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Province of British Columbia
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Petroleum Resources

MINERAL RESOURCES DIVISION
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FELDSPATHIC MINERAL OCCURRENCES IN BRITISH COLUMBIA

By M.E. MacLean and G.V. White

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SUMMARY

There is currently no production of feldspathic minerals in western Canada; British Columbia imports feldspathic sand from Idaho and nepheline syenite from Ontario. During the early 1960s, a limited amount of feldspathic sand was produced for local markets, but the deposit was not developed further.

Potential sources of feldspathic minerals are pegmatites, nepheline syenite, phonolite, aplite, leucocratic granite and feldspathic sands. All of these types of deposits occur in British Columbia and only a few have received serious attention by industry.

The single most important factor in evaluating a deposit's potential as a feldspathic mineral source, besides meeting the quality requirements of industry, is proximity to established transportation routes. The cost of transportation per unit weight frequently far exceeds the value of the mineral itself, so that even the 'purest' of deposits will not be economic if the infrastructure does not exist.

The most significant use of feldspathic minerals is as a source of alumina, alkalis and silica, in the glass and ceramics industries. These elements influence the rate and temperature of melting, the fluidity of the melt and the physical properties of the finished product. The ratios of alumina, sodium, potassium and silica are specified for each industrial use. Contaminants such as iron must be low (%) or virtually absent as with copper and manganese or other colouring elements. Refractory minerals such as corundum, spinel or mica must be absent in material to be used in glass manufacturing.

Grain size is also an important specification; for glass the range must be -40 +100 mesh, and for ceramics finer material at -200 or -325 mesh is required.

A field study of potential and known deposits of feldspathic minerals was carried out by the British Columbia Geological Survey Branch. The sites chosen for evaluation are all in southern British Columbia and close to transportation links. Mineral processing studies were conducted by CANMET laboratories of Energy, Mines and Resources Canada in Ottawa.

Of the eleven prospects studied, four sites (Lumby, Hellroaring Creek, Scuzzy Creek and Trident Mountain) can produce a feldspathic product comparable to material currently being imported. The Lumby and Hellroaring Creek sites, which contain glass and ceramic-grade feldspathic material, have been evaluated by industry. The Barrière, Sumas Mountain and Blue River properties also have development potential.

A market study of feldspathic minerals which could be produced in the province indicates that local producers would enjoy a marked freight advantage over eastern (Ontario) or southern (U.S.A. or Mexico) suppliers. The market for British Columbia feldspar products could also expand to include Pacific Rim countries such as Japan and South Korea. It is estimated that about 29 700 tonnes per year of feldspar or 23 400 tonnes per year of nepheline syenite could be marketed in northwestern North America with an additional 23 400 tonnes nepheline syenite per year for Pacific Rim countries. The possibility also exists for penetration of nepheline syenite into the aplite market in Japan; another 40 500 tonnes per year.

In total, markets of 22 500 to 90 000 tonnes per year are potentially attainable by a British Columbia producer of feldspathic minerals. This is, of course, dependant on the relative quality of the product, the reliability of the supplier, the establishment of a competitive price and effective sales and marketing strategy (McVey, 1988).

TABLE OF CONTENTS

TABLES

INTRODUCTION

This report is a compilation and assessment of the feldspathic mineral prospects in British Columbia. The project was initiated in 1987 by G.V. White who carried out field investigations of ten occurrences selected for their accessibility and the presence of feldspathic sand, nepheline syenite, aplite or phonolite.

Property descriptions have been published by G.V. White on the Hellroaring Creek and Lumby pegmatites (White, 1988a, b), and a preliminary summary report of all the occurrences was included in *Geological Fieldwork 1988* (White, 1989).

Mineral processing tests were carried out by CANMET laboratories of Energy, Mines and Resources Canada in Ottawa, and spectrographic work was done by the British Columbia Geological Survey Branch laboratory; results are included in the deposit descriptions.

In October 1989, M. MacLean updated the deposit descriptions, including petrographic observations, wrote the accompanying sections and compiled this final report.

Material is from numerous sources, including both federal and provincial government publications, assessment reports, private company reports and personal communications. Marketing information was derived largely from a marketing study by H. McVey of Mineral Marketing, Inc., commissioned by the British Columbia Geological Survey Branch.

The information presented here is by no means complete; any corrections or additional information concerning the occurrences is welcomed by the authors.

All the occurrences are listed in the Ministry's MINFILE database, reference to which is given for each property. Information on minor occurrences of nepheline syenite and feldspar obtained through the MINFILE system is appended.

SOURCES OF FELDSPATHIC MATERIAL

FELDSPARS

Feldspars are the most abundant rock-forming minerals, commonly found in igneous rocks. They are classified in two main groups, the alkali series and the plagioclase series; with a third, small overlapping group in the solid solution series. Alkali feldspars are in the compositional range of $KAlSi_3O_8$ and $NaAlSi_3O_8$, and plagioclase ranges from $NaAlSi_3O_8$ to $CaAl_2Si_2O_8$. Plagioclase feldspars are more widely distributed and more abundant than potassic feldspars. The various feldspar species are described in Table 1.

FELDSPATHIC SOURCE MATERIALS

Feldspathic material is found in economic deposits in nepheline syenite, phonolite, pegmatite, aplite, alaskite, leucocratic granite and feldspathic sand.

TABLE 1
THE FELDSPAR SERIES

POTASH FELDSPARS: $KAlSi_3O_8$

Orthoclase:	monoclinic found in quickly cooled granites, granodiorites and syenites.
Microcline:	triclinic, found in more slowly cooled granites, granodiorites and syenites.
Sanidine:	monoclinic, high temperature, found as phenocrysts in rhyolites and trachytes.
Adularia:	mixed crystallography, low temperature, in hydrothermal veins.

PLAGIOCLASE FELDSPARS:
$NaAlSi_3O_8$ (Ab) - $CaAl_2Si_2O_8$ (An)

Albite:	0-10% An, "soda-spar", triclinic.
Oligoclase:	10-30% An, triclinic, found in granodiorite and monzonite.
Andesine:	30-50% An, triclinic, rare, found in andesites and diorites.
Labradorite:	50-70% An, triclinic, found in gabbros and basalts.
Bytownite:	70-90% An, triclinic, found in gabbros, not used commercially.
Anorthite:	90-100% An, triclinic, rarer than albite, found in mafic-rich rocks.

SOLID SOLUTION BETWEEN SODIUM AND POTASSIUM FELDSPAR

Above 600°C:	Anorthoclase: $Or_{70}Ab_{30}$ - $Or_{10}Ab_{90}$ - triclinic
Below 600°C:	Gap in solid solution series causes exsolution of sodium/potassium feldspars: Perthite: >50% or Antiperthite: >50% Ab.

NEPHELINE SYENITE AND PHONOLITE

Nepheline syenites contain the commercially important mineral nepheline, and a mixture of microcline and albite. Generally, syenites contain alkali feldspar; orthoclase, sanidine, microcline or anorthoclase with albite, nepheline, sodalite, amphibole, pyroxene, analcite, biotite, olivine and calcite with accessory zircon, sphene, iron ores, muscovite, corundum and fluorite (Ehlers and Blatt, 1980). Nepheline is a difficult mineral to identify macroscopically but is recognizable by alteration products cancrinite and sodalite.

Nepheline syenite is generally considered igneous in origin, but may also be metamorphic. Nephelinitic magmas, which are often associated with basaltic rocks, originate deep in the mantle and may contain inclusions of upper mantle lithology (for example, kimberlites). Nepheline syenite compositions may also result from the remelting of pre-existing alkaline rocks that are high in rare earths, indicative of late magmatic phases, and low in chromium and nickel which is indicative of early melting phases. Nephelinitic rocks may also result from metasomatism of pre-existing rocks, with or without partial melting, and is usually discernible by textures and field relations (Currie, 1976a).

The extrusive equivalent of nepheline syenite is phonolite, which may also be a potential source of feldspathic materials. Phonolites contain alkali feldspar (sanidine, anorthoclase or orthoclase), nepheline, rare plagioclase with sodalite, hauyne, analcite, iron-rich olivine, sodium-rich amphiboles or pyroxene, biotite, leucite, phlogopite and accessory sphene, apatite, corundum, zircon and iron ores (Ehlers and Blatt, 1980). Leucite, $KAlSi_2O_6$, is potentially useful as a source of aluminum.

PEGMATITE AND APLITE

Pegmatites are defined as coarse-grained igneous rocks found usually as dikes associated with a larger plutonic mass of finer grain size. The term pegmatite denotes texture only, not composition. The gross composition is usually granite but compositions similar to other rock types are known.

During the normal sequence of crystallization of a magma, the stage is reached where the residual fluid is rich enough in volatile materials to form coarse-grained rock more or less equivalent in composition to the parent rock; this phase of crystallization produces pegmatites.

Pegmatites consist chiefly of quartz and alkali feldspar (+ muscovite/biotite) but being rich in volatiles and elements excluded from crystallization within normal silicate structures, they often contain abundant less-common minerals with elements such as lithium, beryllium, niobium, tantalum, tin, uranium, thorium, tungsten, zirconium and rare earths.

Aplite is a fine-grained, sugary textured, late-crystallizing rock composed of quartz and alkali feldspar. Pegmatites may be found with aplite within the same dike, with sharp or gradational contacts. Pegmatites and aplites in the same vein may be due to either simultaneous or sequential crystallization of both melt and water-rich phases or from anatexis, the partial melting or 'sweating out' of granitic fractions during high-grade metamorphism.

Aplite is correctly defined as containing minor quartz and mixed feldspars, but in Viriginia it is used as the commercial name of a rock which is almost totally andesine feldspar.

ALASKITE AND LEUCOCRATIC GRANITE

'Alaskite', actually a muscovite granite, is mined for feldspar in North Carolina. Alaskite is usually defined as a leucocratic granite composed of alkali feldspar, quartz and few mafics.

