established. It appears to be a generally narrow layer within a more abundant, dark grey veined gneiss and may have good strike extension.

The dark grey stone has *lit-par-lit* and cross-cutting veinlets of granite and pegmatite and displays drag folding. Although it, too, is attractive, time and budget did not permit sampling of this and other interesting potential resources in the gneissic belt. There is no

doubt, however, that this locale is an example of where more than one variety would have to be produced to make quarrying economic. Large blocks (2 m³ plus) could be produced with less than 50 per cent waste.

The ornamental black stone takes a good polish, closure of the grains is good, and hairline fractures do not occur. The favourable fracture pattern suggests that large panels having an excellent finish and wider architectural application than the Maligne Lake stone, could be realized.

Dry Crushing Strength* (MPa - avg)	Absorption %
127.6	0.41

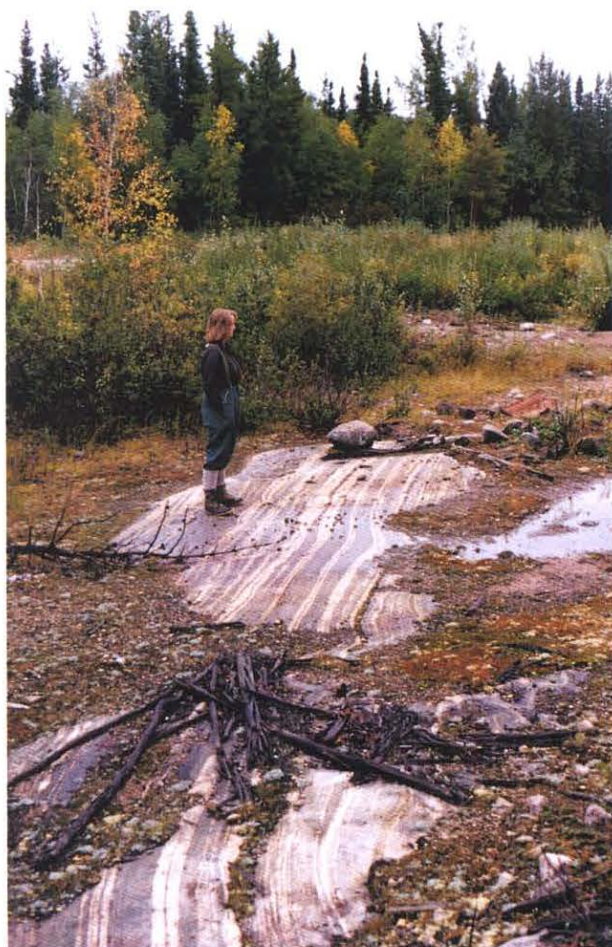
*Tests were done on surface stone; better results can be expected from fresh stone.



Jan Lake Ornamental Black.

c) Pelletier Lake Lit-par-lit

Pelletier Lake *Lit-par-lit* strikes 150° and dips steeply. This stone is almost free of cracks which promises a yield of large blocks (4 m³ plus) with minimal waste perhaps no more than 20 per cent. The layers are surprisingly cohesive and the stone tends to split in a direction at right angles to the foliation/banding. This characteristic permits strong panels to be produced that display the stone's aesthetics most strikingly. Because of these qualities and the flatness of the outcrop, sampling using a portable drill was difficult. The stone yielded by splitting into horizontal plates which were subsequently cast in concrete to permit sawing into tiles. No engineering tests or polishing trials were done.



Pelletier Lake Lit-par-lit. Pink bands are pegmatitic "augen" injections. Fractures are widely spaced.



Unexpected strength parallel to foliation make sampling difficult.



This stone should produce aesthetically pleasing panels and tiles of good strength.

Sahli Granite

The Sahli Granite is a multiphase charnockite stock of about 100 km² lying between Mirond, Pelican, and Jan lakes. It is accessible by Highway 135 which crosses it starting 30 km north of the junction with the Hanson Lake Road (Highway 106).

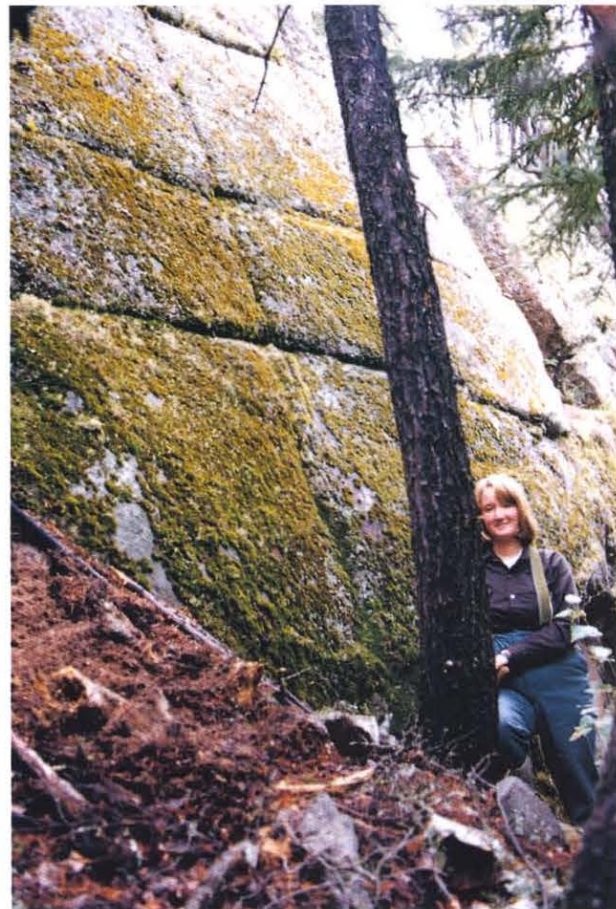
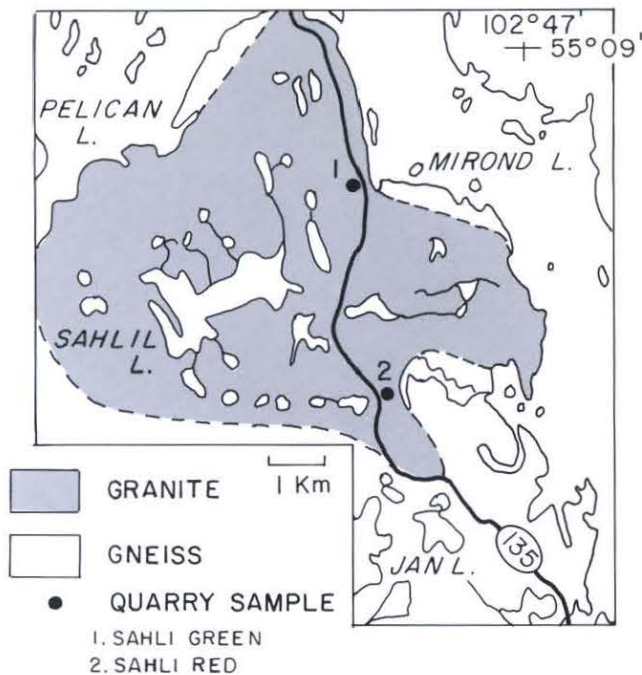
The area is well exposed, well drained, and has a maximum relief over the deposit of 100 m. Local relief is up to 70 m and cliffs are a common feature of the terrain.

Several types of the granite occur: dark olive to jade green stone and a red “tiger stripe” stone. Both are coarse grained and have a similar texture with dark pyroxene “tiger stripes” (up to 20 per cent) alternating with quartzofeldspathic folia (quartz 25 per cent, feldspar up to 50 per cent). Sample blocks of each were quarried. Green stone was taken at UTM 637800E, 6103700N and red at 636800E, 6109500N. Other varieties include:

a) red granite characterized by aligned red quartzofeldspathic rods 7 to 10 cm long

- with an oval cross-section 1 by 2 cm in a matrix of dark pyroxene, greenish feldspar, and quartz;
- b) brownish “mahogany” stone which appears to be transitional between the red and green stone; and
- c) a black, fine-grained phase.

Red garnet from 0.1 to 3 mm occurs in all varieties making up 5 to 10 per cent. It occurs only in association with the mafics and is coarser in the red granite (averages 2 mm) than in the green (averages 1 mm). Each type is sufficiently abundant to be quarried separately but the black phase is much more highly fractured (where observed) than the others.



Cliff faces are a common feature of the Sahli Granite terrain. Orthogonal fracturing is well illustrated in such exposures.



Lichens delineate the wide spacing of fractures in this stone.

The relations between phases is complex. From quick reconnaissance, the red stone forms the border phase and the green the core; however, in detail, these phases alternate and may have cross-cutting relationships. Time did not permit detailed mapping of this complex but on both economic and scientific grounds such a project is strongly recommended.

Except for the black phase, the stone has an excellent orthogonal fracture pattern. Near horizontal sheet fractures are spaced from 0.5 m to over a metre apart and steeply dipping sets striking 040° and 140° are spaced 2 to 5 m apart. In a few locations, a “plunging prism” fracture pattern occurs (explained under Denare Red Granite).

An example of the fracture pattern along the Pelican Narrows Road (Pearse, 1991, p3) shows fractures oriented 050° dipping 45°N, 050° dipping 45°S, and a widely spaced third set at 160° with a vertical dip. This gives an unusual orthogonal fracture orientation.



Sahli Granite splits readily along a planar “grain” direction - an excellent quarrying feature.

A fracture pattern analysis was done on a cliff face at the locality shown in the photo on page 28. The fracture defining the cliff face has an average spacing of 2 m plus, and strikes 040° dipping 70°E. The supplement to this fracture set strikes 145°, dips 90°, with an average 3.5 m spacing, but ranging from 1 to 4.5 m. This is a foliation-guided fracture set (the “grain”).

An estimate of possible block production indicates 70 per cent yield for blocks 2 m³ and larger with 60 per cent of the blocks greater than 4 m³. Observations made on a highway cut (Pearse, 1991, p3) reveals that this stone breaks readily along the orthogonal fracture directions when blasted. This feature could be exploited in producing curbstones, cobblestones, and masonry wall stone from waste using an hydraulic splitter.

	Dry Crushing Strength* (MPa - avg)	Absorption %
Sahli Green	141.0	0.50
Sahli Red	107.0	0.68

*Tests were done on surface stone; better results can be expected from fresh stone.

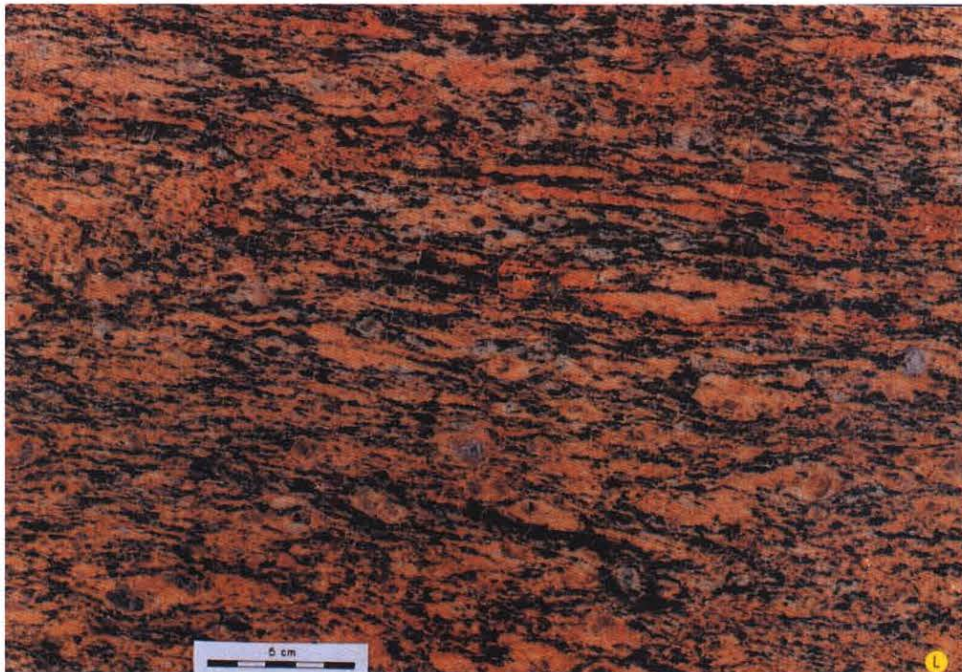
Quarry testing demonstrated that both the red and green stone split readily along a remarkably planar grain direction. This feature, and

the consistent, widely spaced, orthogonal fracture pattern, indicate that a low-cost plug and feather production method could be used, with drill hole spacing of 30 to 50 cm.

Another quarrying test was conducted on the Sahli green granite in 1994-95 by Eagle Stone Limited. The quarry site was located near the edge of the body and about 5 km west of the Pelican Narrows road. The top meter of weathered and fractured rock was removed and larger blocks were quarried from the exposed bench and from a deeper level in the bench. Also the stone was penetrated an additional 4 m with a rock cutting torch. Unfortunately randomly oriented hairline fractures were evident at all levels and increased in frequency with depth. It is emphasized however, that the site is near the periphery of the body where stress microfracturing is most likely to occur. Because the body is extensive, it is likely that this problem will disappear or improve toward its central parts.



Sahli Green Granite; polished.



Sahli Red Granite; polished.

Limestone Lake Marble

This stone, which occurs in the Limestone Lake–Deschambault Lake area is part of the same Red River Formation dolomites that are included in the Amisk Lake–McNally Lake stone described in the next section. Graham Construction quarried a rough veneer stone for wall construction at this locality.

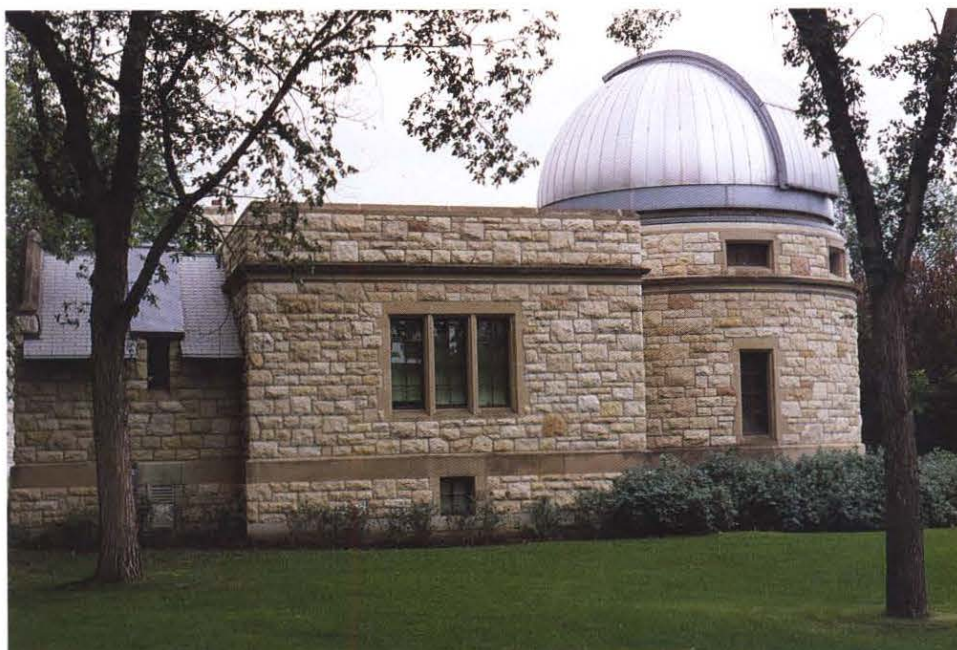
The stone displays a range of colours from buff, yellow, grey, red, orange, and mottled combinations of these. Local basement-controlled fracturing complicates the orthogonal fracture pattern commonly found in this formation. Generally two to four vertical fracture sets occur at any one locality as well as nonsystematic curvilinear joints which terminate against systematic joints. Wavy closely spaced horizontal partings which are a feature of the Amisk Lake–McNally Lake marble also occur in the Limestone Lake area. These

fractures are exploited in the production of brick-sized units for wall veneer. Vertical joints are spaced from less than 0.2 to 8 m.

Evidence of healing of the horizontal partings at other localities suggests that, with depth (below the frost line) larger blocks may be producible, especially where basement fracturing effects are also minimal.

Mottling and the presence of fossils, large and small, are typical of the Red River Formation and are well represented in the Limestone Lake area. These features enhance the character of the stone. Fauna include corals, gastropods, crinoids, brachiopods, and sponges.

The hardness and density of the stone permits a good polish, which is the pivotal criterion for classification (commercially) as a marble.



Dolomite (marble) fieldstone used in early construction at the University of Saskatchewan Campus, Saskatoon.

Physical tests on drill core and bulk samples yielded the following averaged results:

Compression - Strength* (MPa - avg)

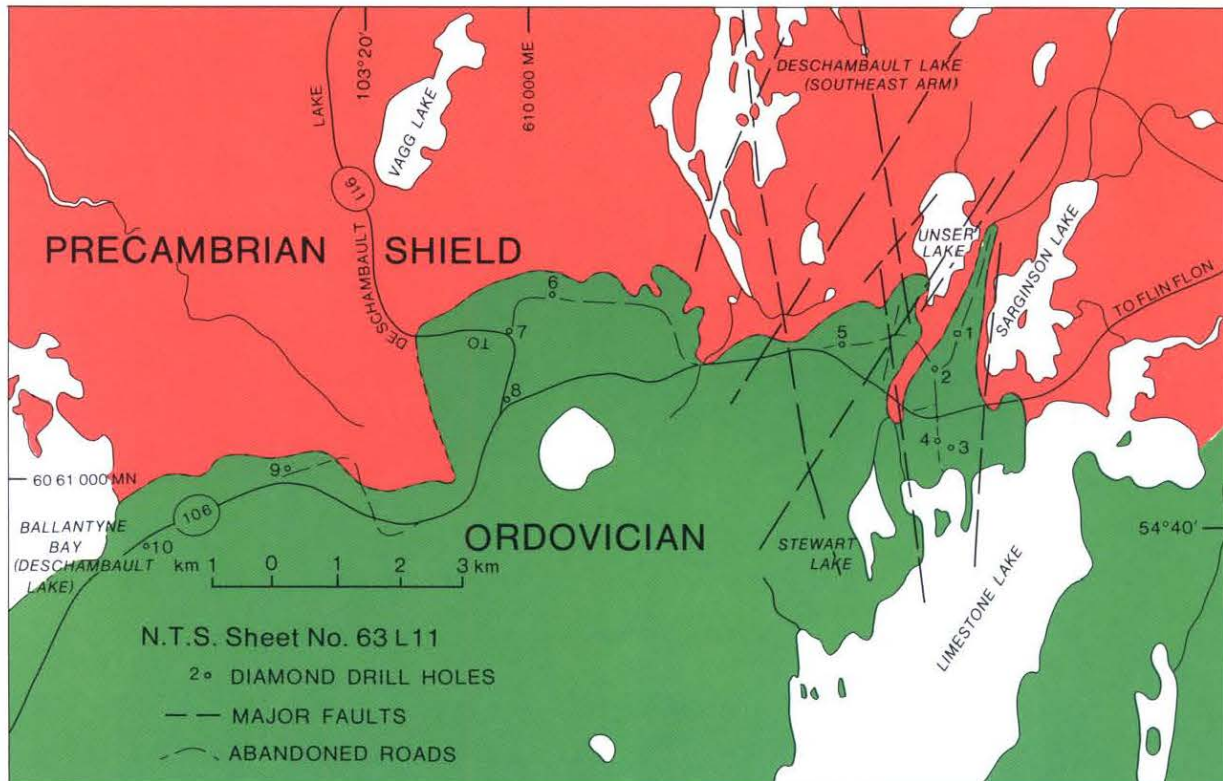
Dry	Wet
187.8	134.2

Modulus of Rupture (MPa - avg)

Dry	Wet
20.2	14.2

Absorption (%)	0.58%
Bulk Specific Gravity	2.78%
Magnesium Sulphate	0.8%

*Tests were done on surface stone; better results can be expected from fresh stone.



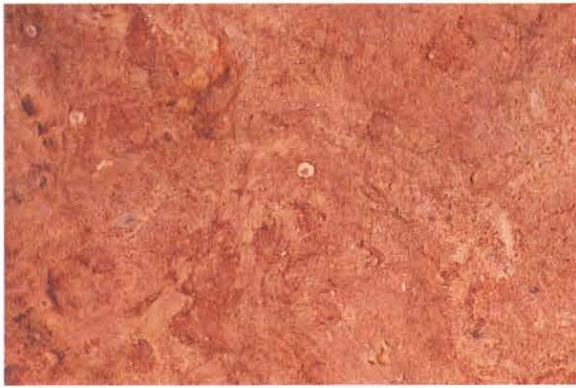
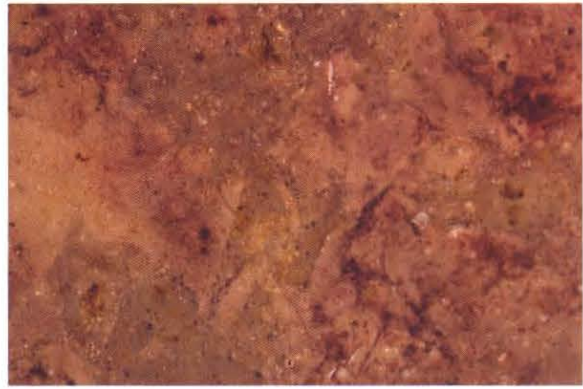
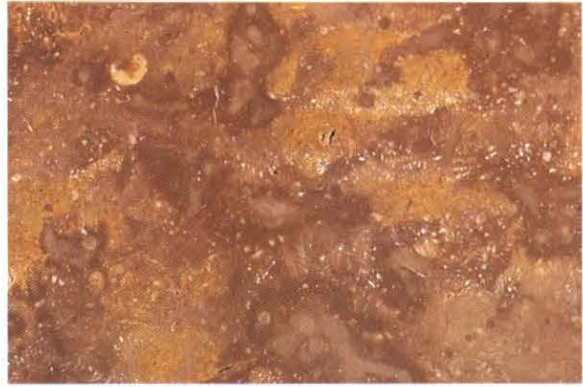
Ordovician dolomite deposits in the Limestone Lake area.



Dolomite evaluation and development at Deschambault Lake.



The recently built Agriculture Building at the University of Saskatchewan featuring dolomite from the Deschambault Lake area.



Ordovician dolomites (marbles) of the Red River Formation; natural face (moist); polished.

Creighton–Amisk Lake Area

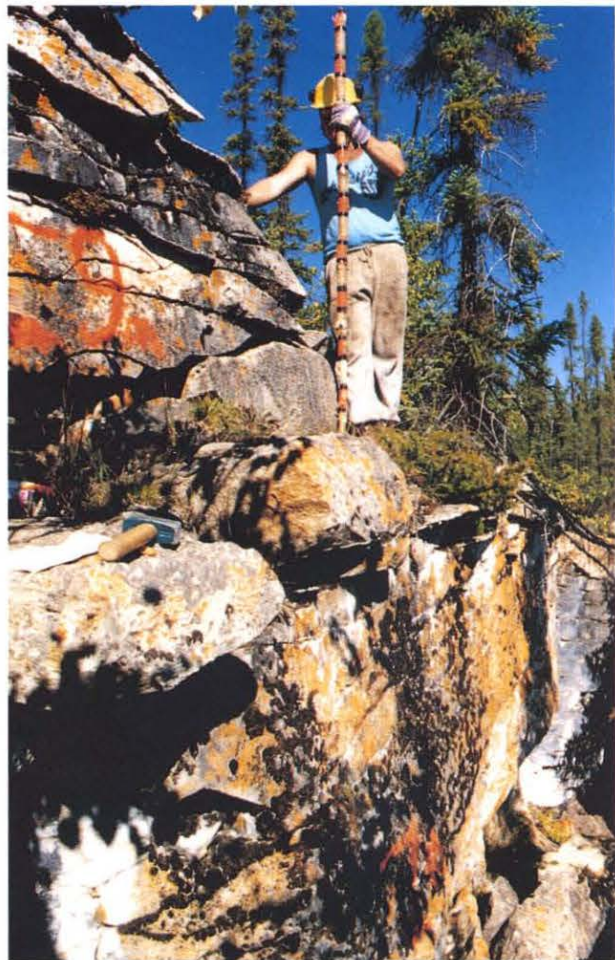
The Creighton–Amisk Lake area lies between the Saskatchewan–Manitoba border and Amisk Lake. The Precambrian–Ordovician contact passes through the southern part of the area. Because of a relatively large population associated with major mining and exploration activities, the area is transected by a good network of primary and secondary roads. The principal road is Highway 167 which connects Denare Beach on Amisk Lake with Creighton.

The coincidence of a large variety of potential stone resources coming to light in an area of excellent access perhaps hints at the magnitude of the potential resources underlying northern Saskatchewan terrain.