FELDSPATHIC SAND

Feldspathic sands are a mixture of approximately equal amounts of quartz and feldspar occurring naturally as an erosional product from granitic rock. The best feldspathic sands are found in stream systems where the entire basin drains only granitic terrain and where Pleistocene glaciation has not contaminated the system (Agricola Mineralia, 1986).

INDUSTRIAL USES OF FELDSPATHIC MATERIALS

The commercial range of feldspars falls generally within the alkaline group, microcline, orthoclase, perthite and albite, commonly found in granites, syenites, rhyolites and pegmatites. Commercial feldspar is mined from fine-grained aplite (Viriginia, Italy), alaskite (North Carolina), pegmatites (east and central U.S.A., Eastern Canada, Finland, Scandinavia), phonolites (Germany), and beach sands and alluvial deposits (Spain). Examples of typical analyses of feldspathic and aluminous materials is shown in Table 2.

TABLE 2
TYPICAL ANALYSES, FELDSPATHIC AND ALUMINOUS MATERIALS (FROM LEFOND, 1983)
(All analyses are in per cent)

	1	2	3	4	5	6
SiO_2	67.54	67.04	71.84	79.20	63.71	61.40
Al_2O_3	19.25	18.02	16.06	12.10	21.89	22.74
Fe_2O_3	0.06	1.94	0.09	0.06	0.09	0.06
CaO	1.94	0.38	0.48	0.52	5.70	0.70
MgO	trace	trace	trace	trace	trace	trace
K_2O	4.05	12.10	7.60	2.62	2.37	4.95
Na_2O	6.96	2.12	3.72	4.80	5.60	9.54
Li_2O	-	-	-	0.35	-	-
TiO_2	-	-	-	-	0.43	-
Loss on ignition	0.13	0.30	0.20	0.35	0.21	0.60

1. Soda flotation feldspar, Spruce Pine, NC.
2. Potash flotation feldspar, Kings Mountain, NC.
3. Dry-ground feldspar, Custer, SD.
4. Feldspathic sand, Bessemer City, NC.
5. Low-iron aplite, Montpelier, VA.
6. Canadian nepheline syenite, Nephton, Ontario.

For commercial use, potassium feldspar must have at least 10 per cent K_2O, plagioclase must have at least 7 per cent Na_2O and nepheline syenite (mixture of microcline and albite, plus nepheline) must have at least 10.2 per cent Na_2O. The choice of feldspathic mineral for each industrial use is governed by the required specifications and the material's availability. Feldspar and nepheline syenite are often interchangeable; each has qualities which make it more or less suitable for different applications. Some basic properties considered in industrial use are compared in Table 3.

Nepheline syenite is a richer source of aluminum than feldspar (22-26% versus 16-20%) and contains no free silica, which are good qualities for glass making. Feldspars have good consistency in condition and purity and contain no volatile constituents; they melt at about 1100 to 1200°C and are readily dissolved in the glass melt. Nepheline syenite has a higher fluxing strength than feldspar and is a cheaper source per unit combined aluminum and alkalis. Because feldspars usually occur with other minerals (*e.g.* in pegmatites) separation and froth flotation and/or dry milling increase the cost of production. As nepheline syenite contains no free silica, it can be dry milled and more easily processed.

Nepheline syenite has a PCE (Pyrometric Cone Equivalent) several cones lower than potash feldspar and is therefore more active in dissolving silica. Nepheline syenite has sintering ranges several cones longer than potash feldspar which gives it a greater workability per unit aluminum. Feldspars have a longer and more controllable vitrification curve than nepheline syenite, which has a narrow fusion range and a lower fusion temperature.

Feldspathics are used mainly as a source of aluminum and alkalis in the glass and ceramics industries, and as a filler in the paint, plastics and rubber industries. They also find use as electrical insulator coatings, match-flame retardants, abrasives and as an arc stabilizer in welding. These industrial applications are discussed in the sections following, and specifications are summarized in Table 4.

TABLE 3
COMPARISON OF PROPERTIES OF NEPHELINE SYENITE AND FELDSPAR CONSIDERED FOR INDUSTRIAL USE

	NEPHELINE SYENITE	FELDSPAR
specific gravity	2.61	2.54-2.76
hardness	5.5	6
aluminum oxide	22-26%	16-20%
combined aluminum and alkalis ($Al_2O_3+Na_2O+K_2O$)	39 units*	31 units

**1 unit (or unit tonne) = 1% tonne = 10 kilograms.*
1 tonne nepheline syenite contains 39 units, or 390 kilograms.

GLASS

Products containing feldspar in the glass industry include container glass, fibreglass, speciality glass and flat glass (dinnerware, *etc.*). The alkali content of the feldspathic material acts as a flux, partially replacing soda ash.

TABLE 4
SPECIFICATIONS FOR THE MAJOR INDUSTRIAL USES OF FELDSPATHICS
(from Agricola Mineralia, 1986)

END USE	GRAIN SIZE*	% Fe_2O_3	OTHER CONTAMINANTS	SPECIFICATIONS
1. GLASS				- nepheline syenite, feldspathic sand, aplite - no colouring oxides: ZrO_3, Cr_2O_3, NiO, Co_3O_4, CuO
high quality	feldspar - -20+100 nepheline syenite - -40+100		Cr - 6 ppm (max)	- no refractory minerals: zircon, corundum, spinel - no sulphates or chlorides - coloured glass bottles - use phonolite
clear glass, flint, coloured and fibreglass, container glass		<0.05 <0.07 0.1-0.6	Co - 2 ppm Alkalis±0.5 (max)	- fibreglass: silica 55%, limestone 25-30%, alumina 14% - container glass: silica 60%, soda ash 19%, limestone 14-19%, alumina 4-5% - flat glass: more magnesium, less Al_2O_3
2. CERAMICS				
sanitary ware		0.5		- 5-10% K_2O
pottery		0.65-0.1		- 'high' K_2O
porcelain	-200, -300	0.05	no garnet, tourmaline, hornblende or mica	- K feldspar + Na feldspar
glazes		0.05		- 'high' K_2O
electrical porcelain		0.05		- 'high' K_2O
3. PLASTICS PAINT, RUBBER (fillers)	101	<0.07		- nepheline syenite and feldspar

**Grain size measured in mesh unless otherwise stated.*

Aluminum is an important constituent in glass-making. Although it is the most abundant metallic element (8% of the earth's crust), it does not occur in nature in the metallic form, but combines to form silicates such as feldspar, mica or clay. When present in a mineral compound, aluminum provides greater durability, hardness and strength. It is extremely refractory and increases viscosity during glass formation, inhibiting devitrification. Aluminous compounds also act to stabilize the final product and may remove deleterious chemicals from the raw materials batch.

Besides feldspar and nepheline syenite already discussed, there are several other competitive sources of aluminum. Kyanite and sillimanite ($Al_2O_3 \cdot SiO_2$) contain 50 to 60 per cent Al_2O_3 and are used for low-alkali glasses although they have a higher iron content than other aluminum sources.

Kaolin ($Al_2O_32 \cdot SiO_2 \cdot 2H_2O$) contains from 36 to 39 per cent Al_2O_3 but is usually too variable in composition and the iron content is often high.

Aluminum hydrate ($Al_2O_3 \cdot 3H_2O$) is artificially produced and contains 65 per cent Al_2O_3. It can be used in glass when alkalis are not desirable or when iron must be kept to a minimum. There are also naturally occurring aluminum hydrates (bauxite, diaspore, gibbsite) but their iron content is too high for use in the glass industry.

Blast-furnace slag may also be used as a source of aluminum.

In terms of relative proportions of aluminum for the most commonly used sources, nepheline syenite contains the highest, followed by soda feldspar and potash feldspar (Table 5).

TABLE 5
RELATIVE PROPORTIONS OF ALUMINUM

Material	Al_2O %
nepheline syenite	22-26
soda feldspar	16-20
potash feldspar	16-19
aplite	10-20
kyanite/sillimanite	50-60
kaolin	36-39

CERAMICS

Ceramics containing feldspathic materials include whiteware (bathroom and kitchen fixtures), wall and floor tiles, pottery, porcelain, enamels and glazes. Clays and silica are the main constituents together with feldspathics, fluorspar and many other possible additions which contribute specific characteristics to the final product. Feldspathics may comprise up to 40 per cent of the ceramic body and 50 per cent of the glaze; relative percentages are given in Table 6.

TABLE 6
FELDSPAR CONTENT (PER CENT)
IN CERAMIC APPLICATIONS

		FELDSPAR %
soft (low temperature) porcelain		25-40
tableware		18-30
sanitary ware		30-36
whiteware, pottery, tile	- body	15-35
	- glaze	30-50

Feldspathics impart strength, toughness and durability to the final product. The final characteristics are affected by the potash to soda ratio in the feldspar, generally a high ratio is desired, in the range of 5:1 to 1:1. Therefore, potassium feldspars (microcline or orthoclase; at least 10% K_2O) are more popular for ceramic use. They produce a high-viscosity melt, with a wide firing range, giving good stability against distortion of ceramics during firing. High-quality potassium feldspar is used in dental porcelain ('dentalspar'). Potassium feldspar is also used in high-tension electrical insulators and electric porcelain insulators which are 15 to 60 per cent K-spar by weight.

The basic natural components used in ceramics, clay and silica sand are themselves quite refractory, clay more so than silica sand. Contaminants like iron oxides and limestone act as fluxes and reduce the fusion temperature of the mineral or blends. Additions to the ceramic mixture are commonly limestone and dolomite, feldspathics, pigmentary minerals, refractory oxides or carbides and special property producers.

Fluxes in ceramics are strong bases which form eutectics with silica and silicates. The elements used as fluxes are lithium, sodium, potassium, calcium, magnesium, boron, iron, lead and fluorine; these are found in a variety of natural or synthetic materials. The fluxing ability depends on the amount of the element present and relative amounts of counteracting elements such as aluminum and silicon which make compounds more refractory.