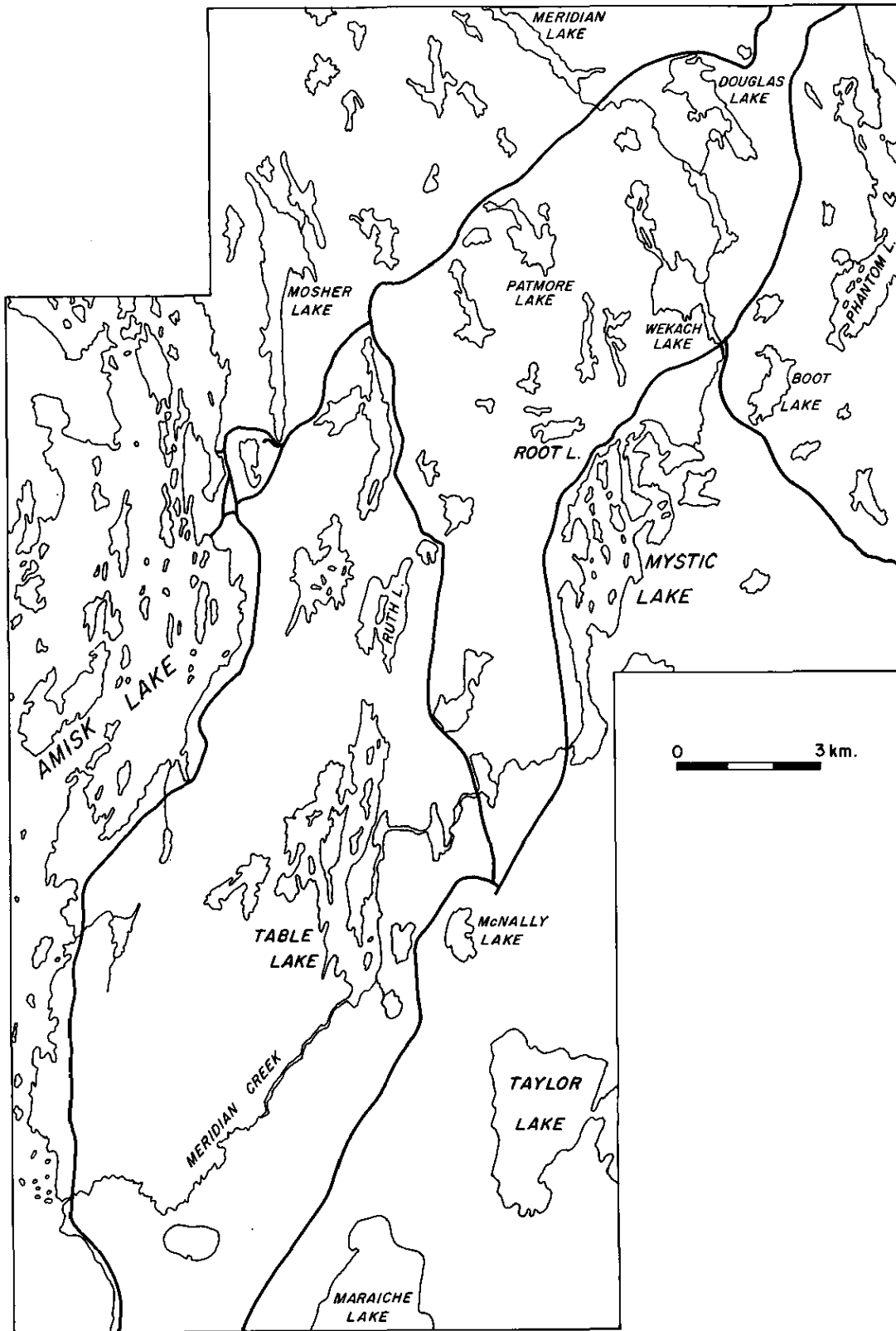
Selected resources studied in the area include eight stone types comprising marbles, granites, and ornamental stone.



Access to block sample site is by log skidder in the McRobbie Lake area.



Contact of overlying Red River Dolomites stands as an escarpment above the Precambrian.



Amisk Lake–McNally Lake Marble

Marble in the Amisk Lake area is part of the Ordovician Red River Formation that extends across this part of Saskatchewan. It is crossed by the Amisk Lake road, and the Mystic Lake–Maraiche Lake roads.

The formation is 30 m thick in the Creighton–Amisk Lake area and occurs as a prominent escarpment along its contact with the Precambrian terrain. It is marked by steep cliffs from 3 m to over 12 m high fronted by a rubble of frost quarried blocks.

The stone is a dense microcrystalline dolomite that takes a superb polish and is therefore properly classified as a true marble in the stone trade. The dominant colour is a mottled “buckskin” buff, but red mottled varieties occur at scattered localities, notably near the mouth of Meridian Creek at Amisk Lake and above the southeast shore of Mystic Lake, east of Wordsworth Bay. The stone resembles material of similar colour from Verona, Italy. Core drilling records in the Prince Albert–Hudson’s Bay Junction region reveal only a

few sites having red dolomite and these occur only within the lower 12 m of the formation. Where red marble does occur, it appears to be largely mottled with orange to buff colouring. The dark red stone depicted appears to be confined to a layer not much more than one metre thick and is bounded above and below by the two-toned mottled stone. The weathered surface tends to mask these variations. The formation displays some dense beds a metre or more thick, but much of the section is characterized by thin “wavy bedding planes” a few centimetres to 15 cm thick. These appear to be healed with carbonate beyond the weathered zone. Carbonate exudate from these planes and the presence of very large blocks (as much as 0.5 hectare) bounded by frost wedged crevasses to the base of the formation suggest good cohesiveness of the bedding planes in fresh stone.

The fracture pattern is orthogonal, vertical, and spaced commonly 3 m and as much as 6 m apart. Major fractures support a growth of grass, shrubs, and trees indicating deep penetration. Minor fractures were determined to be due to a shallow spalling phenomenon.



Fracture pattern in buff marble. Note vegetation indicates deep penetration of major fractures.

Marble block sample locations are UTM 685200E, 6045700N at Amisk Lake for the red and red mottled and UTM 692500E, 6051000N between McNally and Cable lakes for the buff stone.

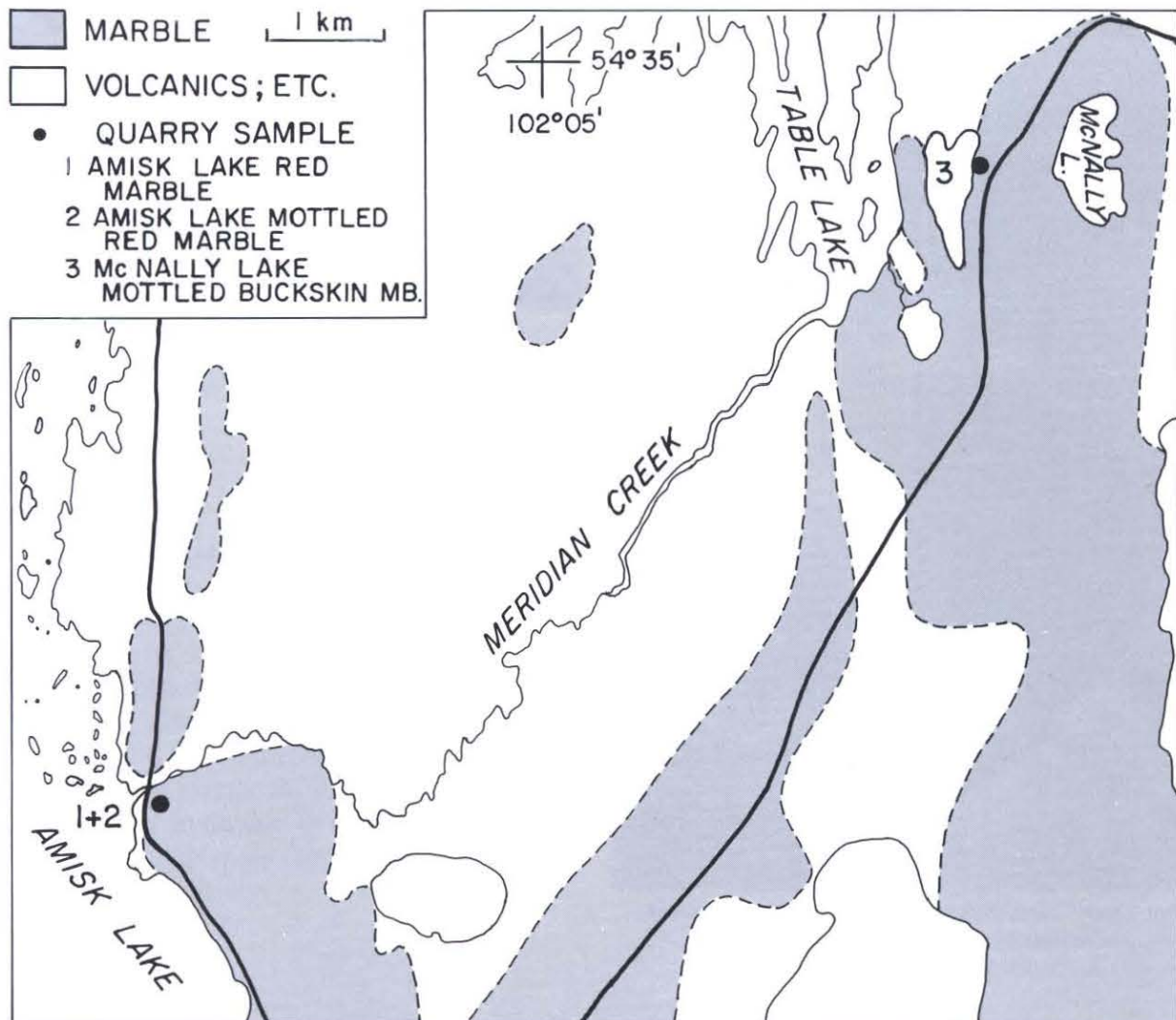
The stone takes a high quality polish.

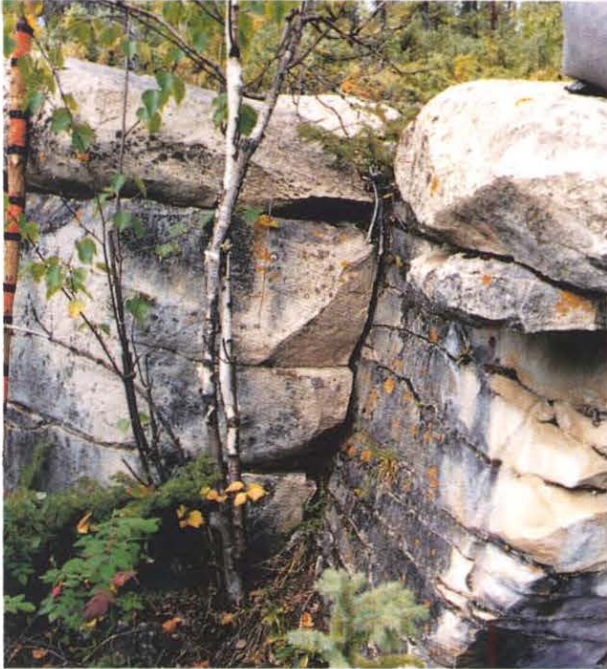
	Dry Crushing Strength* (MPa - avg)	Absorption %
Buff Marble	162	0.05
Mottled Red	87	0.61

*Tests were done on surface stone; better results can be expected from fresh stone.

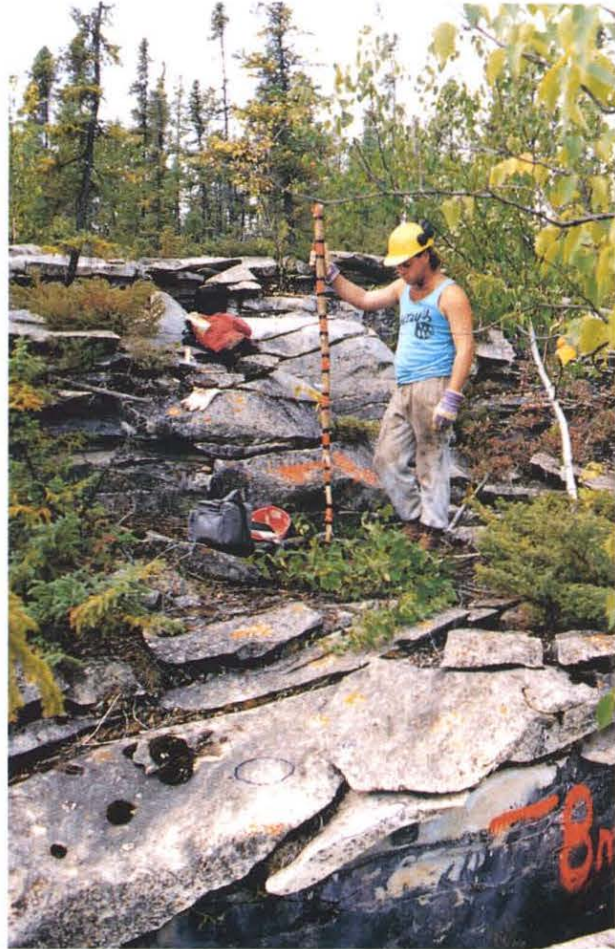


Most minor fractures on the marble surface end on a horizontal spall.





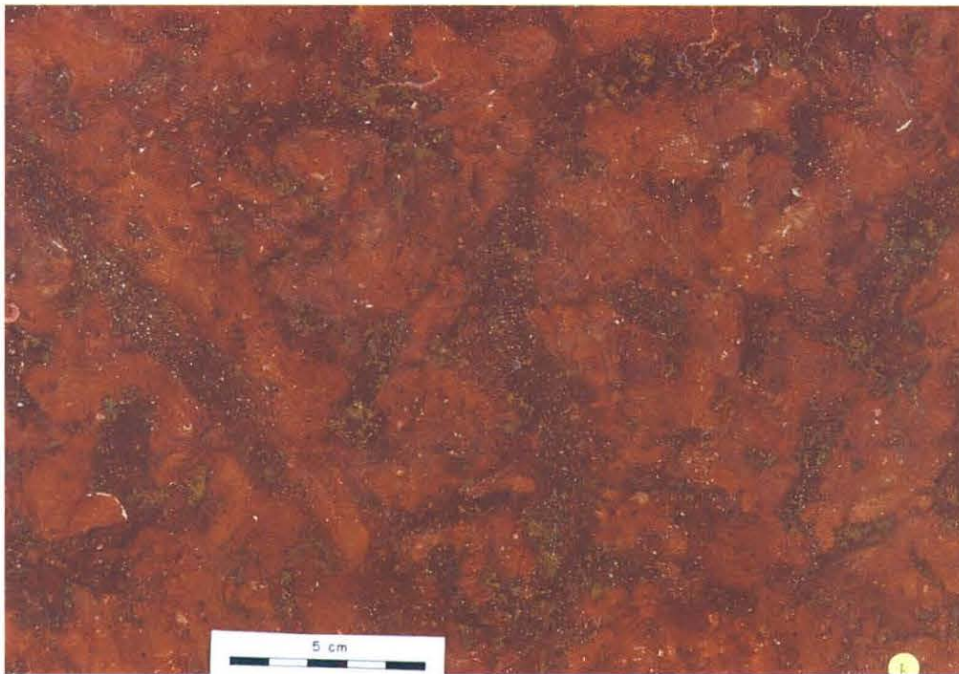
Thin "beds" terminate abruptly on strike with thicker beds. These may be post-depositional fracturing (sheets) due to unloading (McNally Lake area).



Crevasses wedged open by ice (foreground) penetrate to the base of the formation. This feature, plus evidence of healed fractures, suggest the stone is solid below the weathered zone.



Red marble occurs locally as a facies of the much more abundant buff marble (Amisk Lake).



Amisk Lake Red; polished.



Amisk Lake Mottled Red; polished.

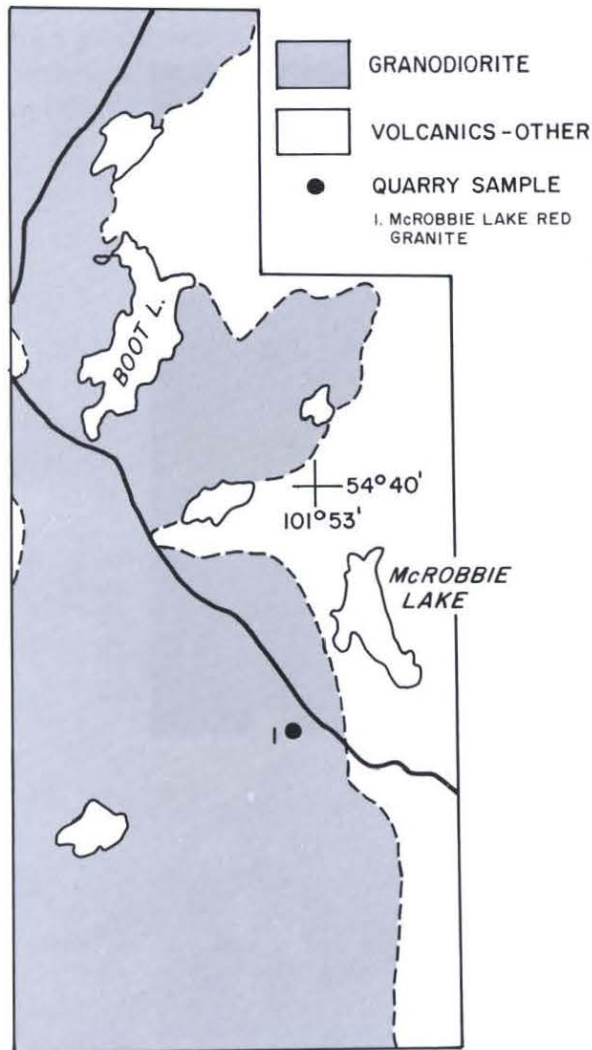


McNally Lake Mottled Buckskin; polished.

McRobbie Lake Red Granite

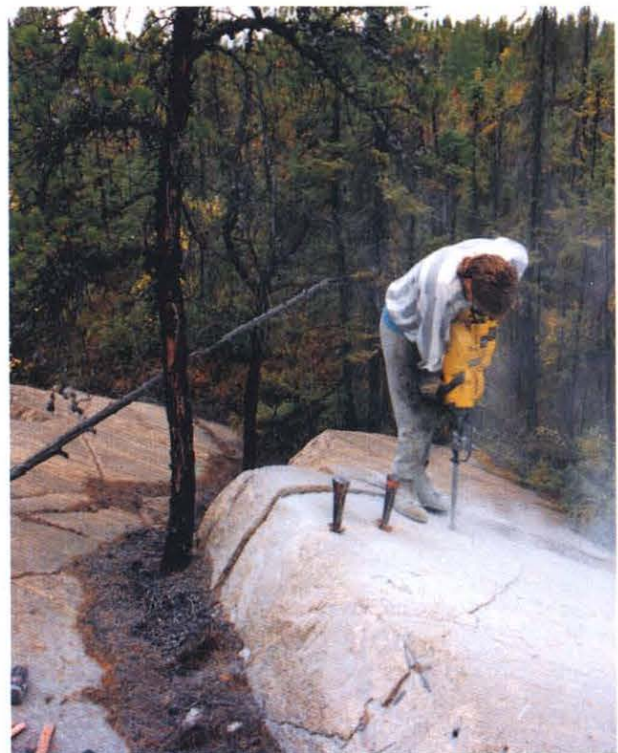
McRobbie Lake Red Granite is an intrusive body which mainly lies west of McRobbie Lake (Schist Lake Sheet). It is crossed by the West Arm Mine Road south from Creighton. The typical McRobbie Lake Red Granite is coarse grained (1 to 3 mm), averages 50 per cent feldspar (mainly pink with minor white specks), 40 per cent jet-black hornblende, and 10 per cent quartz.

A less coarse and less mafic variety carries up to 10 per cent biotite. The stone is criss-crossed to varying degrees with feldspathization alteration in bands from millimetres to



several centimetres wide which are, most commonly, parallel to the northeasterly fracture direction. The bands are spaced from less than 0.5 m to several metres apart and are more closely spaced in local fracture cleavage zones. The bands are notably enriched in brick-red feldspar and commonly have a central seam of epidote-carbonate (and sericite?). The stone appears to be most sound where the bands are sparse. Their presence does, however, add character.

The best stone has approximately orthogonal fracturing striking 040° to 080° and 130° to 170° and dipping steeply. Sheet fractures generally trend about 100° and dip 20° to 30° north. The northeasterly set is the most prominent with fracture spacing averaging 1 m and ranging from 0.5 to 3 m. The southeasterly set averages 1.5 m, and ranges from 1 to 4 m. Wherever more than one sheet fracture is exposed, the lower sheets are more widely spaced. The first fracture is generally below



McRobbie Lake Red Granite sample site. Note dipping sheets.

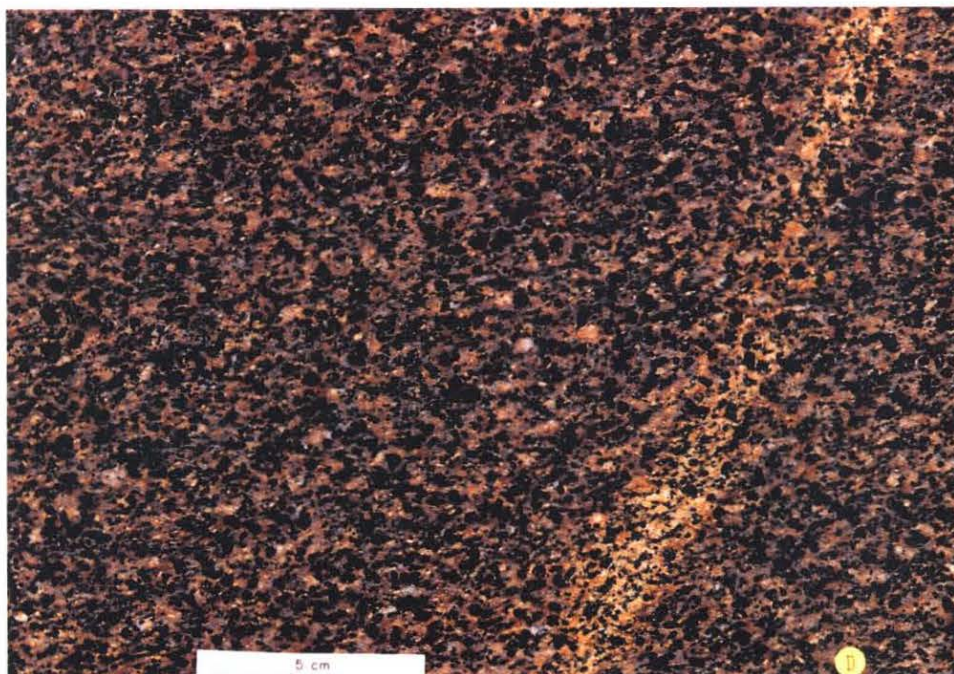
1 m depth with second and third fracture-bounded layers being 1 to 3 m thick.

Without discounting surface stone for its more abundant fractures in the top sheets, estimates of block yield from outcrops in a 5 km² area west of McRobbie Lake range from 10 per cent 1 m³ blocks to 30 per cent large blocks (2 to 4 m³). A rough, weighted average indicates 20 per cent 1 m³ blocks and 5 per cent large blocks (2 to 4 m³). Capping 3 to 5 m off the top could raise the yield for the better outcrops to 50 per cent plus of blocks 2 m³ plus in size. Localities where a good percentage of large blocks could be produced are to be found in the central part of the pluton

west of McRobbie Lake. The granite is fairly hard and compact, takes a good polish, and shows good closure. The polished surface has a dark cast because of the high proportion of black hornblende. In contrast, the feldspars are a delicate pink. Sparse feldspathization alteration shows as narrow, low mafic, pinkish bands with gradational contacts.

Dry Crushing Strength* (MPa - avg)	Absorption %
137.6	0.38

*Tests were done on surface stone; better results can be expected from fresh stone.



McRobbie Lake Red Granite; polished.

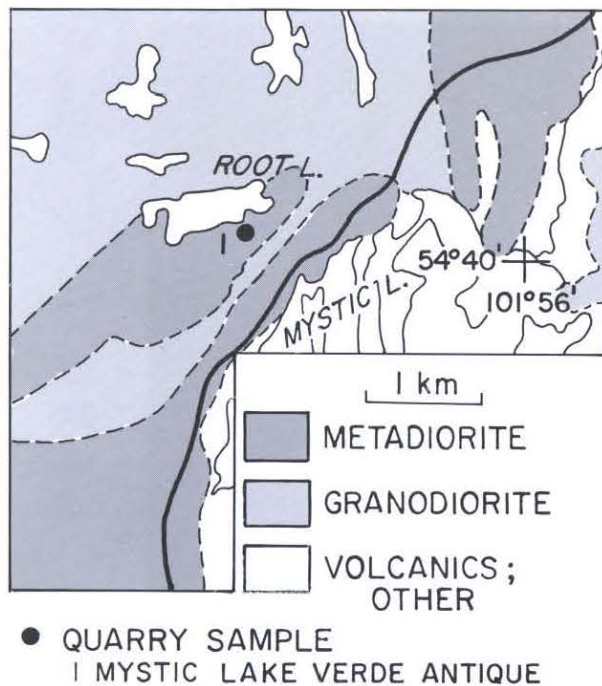
Mystic Lake Verde Antique

Mafic rocks in the Wekach Lake–Mystic Lake area have a border phase containing a profusion of veinlets and is altered to a dark greenish colour where it is in contact with granodiorite. The best material occurs: a) in the western half of the Wekach Lake basin; b) north of Green Bay on Mystic Lake, and c) west of the road opposite the north end of Mystic Lake (Root Lake area). The Wekach Lake area is in military reserve land and is not available for development. The Mystic Lake road, a former rail line to the Coronation Mine south of Creighton provides access to this stone.