A balance must be reached between maximum fluidity of the melt and stability in the final product. If water is used in the processing, insoluble fluxes are preferred. The less soluble and fusible fluxes used in earthenware, porcelain and stoneware are potassium feldspar (microcline, orthoclase), sodium feldspar (albite) or perthitic mixtures. High-calcium feldspar (anorthite) is not usually used as a flux; it is more refractory than the potassic or sodic feldspars and so melts at a higher temperature. If used, it may cause devitrification or crystallization. Nepheline syenite and synthetic frits have a higher fluxing power than feldspar and are used as substitutes. Lithium minerals such as spodumene and derivatives are often used when blended with feldspar.

For use in porcelain and glazes, no garnet, hornblende, tourmaline or mica may be present in the raw materials. The iron content is carefully monitored; in pottery Fe_2O_3 must range between 0.05 and 0.1 per cent and for most other ceramic uses Fe_2O_3 must be less than 0.05 per cent.

PAINTS, PLASTICS AND RUBBER

Very finely ground feldspathic materials (silt-sized, 10 microns) are used as fillers, extenders and adsorbants in the paint, plastics and rubber industries. Mineral fillers in general must be very consistent as there are rigid chemical and physical specifications to be met. The general advantage in their use is a reduction in the cost of the end product but they also contribute many useful properties.

In plastics, feldspathics are used as fillers and extenders, colorants and as flame retardants. Their low density reduces the overall density of the final product, and they contribute to hardness, possibly whiteness and are easily dispersed. Nepheline syenite has the same refractive index as polyvinyl chloride plastics (PVCs) and can therefore be used as a filler without sacrificing translucency. Micronized nepheline syenite has a low tinting strength and high brightness, it is inert, has easy wettability, rapid dispersion, excellent impact strength, dimensional stability and high heat-deflection temperatures.

In paints, feldspathics offer excellent exterior durability, tint retention and resistance to chalking. Their hardness contributes to the washability of exterior paints, and also acts as a grinding aid in the dispersion of other pigments. In aqueous solution, nepheline syenite, with a pH of 9.9, aids the storage of latex paints and gives a uniform sheen on interior flat paints. As an extender it is safe, nontoxic, low dusting, has no free quartz or silica and is low in heavy metal content.

Tailings and dust from crushing operations should be considered for use as mineral fillers, for health as well as economic reasons. In the Peterborough area of Ontario, nepheline syenite tailings are currently used as an additive in Portland cement and could find potential use as a filler in asphalt and concrete mixes. The dust (45 microns) could be used as a bitumen extender in asphalt mixes, in plastic piping, in joint cement and brick and block manufacturing (Collings, 1981).

Many other minerals compete as extenders and fillers such as calcium carbonate, kaolinite, clays, talc, pyrophyllite and wollastonite.

OTHER USES

Feldspathic materials are used as a coating on electrodes, mostly in manual metal arc processes. They act as an arc stabilizer and help in weld-pool protection. Being inert, they do not react with alkaline silicate binders. Both potassium feldspar and sodium feldspar are used, although K-spar is favoured as it tends to give a smoother arc. A consistent particle size and chemical composition is required to avoid unpredictable welding characteristics. The size of feldspathic material must be not more than 250 microns with a mean size of 70 microns.

Calcium feldspar is mined in the U.S.S.R. as a source of lime; it is the primary calcium-aluminum silicate source used to manufacture cement. Ground feldspar is also a natural abrasive, and is used as a non-skid dusting agent.

BENEFICIATION/SPECIFICATIONS

Feldspar was traditionally recovered from coarse-grained pegmatites by hand cobbing. In the early 1930s, feldspar flotation techniques were developed, which allowed separation of feldspar from quartz and mica, and now the process of froth flotation has been refined.

Crude ore is crushed, ground and screened to suitable liberation mesh sizes, deslimed and micaceous minerals are removed using amine collection in an acidic environment. Often an operation may liberate more than one marketable product, such as mica or lithium minerals from pegmatites or silica from alaskite, aplite and feldspathic sands.

IMPURITIES

At the early developmental stages of a deposit, it is important to evaluate the feasibility of obtaining a pure enough, marketable feldspathic product. This should involve petrographic studies as well as beneficiation testing for the removal of impurities.

The limiting factor for many feldspathic materials is the iron oxide content, each industrial use has set restrictions (Table 7).

TABLE 7
IRON-OXIDE RESTRICTIONS FOR INDUSTRIAL USES OF FELDSPATHICS

MATERIAL		Fe_2O_3 (%)
Glass	clear	<0.05 %
	flint	<0.07 %
	coloured glass & fibreglass	0.1 - 0.6%
	green/amber glass	<0.5 %
Ceramics	pottery	<0.05 %
	most other ceramics	0.05-0.1%
Fillers/extenders		<0.07%

If iron is contained in medium-sized or coarse biotite and magnetite (as is the case in the Blue Mountain nepheline syenites in Ontario), they can usually be easily removed by magnetic separation. If, however, iron-bearing compounds like ferrohastingsite or aegerine-augite are intimately intergrown with feldspar, they may not be easily liberated. Grain size is a critical factor in mineral separation; the material must all be a uniform grain size and if smaller or intergrown grains of deleterious composition are mixed with the feldspar, they will not be separable. For glass applications, material cannot be finer than +100 to +140 mesh, so further crushing to liberate small iron-bearing minerals is not an acceptable solution.

Other unwanted minerals are those which are refractory as they affect the final glass or ceramic product. Corundum, spinel and zircon (refractory minerals), iron ores and sulphides are common accessory minerals in nepheline syenites and phonolites.

For porcelain, material may not contain garnet, hornblende, tourmaline or mica.

In glass making, colouring oxides, such as ZrO_3, Cr_2O_3, NiO, Co_3O_4 and CuO, are prohibitive. As well, sulphates and chlorides may cause melting and deformation problems.

GRAIN SIZING

Grain size is an important parameter in glass, ceramic and filler industries. Material can always be crushed to a finer size, at added expense, but if the original material is already too fine grained, beneficiation is impossible.

For the glass industry, material must range between the minimum of +100 to +140 mesh to a maximum of -20 to -40 mesh. This is approximately the range of fine to medium sand using the Wentworth scale (*see* Table 8). Any larger material leaves residual particles, and any

TABLE 8
CONVERSION CHART

MESH* SCALE	MILLIMETRES	WENTWORTH
		very coarse sand
18	1.0	
		coarse sand
35	0.5 (1/2)	
		medium sand
60	0.25 (1/4)	
		fine sand
120	0.125 (1/8)	
		very fine sand
230	0.0625 (1/16)	
		coarse silt

**Mesh = no. openings in a 1" screen*
e.g. '-40 +100 mesh' indicates material which passes through a 40-mesh screen (smaller than 40 mesh) and which will not pass through a 100 mesh screen (larger than 100-mesh).

TABLE 9
RESULTS OF FIRING TESTS FOR GLAZE POTENTIAL

	COLOUR	SURFACE
TEST #1: FIRED AT 1250°C FOR 3-4 HOURS		
Trident Mountain (nepheline syenite)	white, translucent, glassy, no spots	smooth
Lumby (pegmatite)	white, glassy, no spots	smooth
Hellroaring Creek (pegmatite)	(1) white, opaque, no spots	smooth
	(2) white, opaque, glassy, no spots	smooth
Scuzzy Creek (feldspathic sand)	(1) white, opaque, few spots	rough gritty
	(2) white, opaque, no spots	rough
TEST #2: FIRED AT 1300°C FOR 3 HOURS		
Scuzzy Creek (feldspathic sand)	(1) white, opaque, no spots	not quite smooth
	2) creamy-white, opaque/glassy, no spots	smooth

TABLE 10
SUMMARY OF RESULTS OF CANMET TESTING

NAME	MINFILE #	REMARKS
PEGMATITES		
Blue River	083D 033	-tested for dry magnetic separation -free quartz eliminated by flotation -96% brightness, <7% acid insolubles
Hellroaring Creek	082FNE110	-can meet industrys standards for mica and feldspar concentrates -full liberation at 50 mesh
Lumby (Bearcub)	082LSE015	-low iron, acceptable aluminum and potassium, very good potential to meet industry standards -full liberation at 20 mesh
Copper Mountain	092HSE152	-low recovery rate of nonmagnetic feldspar concentrate -too high iron content, poor potential, dikes may be better
NEPHELINE SYENITE		
Mount Kruger	082ESW106	-low alumina, high iron -limited potential
Mount Copeland	082M 002	-full liberation at -100 mesh -high iron: 0.19% -titanium: 0.40% -low potential
Trident Mountain	082M 173	-low iron, high potential -brightness 85% -high recovery of nonmagnetics
Barrière	092P 159	-high iron, impurities finely intergrown with feldspars
PHONOLITE		
Yellow Lake	082ESW200	-high iron -too fine-grained for processing testing, low potential
LEUCOCRATIC GRANITE		
Boundary Creek	082ESE224	-low K_2O, needs additi testing to reduce iron
APLITE		
Sumas Mountain	092GSE037	-not tested, too fine-gra for processing -iron high
FELDSPATHIC SAND		
Scuzzy Creek	092HNW052	-recovery rates for feldsp low -magnetic separation testi gives high aluminum and calcium rates -moderate iron (<0.1%) -large reserves, easy access -good potential for glass industry

smaller grains will tend to cause "dusting" and too rapid solution reactions.

Most ceramic applications require material ranging between -200 and -300 mesh, and for fillers, material is pulverized to a fine silt (10 microns).

For use in arc welding, material not greater than 250 microns and with a mean of 70 microns is used.

For paint and plastics, feldspathics are very finely ground to aid dispersion, flow, viscosity and oil adsorption.

CANMET TESTING

Selected properties in British Columbia were sampled in the field and bulk samples were sent to CANMET in Ottawa for beneficiation tests. The tests included grain sizing, crushing and screening, mineral separations by froth flotation and, magnetic separation and glaze quality (firing) testing (Table 9). The results of glaze testing are summarized in Table 9; the results from the other tests are included with the individual property descriptions, and are summarized in Table 10.