Strictly speaking, the term “Verde Antique”, is applied to a green serpentinite with white carbonate-magnesite veining. A larger family of green “marbles” have the prefix Verde as part of the name. The Mystic Lake stone is an amphibolite with granitic and other siliceous veining and as such is a “new” stone. The field term Verde Antique was used for lack of another existing trade name. Ultimately it



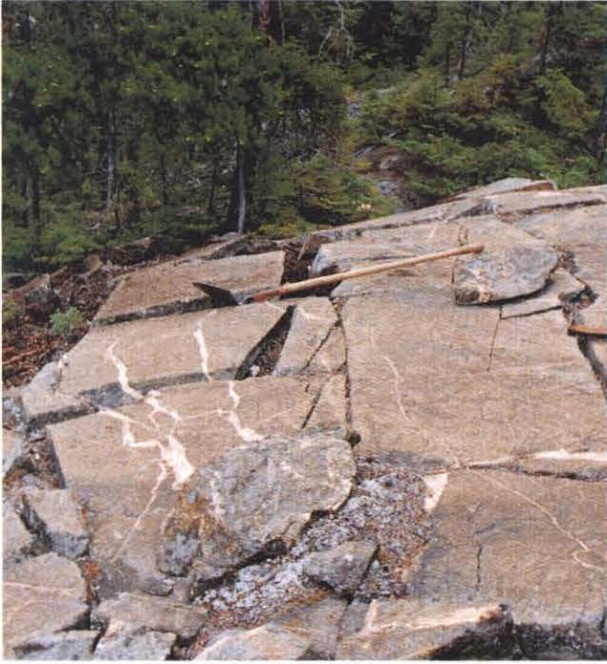
Intricate veining and excellent physical characteristics makes this a prime stone.



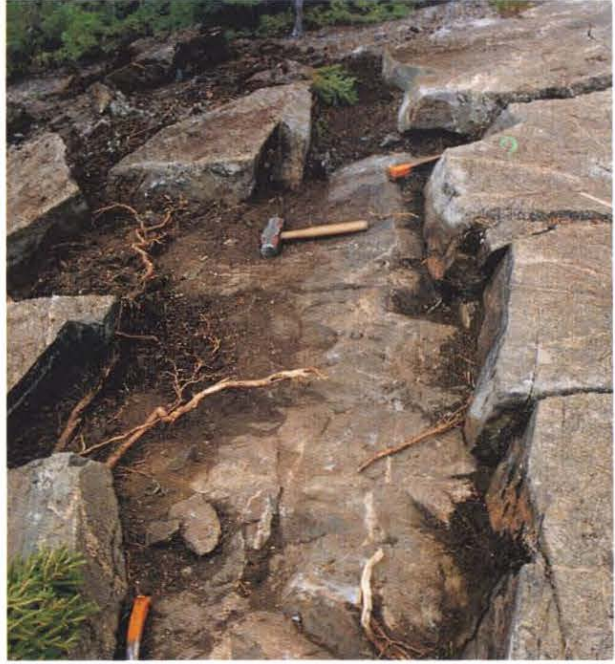
would be worthwhile to find a new name to differentiate this fine stone in the marketplace.

The amphibolite matrix has a gabbroic texture with white feldspars and dark greenish-black hornblende. Veinlets of pink granite a centimetre and more thick as well as thinner braided white to pale greenish veining characterize this stone. The full pattern is not revealed on panels smaller than 1 to 2 m². It is harder and stronger than the classic Verde Antique type and would serve well on floors as well as walls. It takes an excellent polish.

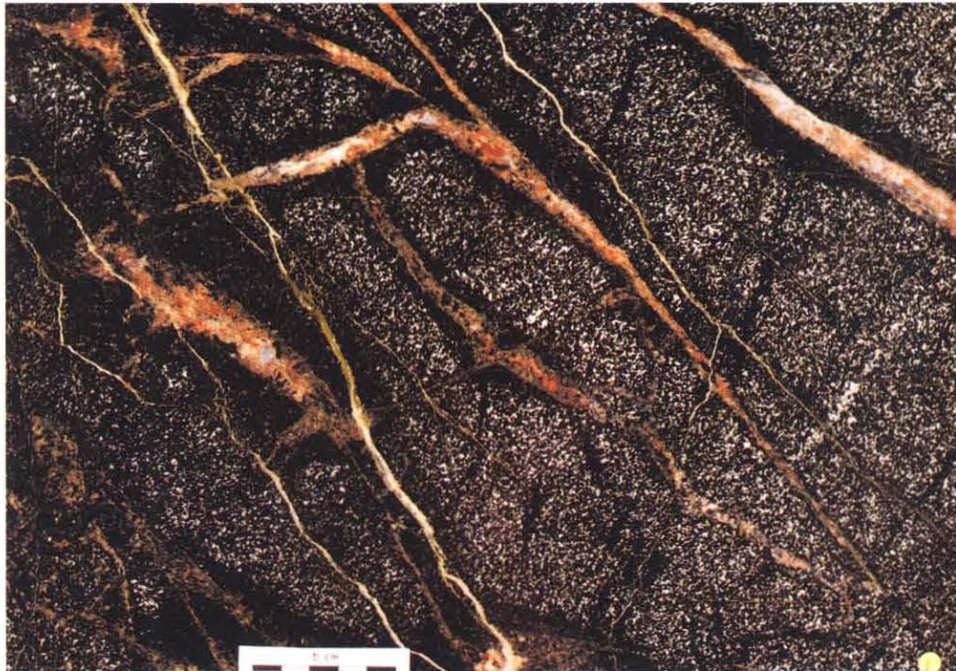
Fairly large grains of pyrite occur locally and may restrict the stones use to interiors unless adequate areas free of pyrite occur in the unit.



Spalling of the surface yields a shell of broken stone below which the stone is remarkably sound.



Removal of spalling reveals most fractures do not persist with depth.



Mystic Lake Verde Antique; polished.

Although orthogonal fracturing occurs (striking 150°, 50° and 90°, 170°, all dipping steeply), fractures most commonly intersect at 45° to 60° angles (and their supplements). Fortunately, substantial areas exist where spacing is sufficiently broad to permit the production of large blocks.

One feature of the verde antique that departs from the usual is that, in many places, sheet fractures appear to be absent. This means that full length blocks might be produced in the vertical direction.

An area of excellent stone along the south shore of Root Lake was chosen for fracture pattern analysis. As with the Amisk marble analysis, minor fractures were evaluated by wedging out plates of stone bounded by minor fractures to ascertain the persistence of the fractures with depth. Similar results were obtained. Most minor fractures represented fragmentation of a spalled layer, possibly guided by carbonate-filled seams which have dissolved. Moreover, mapping shows fractures to be generally impersistent on strike

suggesting that the stone is unfractured at depth.

Assuming no sheet fractures and that spalling accounts for all minor fractures, 83 per cent of the 670 m² test area would yield full size blocks. Such a low waste factor (17 per cent) would be very exceptional. Counting areas where minor fracturing is intense and might reflect deeper penetration reduces the yield of full size blocks to 60 per cent of the total volume (estimated on an areal basis). This still represents a very healthy prospect.

A one tonne sample was taken from an outcrop close to the south shore of Root Lake, (UTM 308300E, 6061800N). The stone takes a superb polish and exhibits a spectacular veined pattern.

	Dry Crushing Strength* (MPa - avg)	Absorption %
1st set	186.5	0.26
2nd set	132.1	0.26

*Tests were done on surface stone; better results can be expected from fresh stone.

Milky Way Granite

“Milky Way” is a jet-black granite with abundant irregularly distributed white to pink feldspars occurring in clusters, swirls, and speckled disseminations. This dramatic stone occurs as a phase of the same amphibolitic intrusion that includes the Verde Antique as a border phase. The stone does not have a granitic texture and like Verde Antique could be accepted as a marble. It covers an area of some 3 to 4 km² mainly west of the Mystic Lake road opposite Wordsworth Bay.

In general, black granites are difficult to assess because of poor exposure. The stone tends to be broken up on the surface, weathers to low relief outcrops and, because of the available plant nutrients yielded by the weathered stone, supports a stronger growth of trees and shrubs. Mafic intrusive rocks also tend to develop three or more fracture sets of nonrectangular pattern and of variable dip, which yield irregular wedge-shaped blocks. Even where fracture spacing is wide, the fracture pattern results in considerable waste.

One Quebec black granite producer has a 90 per cent waste factor. An additional unfavour-

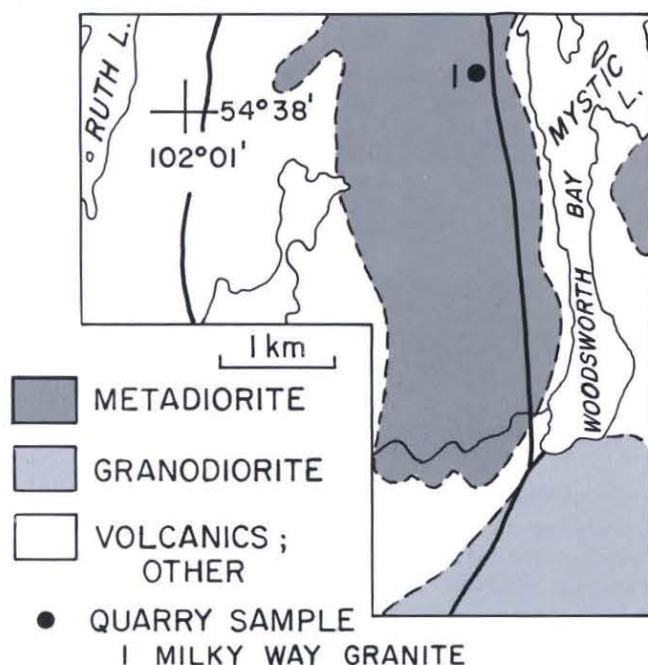


Black granites tend to be generally lower relief and support obscuring vegetation.

able tendency is for such stone types to host mineralization. Minor pyrite is deleterious, particularly in exterior applications. These factors all combine to make quarriable black granite a very rare resource despite the general abundance of the rock type itself.

Fracture directions varying 10° or so either side of 060°, 160°, 020°, and 120° are the most common throughout the main mafic complex. Generally three of these are present, but all have been noted in some outcrops. Although dips are typically steep, dips range from 60° in one direction to 60° in the opposite.

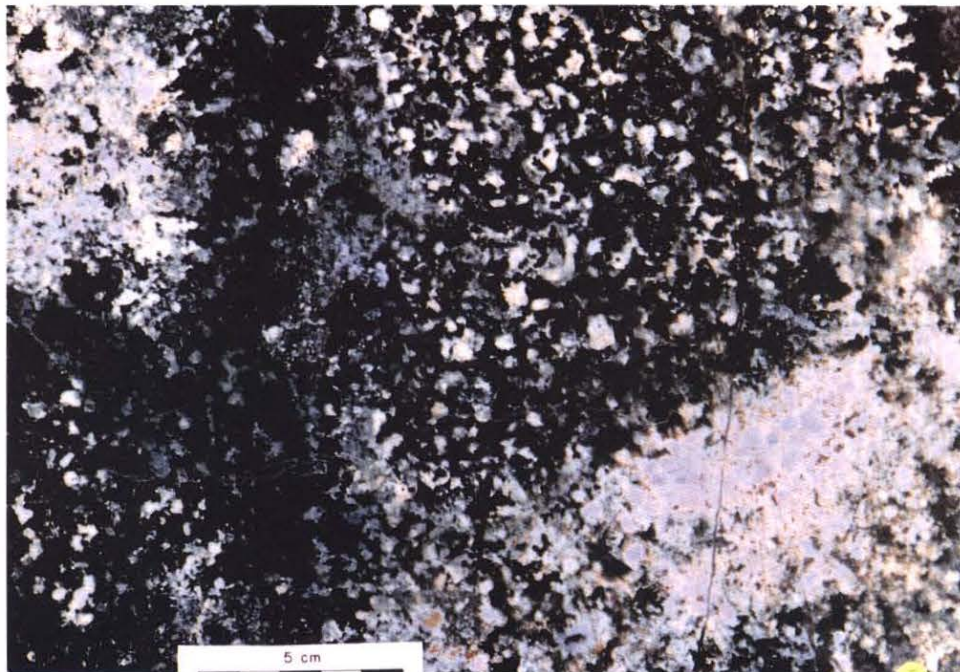
No site suitable for fracture analysis (without considerable bulldozer scraping) could be found in the best exposed speckled black granite areas. However, it appears that blocks greater than a cubic metre could be produced in the best localities with somewhat less waste than in the associated black phases of the intrusion. Larger block sizes and less waste might be expected at greater depth.



Full evaluation and quarry development for the Milky Way stone would require considerable stripping and capping off costs but this could be well rewarded with a stone of beauty and superb engineering properties. Milky Way Granite polished well.

Dry Crushing Strength* (MPa - avg)	Absorption %
218.0	0.01

*Tests were done on surface stone; better results can be expected from fresh stone.

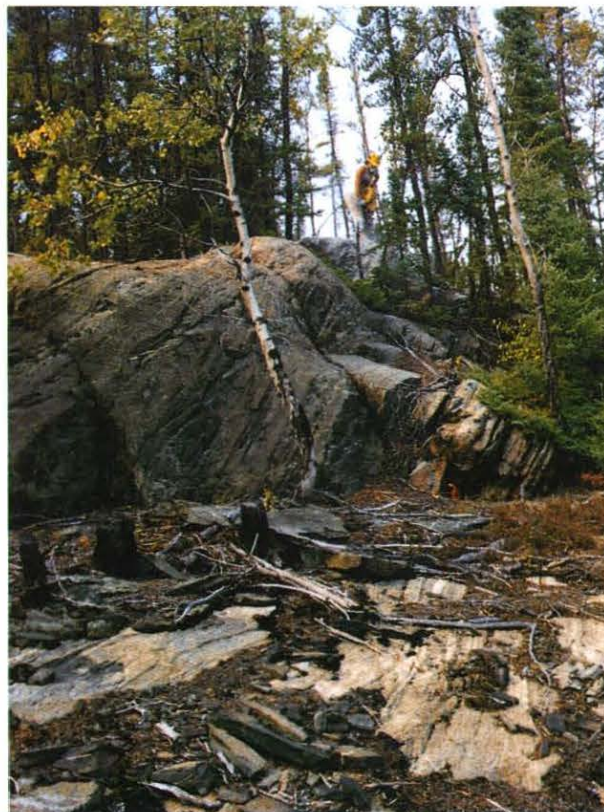
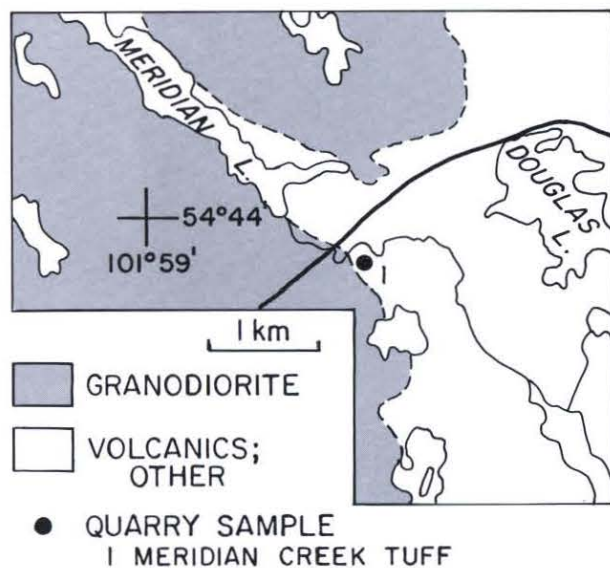


Milky Way Granite; polished.

Meridian Creek Tuff

Meridian Creek Tuff occurs in a northerly trending belt of largely pyroclastic rocks up to 3 km wide and over 15 km long, west of Douglas Lake, extending from Meridian Lake south beyond Mystic Lake. The belt is pinched in the middle by a metagabbro intrusion at Wekach Lake. The area selected for study and sampling occurs on the west side of Meridian Creek and is crossed by a section of old Highway 35 (now abandoned and re-routed as Highway 167). The stone is a dark green, very fine-grained to near aphanitic amphibolite. It displays fine tuffaceous bedding defined by pale green laminae 1 to 2 mm thick. Cross-bedding, cut and fill, and other sedimentary structures are present giving good top determinations. Harder, creamy weathering, lighter green bands up to 25 cm thick possibly represent more acid tuff composition, thin sills or metasomatic (autometamorphic) alteration bands. Pyrite was observed, although not in abundance.

Bedding plane partings penetrate 2 to 3 m making reconnaissance sampling difficult. Quartz-carbonate fracture fillings are dissolved out to a depth of about 10 cm and contribute to the typically fractured and rubbly surface appearance.



Except for bedding plane partings in the weathered zone, the stone has few persistent fractures.

Two principal fracture directions occur in the fracture analysis site, the most prominent in terms of persistence being the bedding plane partings which trend 135° to 140° and dip 65° N. These average 2 to 3 m spacing and range from 0.5 to over 5 m apart. The most persistent fracture is 23 m long but typically, fractures are less than 5 m long and occur in interrupted lines and in an *en echelon* pattern. This suggests that the fractures disappear at moderate depth. A cross-cutting fracture set trends 025° to 050° , dips vertically, and averages 1 m spacing. They represent old fractures healed with quartz and carbonate that have been partially dissolved out. Individual fractures generally persist 3 to 5 m in length and their healed nature is observable where recent spalling of the surface has occurred. A third, less prominent set trends 090° to 100° , dips 65° S, with spacing averaging 2 to 3 m. This similarly represents an old set that has

been subsequently healed with quartz and carbonate. Sheet fracturing appears to be absent in some localities, but is widely spaced and impersistent in others.

The scope of the project didn't permit capping off the 3 m or so necessary to obtain a sample free of penetrating fractures, but a block was taken and dressed stone tiles were produced that, although prone to breakage along microfractures, invite further investigation of this resource. It is anticipated that, below a depth of about 3 m, large blocks are producible with a waste factor below 50 per cent.

The tuff took a good polish and the surface reveals the intricate structures of this bedded deposit. Also the white cross-cutting veinlets produces a stark contrast to the alternating green tones of the lamellae. Cutting this stone in the bedding direction would yield an interesting fleury pattern ("contour line" effect) and, as a bonus, would produce structurally stronger slabs and tiles.

Dry Crushing Strength* (MPa - avg)	Absorption %
130.4	0.51

*Tests were done on surface stone; better results can be expected from fresh stone.



Meridian Creek Tuff; polished.

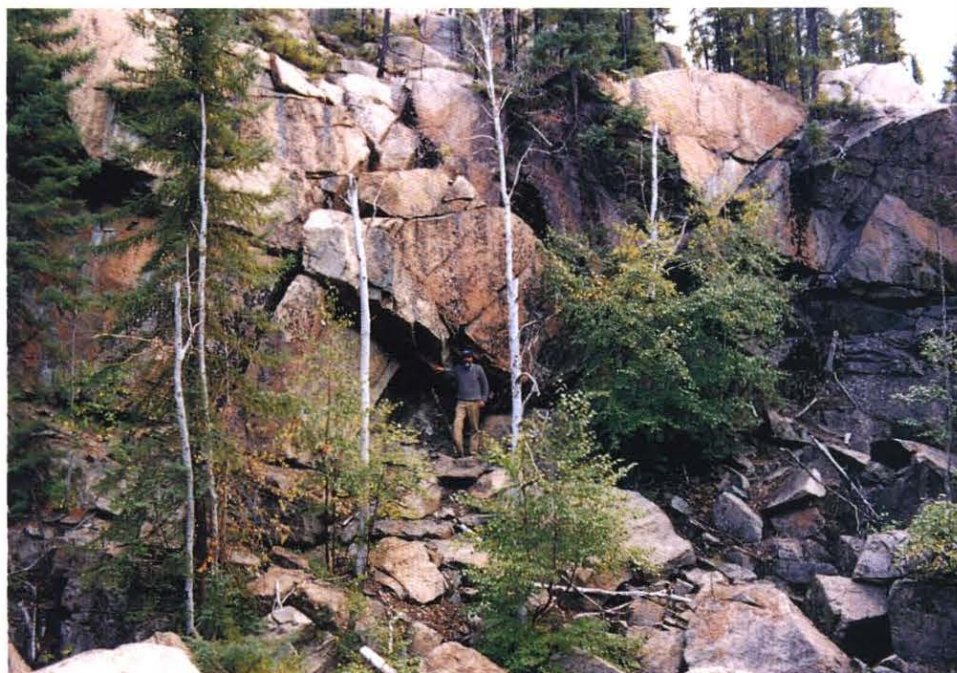
Denare Red Granite

Denare Red Granite is part of an intrusive complex composed of biotite granodiorite, hornblende granodiorite, granite porphyry, and mixed varieties, that is crossed by Highway 167 west of Meridian Lake. The core of the body is a granite porphyry with the Denare Red Granite being part of it. This stone has scattered recognizable feldspar phenocrysts and what appear to be poikilitic feldspar patches. The approximate composition is: 30 per cent blue-grey anhedral patches of quartz 3 to 7 mm across; 40 per cent irregular anhedral pink feldspar crystal aggregates (some with a greenish cast) and partially resorbed phenocrysts 3 to 15 mm across; 20 per cent white subhedral to euhedral feldspar (some displaying zoning) 0.5 to 3 mm (average 1 mm in diameter); 10 per cent anhedral black hornblende 0.5 to 4 mm; and minor biotite.

Denare Red Granite displays both regular and what are termed “plunging prism” fracturing patterns. In the latter, sheet fractures are replaced by two fracture sets having roughly

the same strike but complimentary dips. A cliff face at the southwestern margin of the study outcrop displays the latter pattern. A fracture study shows the south to north transition from the plunging prism system to a regular system by way of a steepening of the fractures and widening of spacing. There is also evidence of the beginning of another plunging prism zone at the northeastern edge of the fracture pattern map (Pearse, 1991, p31).

Although some large blocks could be produced in the plunging prism zone, block estimates were made only in the area of the regular fracture systems. Here, the two main fracture sets are: 130° , dipping steeply (75°E to 65°W) and 020° dipping 90° with fracture spacings both averaging 3 m (range is 1 to 5 m). Short, discontinuous fractures probably disappear with depth. No sheet fractures were observed in the most favourable area of outcrop. In the much more fractured stone in the low country to the north, closely spaced sheeting trending 120° and dipping 30°N was observed; however, sheet fractures are not well



A plunging prism fracture pattern characterized at least part of the Denare Red Granite.

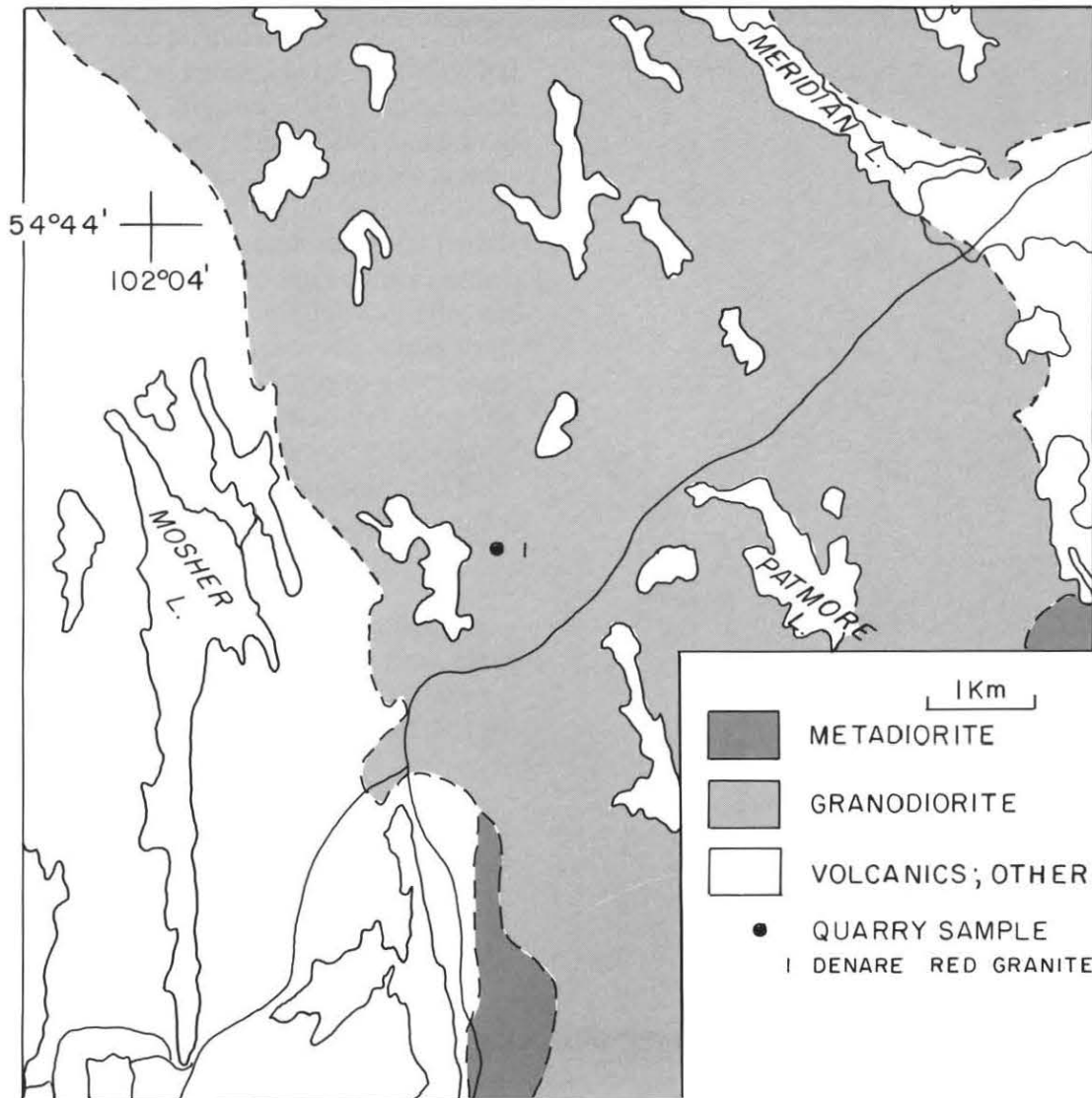
developed in the granite porphyry pluton as a whole.