GLAZE TESTING

Four deposits were tested as potential glaze material by Clayburn Refractories Ltd. of Abbotsford, British Columbia; nepheline syenite from Trident Mountain, pegmatites from Lumby and Hellroaring Creek, and feldspathic sand from Scuzzy Creek (Table 9). In the first test, crushed material was heated to 1250°C for 3 to 4 hours. All but the samples from Scuzzy Creek produced a potential glaze material after this test. The material from Scuzzy Creek was then processed by heating to 1300°C for an additional 3 hours, at which time only one of the two samples produced an acceptable glaze material. The different melting characteristics reflect the different compositions of feldspar present. The Scuzzy Creek material contains more calcium-rich feldspar, which is more refractory than potassium or sodium feldspars.

MARKETING

A marketing study for British Columbia's feldspar and nepheline syenite was conducted in 1988 by Hal McVey of Minerals Marketing Inc.; the following summary is derived largely from this MDA report (McVey, 1988).

There is currently no production of feldspathic minerals in western Canada. British Columbia imports feldspathic sand from Idaho and nepheline syenite from Ontario.

Because transportation costs are the limiting factor for feldspathic materials, a British Columbia supplier to western markets would enjoy a marked freight advantage over eastern or southern sources. The most viable markets are therefore western Canada, the Pacific Northwest states and northern California. When southern California and the western states including Oklahoma and Texas are considered, freight is costly and a British Columbia producer can probably not compete with mines in South Dakota, California and Mexico.

There is no tariff on exports of nepheline syenite to the United States. Crude feldspar is exported duty free and ground feldspar will also be duty free under the Canada - U.S. Free Trade Agreement.

As with many industrial minerals, many substitutions may be made for the same purpose, and a consumer will choose whatever raw material is most economic. Factors such as proximity to manufacturers' facilities, and freight rates, may have more bearing on the choice of a raw material than the relative quality of purity of the material itself. On the other hand, manufacturers are loath to change products once a formula has been established, and would rather stay with a material of consistent composition, than change and have to adjust to a new product. Because of this, it is often difficult for new deposits to penetrate the established industrial minerals market, unless the material is of superior quality or has unique characteristics, or can be supplied at substantial savings. In Manitoba for instance, rubidium feldspar (>1.3% rubidium oxide) is found to be superior to K-spar in electrical insulator porcelain and may have other advantages for glass and ceramic applications.

MATERIALS

The materials competing in western markets are feldspar, nepheline syenite, aplite and feldspathic sands. In the eastern states and Canada the glass industry (mainly container glass and fibreglass) is supported by local deposits of high-purity silica sand, supplemented with feldspar and nepheline syenite as alumina sources. In the west, however, glass industries use feldspathic sands which vary considerably in composition and are low in aluminum. If a source of high-purity silica sand were developed on the west coast (in California, for example) or imported from overseas, the demand for feldspar and nepheline syenite would increase. British Columbia's silica deposits are documented in Open File 1987-15, which outlines several sites with glass-grade material. High-purity silica sands may also be imported from Australia.

Feldspar is used only in ceramics in the western market area, and competition with high-quality potassium feldspar from South Dakota would make it difficult to penetrate this market. As well, any substitution of materials requires extensive testing, which is an expensive venture for consumers.

Aluminum and alkali content are the most important factors in feldspathic materials. Raw tonnages are converted to tonnes of contained alumina using the assumed percentages given in Table 11, and transportation costs may be calculated per unit aluminum plus alkalis.

TABLE 11

PERCENTAGES USED TO CONVERT RAW TONNAGES TO TONNES OF CONTAINED ALUMINA

	Al_2O_3
feldspar	18%
nepheline syenite	23%
aplite (U.S.A.)	22%
feldspathic sand	5-6%

CONSUMPTION/TRENDS

Of the total 42 750 tonnes of alumina used in the western market (Table 12), about half is consumed by a single glass manufacturer in California who uses strictly feldspathic sand. However, an estimated 5440 tonnes per year of equivalent alumina could potentially be converted to feldspar or nepheline syenite markets. In terms of tonnages of material, this equals 29 940 tonnes feldspar or 23 590 tonnes of nepheline syenite.

The market area of southern California, western United States, Oklahama and Texas consumes 25 010 tonnes of equivalent alumina per year. This area is dominated by local sources of feldspar and feldspathic sand and it is unlikely that British Columbia could complete

TABLE 12
CONSUMPTION OF FELDSPATHIC MATERIAL IN POTENTIAL BRITISH COLUMBIA MARKETS

Western Provinces, Pacific Northwest and Northern California

	Material	Tonnages Consumed (metric tonnes)	Alumina Contained
Container Glass	Feldspathic sand	573 340	31 790
	Nepheline syenite	10 980	2 520
Fibreglass:	Feldspathic sand	907 180	5 440
	Nepheline syenite	9 800	2 260
Ceramics:	Nepheline syenite	1 810	420
	Feldspar	1 360	320
Total Alumina:			42 750

TABLE 13
CANADIAN EXPORT AND IMPORT STATISTICS

EXPORTS

	FELDSPAR	NEPHELINE SYENITE*
1988	337 Mt** $ 71 000	589 086 Mt+ $ 21 692 000
1989 (to Nov.)	331 Mt $ 88 000	370 647 Mt++ $ 17 881 000

* *listed as leucite; nepheline and nepheline syenite.*
** *metric tonnes.*
\+ *exported to U.S.A., Netherlands, U.K., Italy and 'others'.*
\+ + *exported to U.S.A., Netherlands, Italy, Spain, Taiwan and 'others'.*

IMPORTS

	FELDSPAR	NEPHELINE SYENITE
1988	13 235 Mt $ 371 000	— —
1989 (to Nov.)	3 747 Mt $ 481 000	2 Mt no $ given

unless the material was of a very high quality or exhibited special characteristics.

Available statistics indicate that Canadian production, consumption and exports of nepheline syenite all declined over the period from 1982 to 1986. The cause of this decline is increased recycling, that is using more cullet in new glass batches, the development of thinner walled containers and increased competition from the plastics and aluminum industries. Demand has increased, however, for fibreglass insulation and for fillers in plastics. The ceramics industry is considered to be a fairly stable market (Agricola Mineralia, 1986).

Three-quarters of the nepheline syenite produced in Canada is exported; of this amount, almost 90 per cent goes to the eastern part of the United States for glass and ceramics manufacture. The 25 per cent of material remaining in Canada is used in glass and fibreglass insulation (77%), ceramics (15%), paints (6%) and miscellaneous uses (2%).

Both Canada and the United States import a modest amount of feldspar; Canadian imports have dropped in the past few years. The U.S.A. imported 4540 tonnes in 1987, mostly from Mexico.

The latest available statistics for Canadian exports and imports (from Statistics Canada) are summarized in Table 13. All trade is with the United States except where otherwise indicated.

In the international market, trade in feldspathic minerals is mostly regional; European countries supply European markets and the same situation exists in North America. There is moderate trade between Pacific Basin countries.

Japan and South Korea are recognized as potential markets for British Columbia materials because of their relative proximity and advanced industrialization. Combined, these countries imported close to 20 000 tonnes for 1986 included 1500 tonnes of Canadian nepheline syenite (mostly to Japan).

Japan produces from 470 000 to 500 000 tonnes per year of its own feldspathic material, 430 000 tonnes of which is aplite. The aluminum content of Japan's aplite is 13 to 14 per cent, making it a much less attractive alternative to feldspar (17% aluminum) or nepheline syenite (23%) aluminum).

Production in the entire Pacific Basin region is restricted to feldspar; there is no nepheline syenite trade. If British Columbia could penetrate the Pacific Basin trade circle, there is potential for supplying 26 000 tonnes per year to existing markets, plus an additional 45 000 tonnes per year to possibly replace 10 per cent of Japan's aplite. In total, this defines a potential market of 71 000 tonnes per year.

GEOLOGICAL SETTING OF FELDSPATHIC MINERAL DEPOSITS

Feldspathic material is found in economic deposits in nepheline syenite, phonolite, pegmatite, aplite, alaskite, leucocratic granite and feldspathic sand (*see* Figure 1).

NEPHELINE SYENITE

Large deposits of nepheline syenite are rare and occur in Norway, Brazil and Canada. There are several occurrences in Canada; one in British Columbia rimming the Frenchman Cap gneiss dome, and the others in the Grenville Province of Ontario and Quebec, including the renowned Blue Mountain deposit near Nephton, Ontario. In British Columbia the largest bodies of nepheline syenite occur at Mount Kruger, Mount Copeland, Barrière and Trident Mountain. The Trident Mountain occurrence has produced commercial quality concentrate on a laboratory scale and therefore has good potential for development.

PEGMATITE

Pegmatites commonly have concordant to discordant, sharp or locally gradational boundaries in border zones of mesozonal intrusive granitoid bodies.

Veined gneisses may contain granitic pegmatites of anatectic origin as seen in deep-seated, high-grade regional metamorphic complexes such as the Shuswap metamorphic complex. In the fringe zone of the complex, metasediments with pegmatite sheets occur in the upper amphibolite facies of the sillimanite zone. The biotite-quartz-feldspar gneisses are derived from quartzofeldspathic sediments. The pegmatites are considered igneous in origin; the plagioclase shows twinning, zoning or ophitic textures indicative of magmatic emplacement as opposed to granitization (replacement) (Hyndman, 1968, 1972).

In the eastern States the pegmatite province extends from Alabama to Maine in the Appalachians. The mid-continental belt of pegmatites contains lithium, beryl, niobium and tantalum minerals. Pegmatites are mined for feldspar in Connecticut, the Carolinas, Georgia, California and South Dakota. The Spruce Pine district in North Carolina is one of the biggest producers in the U.S.; feldspar is hosted in coarse-grained alaskite with irregular masses of pegmatite.

In the Kings Mountain pegmatite district in North Carolina, feldspar is a byproduct of lithium mining, and a feldspar-silica byproduct results from a mica operation.

Pegmatites have been mined in western Quebec and eastern Ontario for the past 100 years. To be competitive, the pegmatite must usually be mined for more than just feldspar, for example mica or lithium.

Feldspar is found in pegmatites in British Columbia at Hellroaring Creek, Lumby, Copper Mountain and Blue River; the first two are currently being considered for development by industry.

APLITE

Aplite is mined from a large intrusion in Virginia, and in British Columbia, aplitic rock is being investigated at Sumas Mountain.

ALASKITE AND LEUCOCRATIC GRANITE

Leucocratic granites considered as possible sources of feldspar occur in the Greenwood area of southern British Columbia.

FELDSPATHIC SAND

Feldspathic sands are mined in Oklahoma, Idaho and Oregon and are also produced in California.

In British Columbia one of the high-potential feldspar deposits is the feldspathic sands found at Scuzzy Creek, which have eroded from the Scuzzy pluton, a biotite quartz diorite.

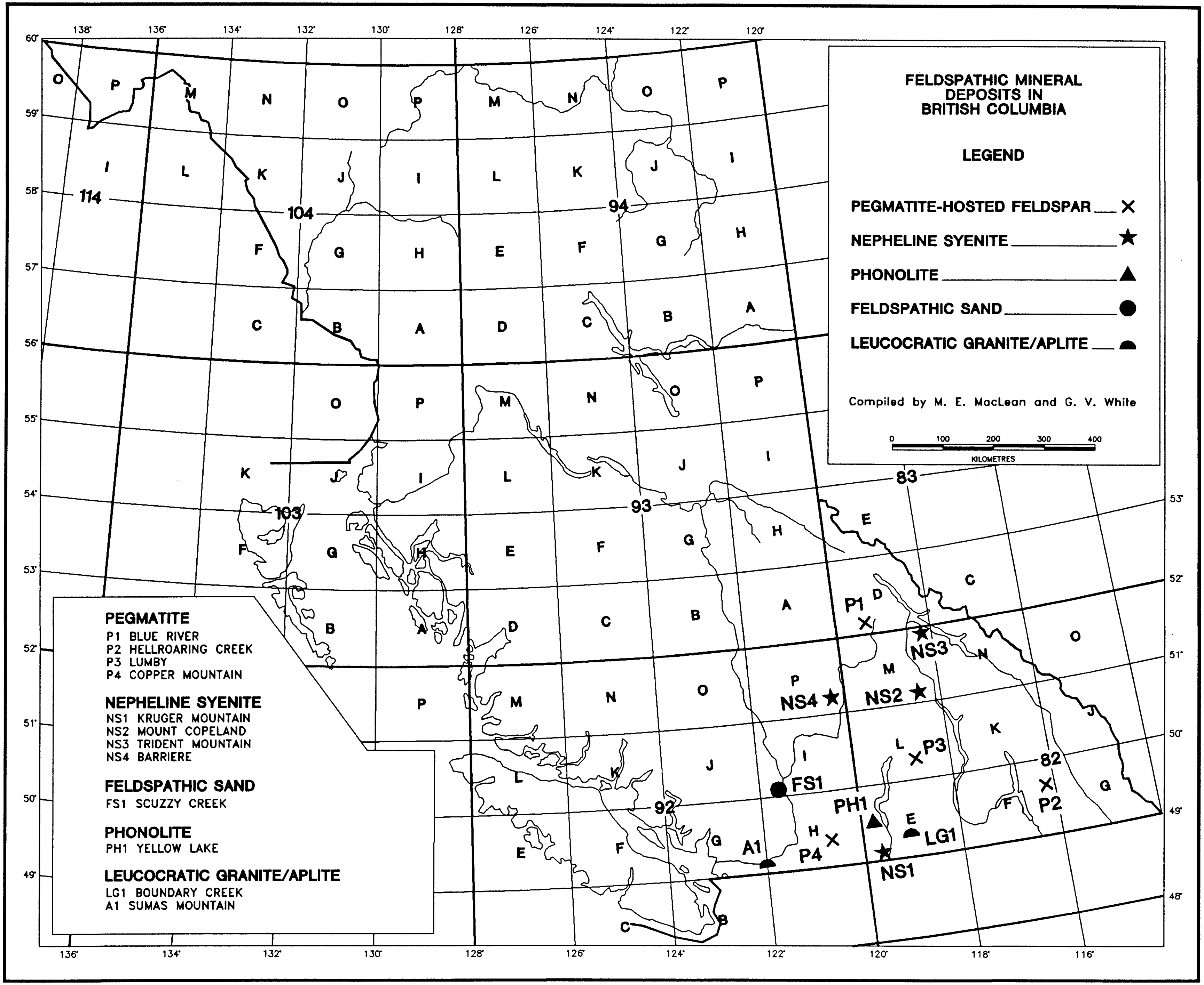


Figure 1. Location map of British Columbia's feldspathic mineral prospects.

DESCRIPTIONS OF BRITISH COLUMBIA DEPOSITS

PEGMATITE

BLUE RIVER (MINFILE 083D 033)

The Blue River pegmatite showing is approximately 3 kilometres west of Blue River, British Columbia, halfway between Vancouver and Edmonton on Highway 5 (Figure 1; P1). The town is also serviced by the Canadian National Railway and an airstrip. The dike follows the north side of the Blue River valley, which is relatively flat and has been logged. The main exposure is 3 kilometres from the railway siding at Blue River, and is accessible by road (Figure 2).

REGIONAL GEOLOGY

The Blue River pegmatite intrudes biotite-quartz-feldspar gneiss of the Hadrynian Horsethief Creek Group at the northeastern edge of the Shuswap metamorphic complex. In this area, the Horsethief Creek Group is comprised of metavolcanics and metasediments (Campbell, 1967; Ghent *et al.*, 1977).

LOCAL GEOLOGY

The deposit consists of a pegmatite dike striking northeasterly and dipping vertically, with an approximate length of 1475 metres and width of 490 metres. The pegmatite, consisting of coarse-grained feldspar and quartz, with accessory mica, is in sharp contact with the gneissic country rocks.

In 1984, a 43-metre hole was drilled to determine the extent of the pegmatite. The hole was drilled west, into the mountainside, at 40°. Two sections of pegmatite, 6.2 and 3.6 metres long were intersected above the main zone which was reached at 26.2 metres depth and continued to the end of the hole, giving a minimum thickness of 16.8 metres.

LABORATORY ANALYSES

Samples were processed by IMD Laboratories Limited with dry magnetic separation and found to yield acceptable grade material. Free quartz can be eliminated by flotation which produces a superior feldspar product with 96 per cent brightness and less than 7 per cent acid

TABLE 14
BLUE RIVER FELDSPAR CONCENTRATE
- XRF ANALYSES*

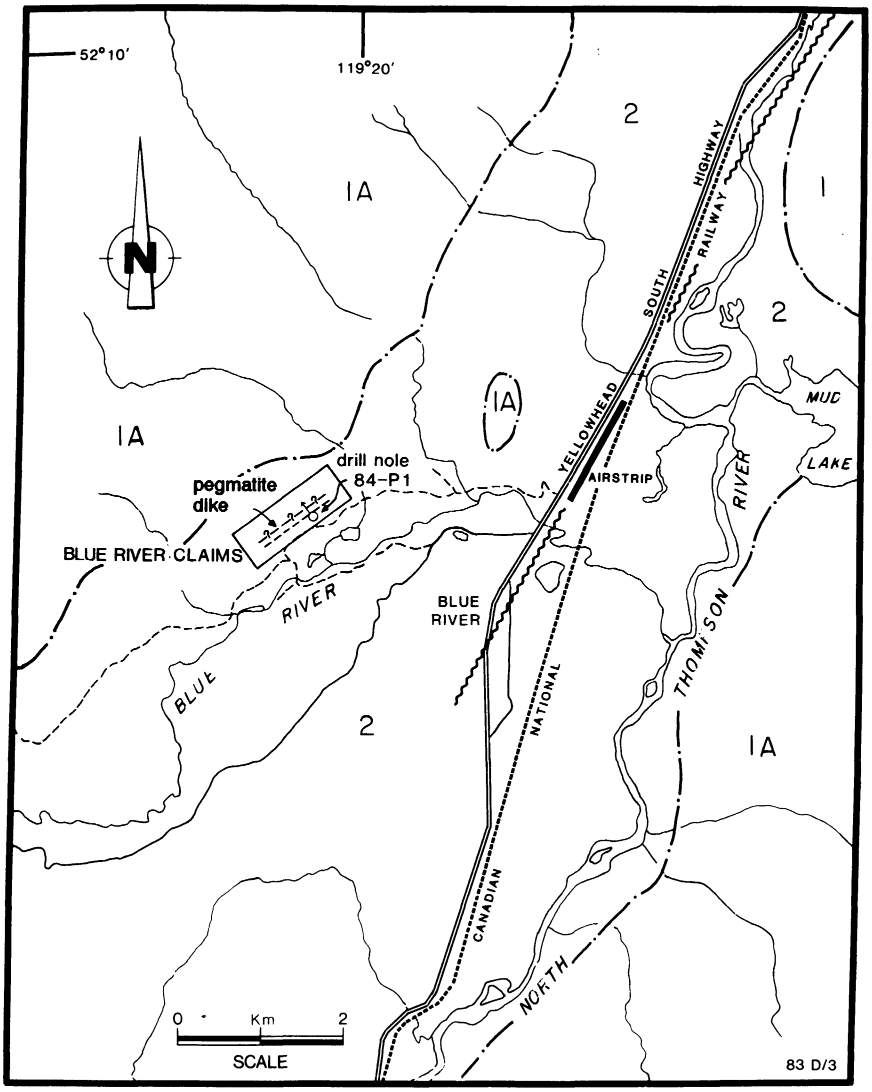
SAMPLE #	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	TiO_2	P_2O_5	LOI
P1-4	73.5	14.8	0.07	1.54	0.04	3.57	5.23	<0.01	0.01	0.03	0.3
P1-5	73.5	15.5	0.069	1.94	0.04	4.02	4.92	<0.01	0.01	0.02	0.47
P1-6	75.5	13.8	0.084	1.57	0.05	3.85	3.95	<0.01	0.01	0.02	0.62
Wtd Avg.	74.4	14.7	0.076	1.73	0.04	3.89	4.53	<0.01	0.01	0.02	0.53

SAMPLE #	Chromium	Rubidium	Strontium	Yttrium	Zirconium	Niobium
P1-4	<10	150	680	<10	<10	30
P1-5	<10	140	660	10	<10	30
P1-6	<10	120	580	<10	10	20
Avg	<10	130	630	<10	<10	20

FOOTAGE SAMPLED

P1-4	6
P1-5	21
P1-6	21
TOTAL	**48 metres**

**Processing by IMD Laboratories Limited.*
XRF Analyses by X-Ray Assay Laboratories Limited.



LEGEND

QUATERNARY

Pleistocene and Recent

2 Alluvium and glacial deposits.

WINDERMERE

1 Horsethief Creek Group - feldspathic quartzite, phyllite, quartz-mica schist, garnet, staurolite, and kyanite-quartz-mica schist, biotitic and /or hornblendic quartzo-feldspathic gneiss; minor marble and amphibolite, minor pegmatite with staurolite-kyanite schist.