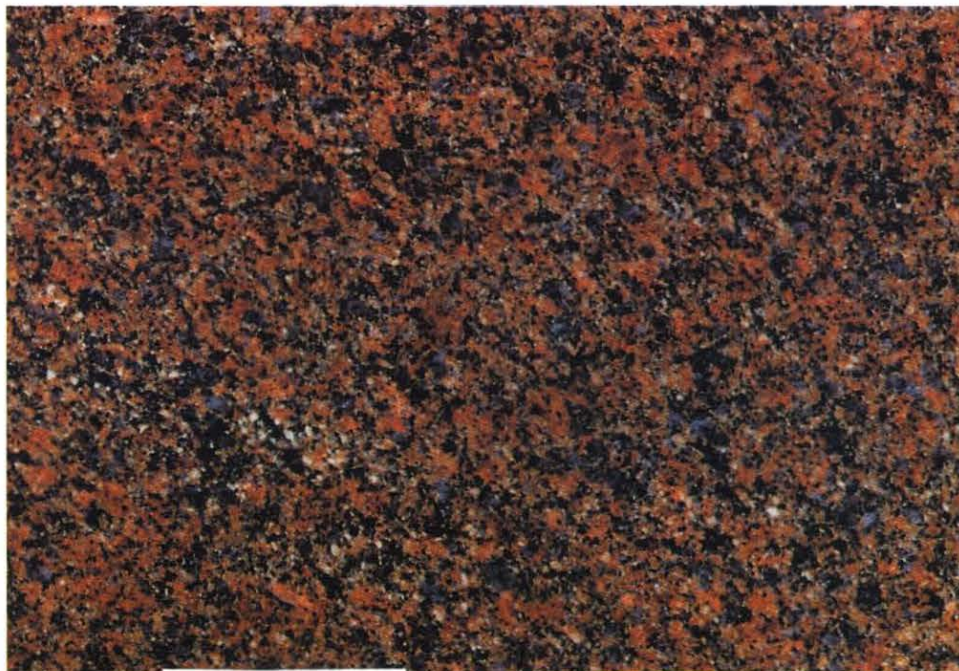
Potential block production to a depth of 1 m from the study area is as follows: 33 blocks 4 m³ (132 m³ or 44 per cent) and 23 blocks 2 m³ (46 m³ or 15 per cent). Of the remaining 41 per cent, about half could be produced in 1 m³ blocks. With the apparent lack of sheet fractures in the best areas, and the extension of good stone beyond the fracture study area and in other outcrops, a quarry operation producing very large blocks could be possible for this stone. A quarry sample was taken at UTM 692000E, 6066300N.

Denare Red Granite takes a fair polish, although there is some plucking of larger mafic grains. On polished surface the stone has a greenish overtone because of a pale greenish to white feldspar matrix. The colouring and texture give the polished stone a "tweedy" look. This stone is exceedingly hard which adds to processing costs, but suggests that good quality, durable monument stone might be produced from it if material from greater depth proves to polish better.

Dry Crushing Strength* (MPa - avg)	Absorption %
134.8	0.48

*Tests were done on surface stone; better results can be expected from fresh stone.





Denare Red Granite; polished.

Glossary

Absorption	percentage by weight of water absorbed into a submerged specimen of stone.
Anorthosite	a plutonic rock composed almost entirely of plagioclase feldspar of a specific range of composition.
Basement Rocks	older crystalline igneous and metamorphic rocks underlying a cover of sedimentary rock, usually synonymous with Precambrian.
Bed	sedimentary layer or stratum; also a layer of granite bounded by sheet structures.
Bench	man-made step in a quarry; in masonry, the lower surface upon which a block of stone rests.
Biotite	a mineral of the mica group, generally black, dark brown or dark green, common to many rock types and generally of a hydrous potassium, magnesium, iron, aluminium silicate composition.
Black Granite	a commercial name for crystalline igneous or metamorphic rock that is black or nearly black when polished.
Bleeding	staining action of corroded metals, metallic minerals, putties, mastics, caulking, etc.
Breccia	rock made up of angular broken fragments which are recemented; commercially, usually a marble.
Chalcopyrite	a bright brassy yellow copper, iron sulphide mineral (CuFeS_2), the presence of which is undesirable in building stone, particularly in exterior applications where it weathers and stains the stone.
Cleavage	ability to break along a natural planar surface or parting (e.g. slate).
Closure	the degree of disappearance of grain boundary "fractures" on a polished surface.
Cut Stone	syn: dimension stone, stone cut to specific shapes and sizes.
Dense	stone (usually sedimentary) with firm, densely packed grains, free of voids.
Dimension Stone	see cut stone.

Dip	the angle that a structural surface, such as a bedding plane or fracture plane, makes with the horizontal as measured perpendicular to the strike; degree and direction of the inclination.
Dolomite	rock of which more than 50 per cent by weight consists of the mineral dolomite ($\text{CaMg}(\text{CO}_3)_2$).
Euhedral	describes a mineral grain bounded completely or largely by its crystal faces (a well formed crystal).
Face	exposed surface of stone on a building or may refer to a quarry face.
Feldspar	a group of rock-forming minerals with a general formula: $\text{M Al}(\text{Al,Si})_3\text{O}_8$ where $\text{M} = \text{K, Na, Ca}$, and to a lesser extent Ba, Rb, Sr , and Fe . Feldspars are the most widespread mineral group and constitute about 60 per cent of the earth's crust.
Flamed	describes the rough surface of a coarse-grained granitic building stone produced by passing a high-temperature flame over its sawn surface. Spalling of the mineral grains, particularly quartz, produce a rough, non-skid surface. Formation group of beds with some common characteristics.
Fracture	any break in a rock due to mechanical failure regardless of any displacement (includes faults, joints, and cracks).
Fracture Pattern	description of fractures in a stone deposit in terms of directions and spacings between fractures, often shown on a plan.
Gabbro	a plutonic rock consisting of calcic plagioclase feldspar and dark minerals such as clinopyroxene, hornblende or olivine. Many variations occur and, depending on the proportion of dark and light minerals, gabbro may be described as leucogabbro (light coloured), mesogabbro (medium dark), and melagabbro (dark coloured). Yields black and grey granites as stone types.
Gneiss	granitic rock showing banding or directional texture resulting from orientation of grains or aggregates of mineral grains.
Grain	particles of minerals or crystals which comprise a rock. Also a direction of relative ease of splitting stone due to grain orientation.
Granite	as a dimension stone granite broadly describes crystalline plutonic and some metamorphic rocks with a granite texture. Colour and textural or structural terms may also be used as part of the commercial descriptive names of granites.
Granodiorite	a group of plutonic (granitic) rocks containing quartz, sodic plagioclase, potassium feldspar with biotite, hornblende, and rarely py-

	roxene as dark minerals. In commercial terms these would be grouped with granite.
Honed	the surface texture of a dimension stone prepared by sawing and grinding to various degrees of fineness short of polishing, a satin smooth finish.
Hornblende	a black, dark green or brown mineral commonly occurring in many igneous and metamorphic rocks; it is the most common member of the amphibole groups, typically occurring as columnar, fibrous or granular crystals. A principal ingredient in some black granites.
Hypersthene	a member of the pyroxene minerals; (Mg, Fe) SiO ₃ , crystallizing in the orthorhombic system; it is common to many igneous rocks including gabbro and has a greyish, greenish, black or dark brown colour and often displays a bronze or greenish-brown play of colour (schiller).
Igneous	having originated or solidified from a molten or partly molten material such as magma or lava. Igneous rocks are members of one of the three major classes into which all rocks are divided (igneous, metamorphic, and sedimentary).
Joint	a surface of fracture or parting in a rock, generally without displacement and often planar but may be curved. Joints commonly occur in parallel or nearly parallel sets and are a determining factor in the size and shape of quarried blocks of dimension stone. In masonry, the space between installed stone units.
Laminae, Lamination	thin layering or bedding (less than 1 cm thick).
Leucogabbro	light-coloured gabbro having a relatively low proportion of dark minerals.
Limestone	stone (or rock) consisting essentially of calcium carbonate (calcite) with earthy (non-polishable) finished surfaces.
Mafic	a term derived from "magnesium" and "ferric" to describe dark coloured rocks or the major minerals in such rocks.
Magnetite	a black, magnetic mineral of the composition Fe ₃ O ₄ . It is widely distributed in rocks of all types, but is particularly common in the darker (mafic and ultramafic) rocks such as gabbro. Magnetite is tolerated in small amounts in dimension stone. The mineral tends to be stable and non-staining.
Masonry	an assembly of stone units usually laid in mortar.
Megacryst	any crystal or grain in an igneous or metamorphic rock that is significantly larger than the surrounding matrix mineral grains; for example,

the large feldspar crystals (phenocrysts) in a porphyritic granite. The term megacryst is applied to the texture of a rock composed largely or entirely of large crystals.

- Metamorphic** one of the three major classes of rocks; these are derived from pre-existing rocks by chemical, mineralogical, and structural changes due to heat, pressure stress, and chemical environment, usually at depth in the earth's crust.
- Mica** family of minerals occurring as flakes and "books" that readily split into thin transparent flexible flakes, common constituent in igneous and metamorphic rocks.
- Microcline** a mineral of the alkali feldspar group (KAlSi_3O_8), clear, white to grey, brick-red or green in colour. It resembles orthoclase, a feldspar to which it is closely related and is sometimes distinguishable in hand specimen by cross-hatched striations on some crystal surfaces due to twinning.
- Modulus of Rupture** a measure of the transverse strength of a material measured in lb/in^2 (psi) or Mpa (megapascals). One Mpa is equivalent to about 145 psi.
- Outcrop** exposure of bedrock on the surface.
- Panel** a unit of stone veneer.
- Phenocryst** the large crystals in a rock with porphyritic texture (see porphyritic).
- Plagioclase** a group of feldspar minerals of triclinic crystal form ranging in composition from $\text{NaAlSi}_3\text{O}_8$ to $\text{CaAl}_2\text{Si}_2\text{O}_8$. Plagioclase is common in igneous and metamorphic rocks. Colours are commonly white, grey or bluish grey and sometimes reddish, greenish, yellowish, brown, and clear. Fine parallel striations on crystal faces are common in plagioclase.
- Pluton** a body of intrusive igneous rock formed at great depth.
- Polished** describes a dimension stone in which a single face is prepared to reflect light without visible streaks or scratches. Polishing brings out the detailed texture and colour of the stone.
- Porphyritic** the texture of an igneous rock in which larger crystals are set in a finer-grained matrix.
- Pyrite** a common bronze or brassy yellow iron sulphide mineral (FeS_2). Pyrite as well as other sulphide minerals are among the most undesirable minerals in any building or monumental stone. Chemical weathering of sulphide minerals may weaken building stone material and cause unsightly rusty spots and streaks. Scattered grains of pyrite in small

amounts may be tolerated in exterior applications and present no significant problems in most interior finishes.