1A Shuswap Metamorphic Complex - biotitic and/or hornblendic quartzo-feldspathic gneiss, sillimanite-garnet-quartz-mica schist and gneiss, amphibolite, pegmatite, foliated granitic rocks, minor augen gneiss and marble.

Symbols:

Fault

Logging road

Geological Boundary

Figure 2. Location and geology of the Blue River deposit.

insolubles (J. Morton, Morton Mica Resources Ltd., personal communication, 1987). X-ray diffraction analyses by the Geological Survey Branch identified quartz, orthoclase, albite and muscovite with trace chlorite, almandine and pyrite. Iron oxide averaged 0.076 per cent (Table 14).

Based on company results, the pegmatite contains feldspathic material which meets industry specifications for glass and ceramic applications.

HELLROARING CREEK (MINFILE 082FNE110)

The Hellroaring Creek pegmatite stock is approximately 20 kilometres southwest of Kimberley and 31 kilometres west-northwest of Cranbrook (Figure 1; P2). Access is by paved road from these communities to St. Mary's Lake, then by well-maintained logging roads. The stock, explored for beryllium by Richfield Oil Corporation during the 1960s, has recently been evaluated by Bearcat Exploration Limited as a source of commercial-grade feldspar, quartz and muscovite.

REGIONAL GEOLOGY

Pegmatite intrudes the Proterozoic Aldridge Formation which consists of argillites, quartzites, argillaceous quartzites and mica schist. Metamorphosed Moyie dioritic sills and dikes intrude the Aldridge Formation, and are also cut by the Hellroaring Creek stock. The stock has been dated using rubidium-strontium isotopes to be approximately 1260 million years old, or middle Proterozoic (Ryan and Blenkinsop, 1971).

The easterly trending St. Mary fault divides the area; the southern half is underlain by Creston Formation, consisting of green, grey and purple argillaceous quartzite, quartzite and argillite. The northern half of the area is underlain by Aldridge Formation, which is folded into an open northwest-plunging anticline with the Hellroaring Creek stock emplaced in the core (Figure 3; Ryan and Blenkinsop, 1971).

LOCAL GEOLOGY

The stock is exposed over an area approximately 1.5 by 4 kilometres. The stock (Figure 4) consists of medium (1-5 millimetres) to coarse (>5 millimetres) grained white to light grey pegmatite. Visible minerals include alkali (microcline) and plagioclase (albite) feldspar, quartz, muscovite, biotite, tourmaline, garnet and minor sulphides. Microcline and albite occur in distinct potassium and sodium-rich zones (Figure 4) comprising between 60 and 70 per cent of the pegmatite in areas examined. Quartz forms 20 to 30 per cent of the pegmatite and also forms silica-rich lenses.

Muscovite is found as fine flakes along fractures or forms books up to 13 centimetres across. It constitutes up to 10 per cent of the total volume and occurs in patches throughout the pegmatite.

Thin, needle-like tourmaline crystals up to 3 by 10 millimetres across are also found in irregular patches. Minor sulphides include pyrite, pyrrhotite and galena. Red to pink garnets (1-2 millimetres) were observed in drill core (Figure 5).

Iron (from mica) and manganese staining is common on outcrop and in drill-core.

DRILLING AND TRENCHING PROGRAMS

Between 1984 and 1986, Lumberton Mines Ltd. drilled 2695.2 metres of diamond-drill core in 30 holes and completed 807 metres of hand and backhoe trenches (Figures 4 and 5). The company has completed beneficiation tests on selected samples and built a series of access roads to the north end of the stock.

LABORATORY ANALYSES

Spectrographic, x-ray diffraction and chemical analyses of 22 samples collected from the study area (Figure 4) are listed in Tables A1, A2, and A3, in the Appendix. Silica ranges from 65 to 75 per cent with siliceous zones up to 98 per cent. Soda and potash percentages vary significantly with location, from a low of 1.97 and 0.45 per cent respectively, to a high of 6.44 and 12.45 per cent respectively. This wide range is dependant on mineralogy, with the lower potassium values from the more sodium-rich zones. Aluminum oxides range from a high of 19 per cent in the potassium-rich zone to a low of 13.65 per cent in the sodium-rich zone, with only minor amounts present in the siliceous zones. Iron oxide content and other trace elements are low; Fe_2O_3 ranges between 0.05 and 4.24 but averages less than 0.5 per cent when one anomalous value is deleted. In thin section, iron is concentrated in the micas and between grains, and proved to be easily removed with beneficiation.

ECONOMIC POTENTIAL

Varying Na:K ratios may cause problems with obtaining a consistent composition throughout the deposit, although selective mining might produce a more consistent product. The pegmatite also contains beryllium, silica and mica which might be recoverable as byproducts. Work done in 1965 by Richfield Oil Corporation outlined a possible 450 000 tonnes of material with an average grade of 0.1 per cent BeO (Chamberlain, 1986).

A sample of feldspar concentrate was tested in Clayburn Refractories Limited laboratory for potential glaze material, with good results after 3 to 4 hours of firing at 1250°C. The glaze produced is translucent and white, with no visible impurities.

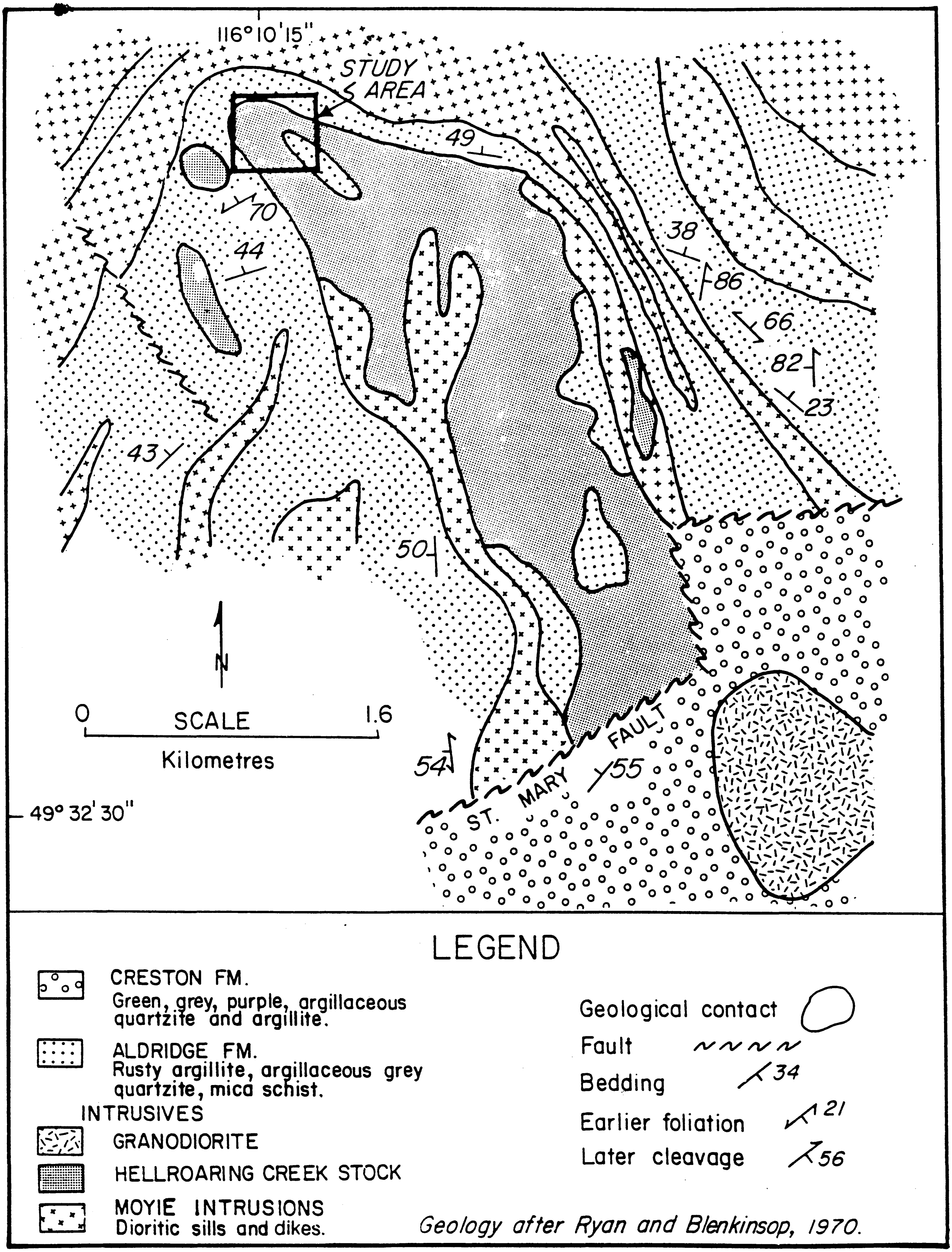


Figure 3. Geology of the Hellroaring Creek stock.

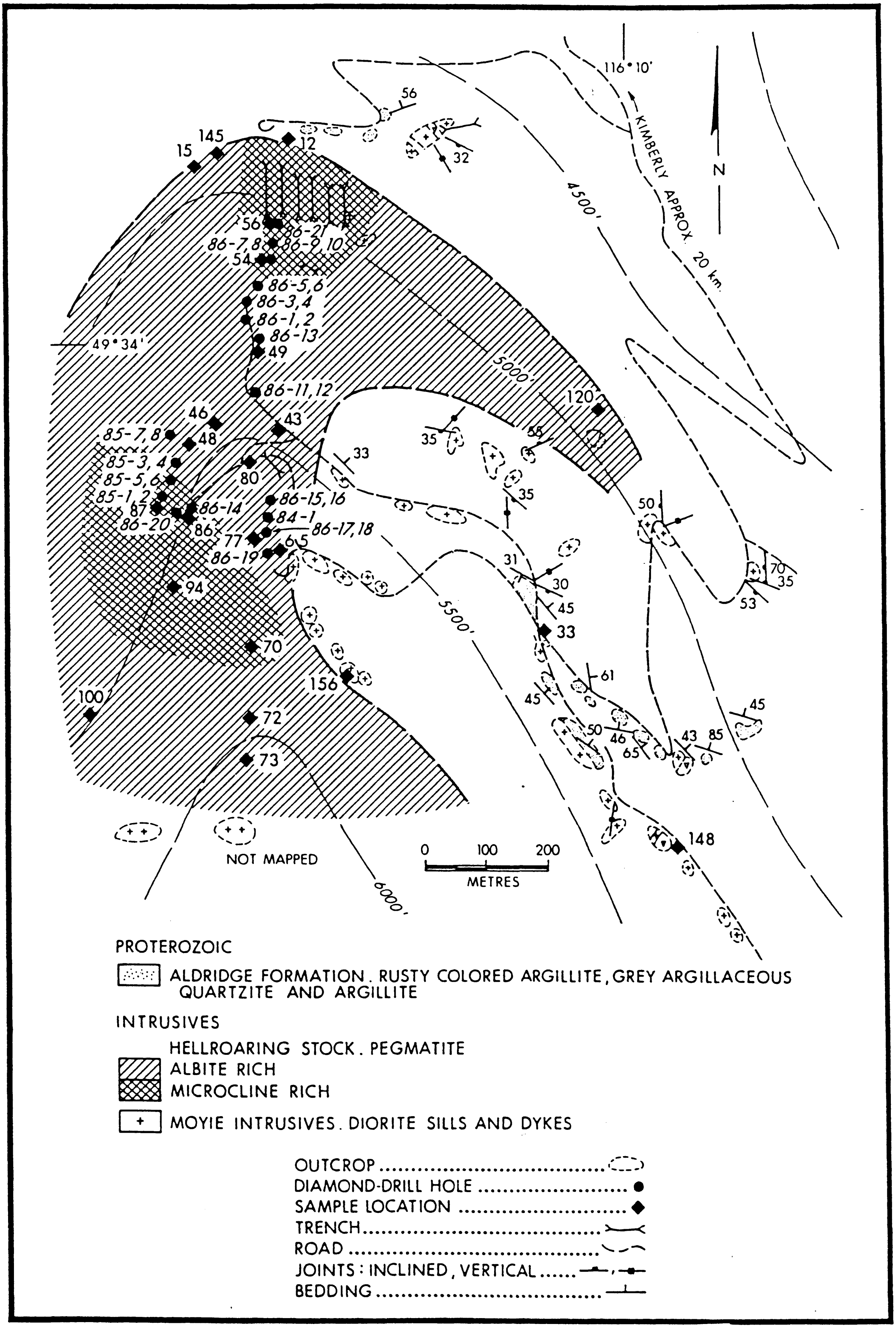


Figure 4. Detailed geology and sample locations, Hellroaring Creek pegmatite.

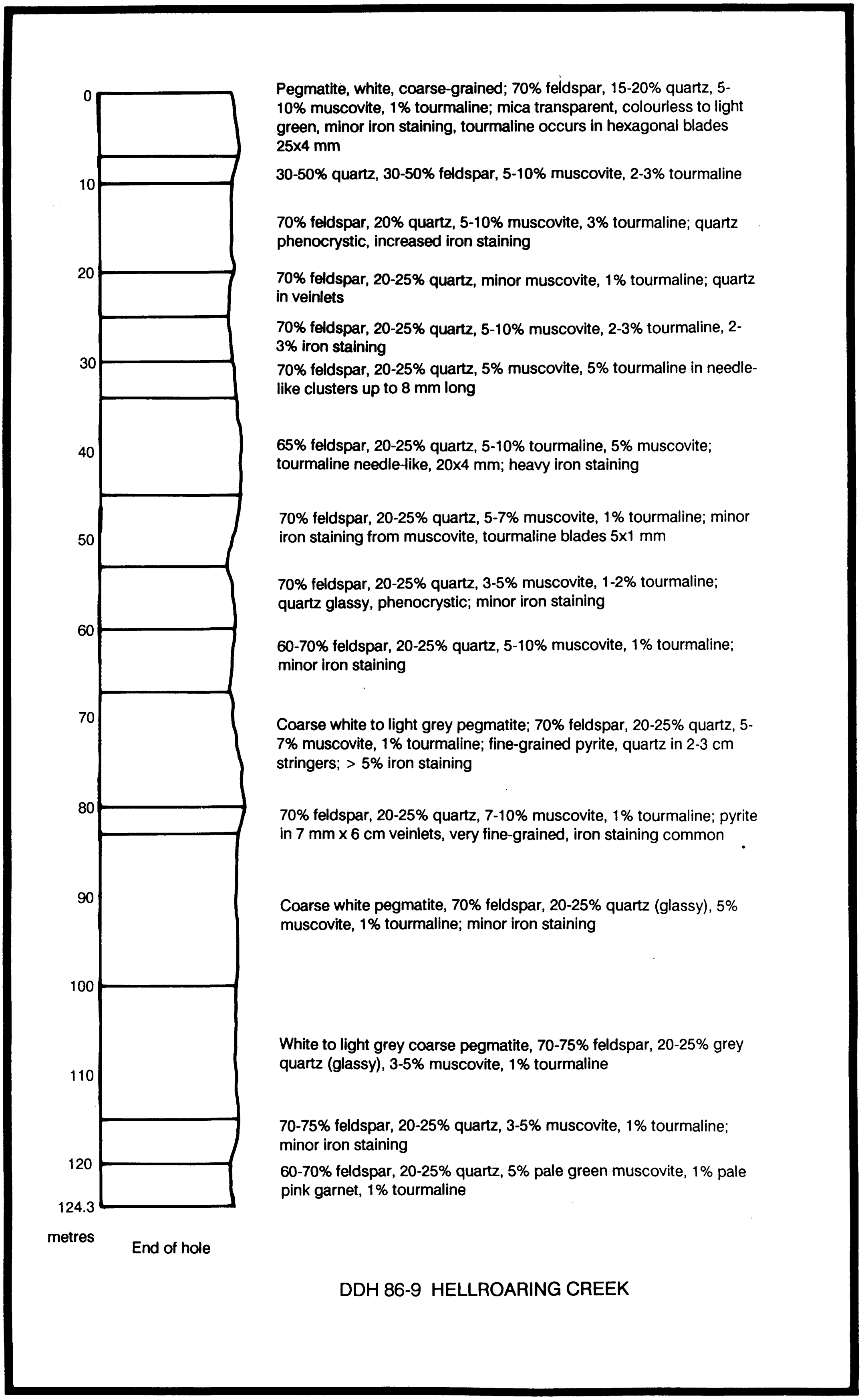


Figure 5. Diamond-drill hole 86-9, Hellroaring Creek.