- Pyroxene** a group of common, dark-coloured, rock-forming minerals of the general formula $ABSi_2O_6$, where A = Ca, Na, Mg, Fe and B = Mg, Mn or Al.
- Pyrrhotite** a common red-brown to bronze iron sulphide mineral of variable composition. The mineral is magnetic, but varies widely in intensity. It weathers easily and is therefore undesirable in building stone especially for exterior use. Pyrrhotite is commonly associated with basic igneous rocks such as gabbro and other hornblende-rich rocks.
- Rubble** rough stone usually of irregular shape and size used for uncoursed setting or roughly squared and of irregular size that may be set in rough courses.
- Sheeting** the natural separation of rock in outcrop or quarry into sheets by horizontal or nearly horizontal joints and fractures. Surface sheets may vary in thickness and commonly follow the surface contours. Sheeting in granitic terrain typically becomes more widely spaced and more horizontal with depth.
- Specific Gravity** the weight of a material relative to an equal volume of water at standard temperature and pressure. For example, at a specific gravity of 2.7 the weight of a rock is 2.7 times heavier than an equal volume of water.
- Strike** the direction or trend of a structural surface expressed by the compass bearing of a horizontal line on the surface.
- Uniformity** the property of general homogeneity of a stone such that panels and tiles cut for a project will be visually similar in colour, texture, and structure. Granular uniformity refers to consistency at the grain level such that a small sample (e.g. 30 cm tile) will be representative. Pattern uniformity applies to stone, usually veined or brecciated, that may require one or more square metres to provide a representative sample of the stone.
- Veneer** thin or relatively thin slabs of stone, either sawn or split, partly shaped or accurately dimensioned and used for wall cladding. Veneer slabs can be used to simulate ashlar and rubble. Ashlar veneer may be coursed or set in random rectangular fashion whereas rubble veneer is polygonal and produces a spider web effect. Full dimensioned and polished veneer slabs are accurately shaped into regular square or rectangular panels.

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Appendix – Stone Market Synopsis

History and Development

During the early years of this century, a new mechanized technology for quarrying and finishing stone promised a new stone age. This was thwarted by the effect of two world wars with the Dirty Thirties sandwiched in between. During the economic boom after the end of World War I, stone production rose dramatically. In 1928, U.S. production of dimension stone had reached 4.5 million tonnes and Italy, Belgium, and France together had an output of 1.5 million tonnes. Production fell in the thirties, a measure of the drop being U.S. output of 1.7 million tonnes in 1938. Since there was very little world trade in stone at that time, production in a given country was close to its consumption and world recessionary demand would have reduced stone production overall to a degree similar to that of the United States. A world output of 2.5 million tonnes is probable for that time.

World War II pushed production down further and recovery after the war was slowed by competition from new, cheaper, lightweight building materials. It took until the 1960s before stone markets began to recover, but new output growth was not evenly spread. United States production continued to slide from 2.5 million tonnes in 1960 to below 1.0 million tonnes in the 1980s, although actual U.S. demand began to rise after 1980 with increasing imports mainly from Italy, where a revolution in technology and aggressive marketing had occurred. U.S. annual imports of rough stone equivalent grew from about 200,000 tonnes during the early 1970s to about ten times this by the 1990s.

In 1993, world annual production of raw dimension stone is estimated to be about 34 Mt (about 12.6 million m³), with Europe accounting for about two thirds of total output. About 50 per cent of world production comes from

six leading countries: Italy, Spain, Greece, the United States, France, and China. Italy has traditionally been the world's leading producer, accounting for about 7 Mt. Also, Italy was the world's leading exporter of rough stone, accounting for about 2.5 Mt in 1993. China ranked second with nearly 15 per cent of the world's exports.

Recent changes in structure of the world industry include:

- a) the rapid development of relatively new important producers over the past several years - notably China, Scandinavia, South Africa, Spain, Portugal, Brazil, and India;
- b) the growing proportion of granite because of its widespread abundance; it currently represents about 40 per cent of stone production; and
- c) the increasing trade in finished stone relative to rough blocks.

Market Structure and Prices

The market is multicomponent, defined by the degree of product finishing and aesthetic characteristics. A given source may sell:

- a) rough quarry blocks to a cutting and polishing plant,
- b) slabs cut from quarry blocks to a plant for polishing and cutting. These are generally 9' by 5' of various thicknesses (1/2", 1", 1-1/4", 1-1/2", etc.),
- c) polished slabs to a stone cutter (similar dimensions as in b), and
- d) finished tiles and panels ready for installation.

Each of the above has an established market.

Since producers of quarry blocks also generally have facilities for finishing the stone,

prices for quarry blocks tend to be at a level that renders processors (category a above) who do not have their own stone, vulnerable to a squeeze on profitability. This was one factor in the closure of a large processor in Canada several years ago.

Categories b and c above (involving slabs) are major markets, especially polished slabs. In this market, building contractors, furniture-makers, etc. buy slabs for custom cutting, manufacturing, and installation.

Category d has two segments: direct wholesale for architectural contracts for building construction, and a broad distribution network of retail shops selling floor tiles, furniture, and other products to the general public. Mark-up in this market is substantial.

Prices range widely according to aesthetic qualities of the stone. For example, finished tiles (one square foot) can be had for as low as \$2.00 per square foot for poor quality stone to over \$100.00 for Argentinean blue marble or black and gold Portoro from Italy.

Canadian Industry Profile

Canada is recognized primarily as a granite producer from an international trade viewpoint. Although limestone and sandstone are venerable parts of the stone industry in this country, they tend to be confined to more localized markets. Marble, the premier stone of choice in the world, is the least well known in Canada, despite the fact that the value of marble imports rivals that of granite.

In 1994, Canada produced an estimated 400,000 tonnes of dimension stone (rough stone equivalent) of all kinds, valued at about \$30 million. Unfortunately this figure includes low value bulk material used for jetty stone, rough masonry, etc. By type, limestone

comprises about 50 per cent, granite 40 per cent, and sandstone 10 per cent. Dimension stone marble production has been sporadic and in small quantities over the years. Recently, new deposits have been developed in the Sudbury and Renfrew County areas of Ontario. Currently, about 50 quarry operations are active; 44 granite, two marble, and the remainder are of sandstone and limestone.

Granite

Rough granite production, especially in Quebec where 90 per cent of Canadian output derives, has grown rapidly over the last 20 years. Tonnage has grown from some 15,000 tonnes valued at \$850,000 in 1977 to a peak of 166,000 tonnes valued at \$33.6 million in 1990. Moreover, with the rapid expansion of finishing capacity in Quebec, output of finished stone has more than doubled from 3.5 million square feet since 1981. The value of architectural granite from both domestic and imported stone manufactured in Quebec has increased tenfold over the past decade to over \$100 million. With the recent downturn, production has declined to 115,000 tonnes in 1994 but is expected to resume good growth beyond 1996 with renewed office building construction in North America, Europe, and Japan.

Marble

Marble is, and has been throughout history, the architects stone of choice where elegance and beauty are the guiding criteria. For this reason, the market range is worldwide. Since most Canadian marble consumption is based on imports, this category presents a good opportunity for development. Some \$30 million worth of finished marble and rough blocks were imported in 1990, a more than five-fold increase over 1981 figures.

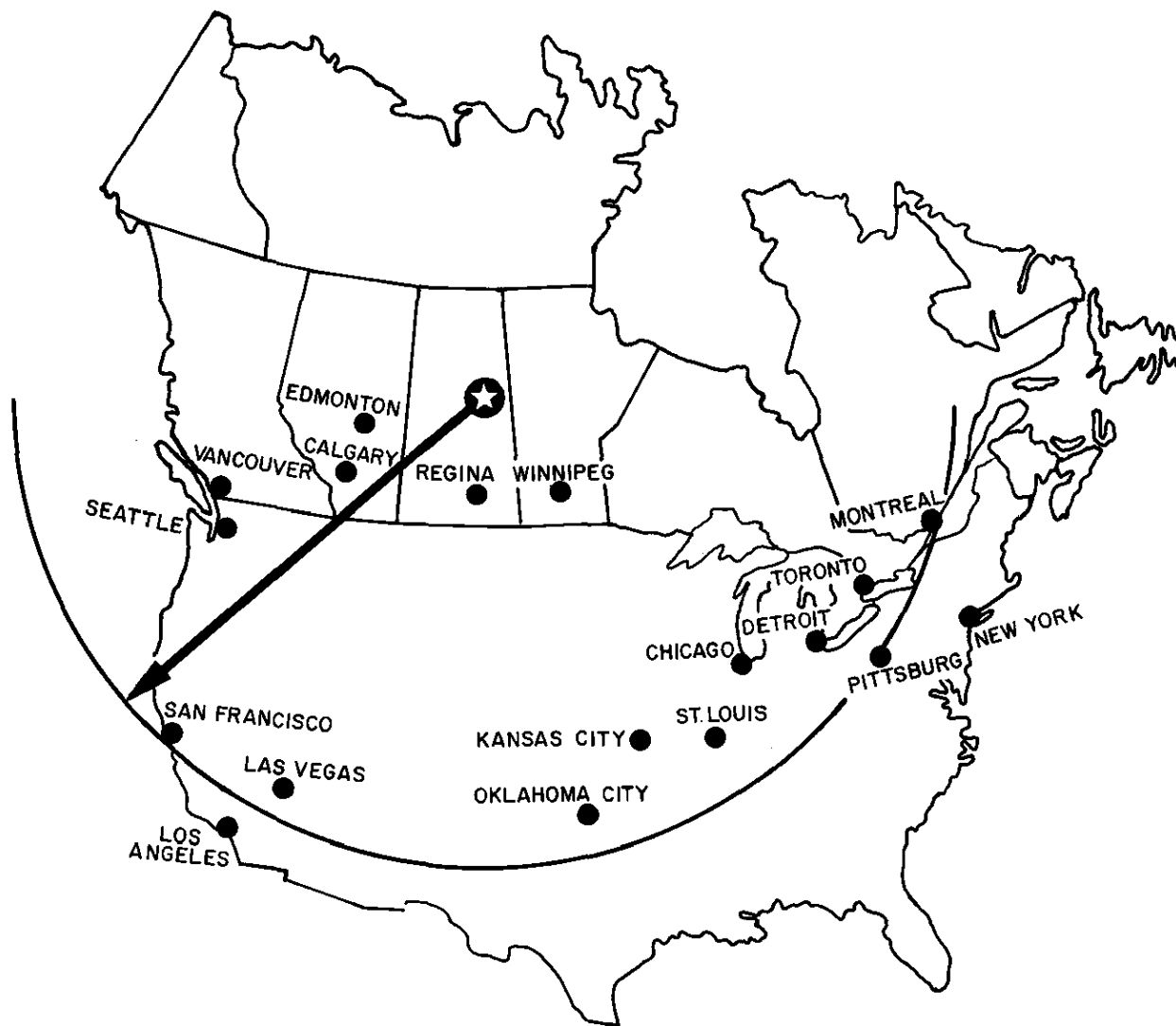
Canadian Production of Dimension Stone

	1992		1993	
	(000t)	(\$000)	(000t)	(\$000)
Granite	127	20,500	134	18,000
Limestone	103	3,750	250	5,555
Marble	10	530	6	2,780
Sandstone	60	4,100	12	3,650
Slate	---	205	1	833

**Canada, Rough Granite, Summary of Production and Trade
1980 and 1985-94**

	Quantity Value	Production ¹	Imports ²	Exports ²
1980	t	81,000	24,130	5,019 ^a
	\$ millions	5.6	1.9	0.7
1985	t	104,000	34,468	12,511 ^a
	\$ millions	12.8	6.2	1.7
1986	t	121,000	33,994	18,450 ^a
	\$ millions	15.7	6.6	2.7
1987	t	112,000	46,370	37,450 ^a
	\$ millions	16.1	7.9	6.0
1988	t	153,000	46,282	86,940 ^r
	\$ millions	24.4	11.2	16.2 ^r
1989	t	162,000	52,337	107,105
	\$ millions	24.8	11.7	17.3
1990	t	166,000	46,163	88,775
	\$ millions	33.6	11.2	19.4
1991	t	122,000	35,038	94,529
	\$ millions	24.0	8.5	22.6
1992	t	127,000	44,951	101,957
	\$ millions	20.3	10.5	21.4
1993	t	134,000	41,484	142,263
	\$ millions	18.1	10.2	20.3
1994	t	115,000 ^e	35,624	122,674
	\$ millions	18.0	10.1	20.0

Sources: Natural Resources Canada; Statistics Canada; °, estimated; †, revised; ^a, coded as building stone, rough (90% is considered to be granite); ¹, includes rough stone for construction, monumental/ornamental, and other uses; and ², includes codes 2516.11 (roughly trimmed block) and 2516.12 (cut block by sawing or otherwise). Some re-exports to the United States may also be involved.



The best Saskatchewan stone could support truck freight of C\$100/ton for rough blocks (average \$1.00/ft² on the contained polished panels/tiles). This is a trucking industry estimate for large container shipping as far as Ottawa/Montreal. Assuming similar ton-mile rates, the rough stone could reach the Great Lakes States, St. Louis, Kansas City, Las Vegas, Seattle, and Vancouver. Container shipping of finished stone is even more economical in that waste from the rough blocks is eliminated. For example, one ton of 3/4" slabs is derived from about 1.7 tons of rough stone.