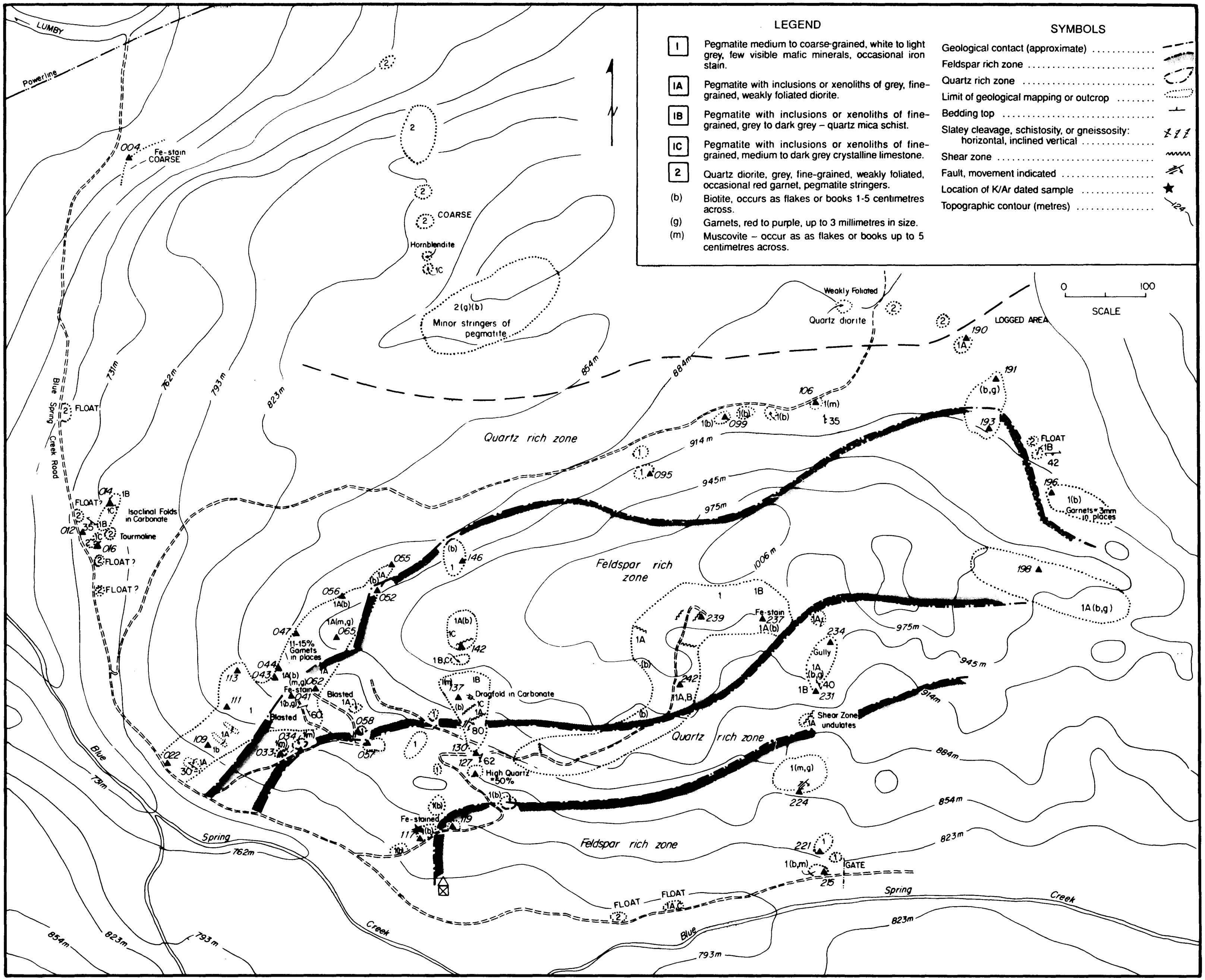


Figure 6. Geology of the Lumby pegmatite.

LUMBY (MINFILE 082LSE015)

A pegmatite stock located 13 kilometres east of Lumby (Figure 1; P3), was investigated for uranium by Boraway Mines Limited during 1970-1971 and by Brenda Mines Limited since 1987 as a potential source of glass and ceramic-grade feldspar.

REGIONAL GEOLOGY

A 52.0±1.8 Ma pegmatite stock (approximately 2.65 by 1.35 kilometres) intrudes quartz-mica schist of the Okanagan plutonic and metamorphic complex (formerly the Monashee Group). It is bound on the south and west by Tertiary Kamloops volcanics, and on the north and east by granitic rocks of the Shuswap metamorphic complex (Okulitch, 1979).

LOCAL GEOLOGY

Four distinct rock types are recognized on the property; pegmatites, quartz-mica schists, carbonates and quartz diorites.

The pegmatite often crops out as topographic highs, appears fresh, massive and most often clean and white in colour but may be cream to yellow to reddish orange when stained by iron leached from mica. Typically the pegmatite consists of 70 to 75 per cent feldspar, 20 to 25 per cent quartz and 5 to 15 per cent mafic minerals, commonly biotite, muscovite, garnet and rarely tourmaline. In some areas quartz constitutes up to 50 per cent of the total volume, and occasional graphic intergrowths of quartz and feldspar are observed. Individual feldspar crystals up to several centimetres long are found in a fine-grained matrix of feldspar or quartz, suggesting different phases of crystal growth. Books of biotite and muscovite up to 5 centimetres across, occur sporadically as clusters in the pegmatite or as finer flakes. The two micas may form 5 per cent of the total volume but are seldom found together.

Red to purple garnets (1 to 3 millimetres) form up to 15 per cent of the total volume and occur in small clusters throughout the pegmatite. In one location, small crystals (1-2 millimetres) of tourmaline were observed but occupy less than 1 per cent of the total volume.

Geological mapping has identified quartz and feldspar-rich zones (Figure 6). Thin section examination and x-ray diffraction of a limited number of samples indicate that within the feldspar-rich zones there are distinct potassium (orthoclase) and sodium-rich (plagioclase) zones (*see* Appendix B), but additional sampling is required to better document these areas.

Xenoliths of fine-grained, medium to dark grey quartz-mica schist are incorporated in the pegmatite. The schist has an east to northeast-trending foliation and contact with pegmatite is abrupt and well defined. The schist may be several metres thick or thinly interbanded with thicker banded gneiss. The schist is locally intruded by lenses of quartz, pegmatite or gneiss and is often sheared. It contains small (1 to 3 millimetres) red to purple garnets.

Medium to dark grey, fine-grained crystalline limestone is incorporated in small isolated blocks in the pegmatite. The carbonate bodies may be several metres thick, and often enclose veinlets of quartz and pegmatite. Small-scale isoclinal folds and boudinage structures are prominent features in the carbonate.

Massive, fine-grained (< 1 millimetre), weakly foliated quartz diorite crops out as a prominent topographic high immediately north of the pegmatite stock (Figure 5). Small red garnets (< 1 millimetre) occur sporadically in the diorite. Veinlets of white, medium-grained pegmatite, 1 to 3 millimetres wide and up to 6 centimetres long cut the intrusive in places.

In the main pegmatite body, xenoliths of diorite up to tens of metres across are common. Contact between the diorite and the enclosing pegmatite is either abrupt or gradational, with diorite becoming increasingly pegmatitic over a 2 to 3 metre interval.

LABORATORY ANALYSES

Results of x-ray diffraction and spectrographic analyses are listed in Tables B1 to B3 in the Appendix. Spectrographic results indicate iron ranges from less than 0.1 per cent to 2.5 per cent, with the average less than 0.37 per cent. From thin section examinations, iron appears to be concentrated in the micas and along microfractures. Other elements occur in minor or trace amounts.

Ground feldspar concentrate was tested for potential glaze material in Clayburn Refractories Ltd. laboratory, with good results after 3 to 4 hours of firing at 1250°C (Table 9). The glaze produced is white, translucent and free from visible impurities.

COPPER MOUNTAIN (MINFILE 092HSE152)

The Copper Mountain occurrence is a coarse, feldspar-bearing pegmatite dike which intrudes the Copper Mountain stock approximately 16 kilometres south of Princeton (Figure 1; P4).

REGIONAL GEOLOGY

Coarse-grained pegmatite is exposed in an oval-shaped intrusive body measuring 1.2 by 2.0 kilometres in the core of the Copper Mountain stock (Figure 7). Potassium-argon dating on the monzonite phases of the stock and on biotite from veins indicates a mean age of emplacement of 193±7 Ma (Sinclair and White, 1968; Preto, 1972). The Copper Mountain stock contains pegmatite, syenite and perthosite in the core with monzonite, gabbro and diorite in the enveloping rocks. The intrusion cuts upper Triassic Nicola Group volcanic and sedimentary rocks, and is unconformably overlain by mid-Eocene Princeton Group volcanics (Preto, 1972; Figure 7).

LABORATORY ANALYSES

Ten grab samples of fresh, coarse-grained (>5 millimetres), orange to white perthosite from the core of the Copper Mountain stock were collected for analysis from outcrops west of the Similkameen River (Figure 8).

Results of chemical and spectrographic analyses and x-ray diffraction tests are listed in Tables C1 to C4 in the Appendix. The range of values for major oxides is given in Table 15. These results indicate the rock may have potential as a source of feldspar and on this basis a 20-kilogram sample was sent to CANMET for beneficiation testing. The results of these tests are summarized in Tables 16, 17 and 18.

TABLE 15
RANGE OF VALUES FOR MAJOR OXIDES, COPPER MOUNTAIN

Major Oxides	Range (weight %)
SiO_2	61.70 - 64.70
Al_2O_3	19.35 - 20.98
Fe_2O_3	0.21 - 1.19
CaO	0.18 - 1.93
Na_2O	4.54 - 8.49
K_2O	2.80 - 9.94

TABLE 16
MAGNETIC SEPARATION

Mesh	Weight %
-10+100 (magnetic)	2.0
10+100 (nonmagnetic)	86.1
-100	11.9

TABLE 17
FLOTATION TEST RESULTS
COPPER MOUNTAIN

Product	Weight %
Slimes	13.9
Mica-iron concentrate	0.4
Feldspar concentrate	18.2
Tailings	67.5

TABLE 18
MAJOR OXIDE ANALYSIS AFTER MAGNETIC SEPARATION, COPPER MOUNTAIN

Major Oxides	Feldspar concentrate (Weight %)	Nonmagnetic concentrate (Weight %)
SiO_2	61.70	61.40
Al_2O_3	18.60	18.80
Fe_2O_3	0.31	0.34
CaO	0.52	0.50
Na_2O	6.71	6.84
K_2O	6.14	5.99

The nonmagnetic fraction comprised 86 per cent of the sample, with a product size acceptable to industry (Table 16). Consequently, a flotation test to reduce mica-iron levels followed (Table 17). Approximately 80 per cent of the sample reported as slime or tailings and only 18 per cent was recovered in the feldspar concentrate. The feldspar concentrate was passed over the magnetic separator and was then analysed (Table 18).

Although the original samples are high in aluminum (up to 20.98 per cent), beneficiation tests could not reduce the iron content below 0.31 per cent with liberation greater than 100 mesh.

In thin section, coarse-grained (up to 3 millimetres) albite and potassium feldspar appear quite altered. Augite grains and iron oxides are much finer grained than the feldspars but do not appear to be intergrown. Accessory minerals include calcite and muscovite.

ECONOMIC POTENTIAL

Chemical analyses of grab samples collected from the core of the Copper Mountain stock indicate the rock is potentially a source of feldspathic material acceptable to glass and ceramic manufacturers. However, beneficiation tests indicate a low recovery rate of nonmagnetic feldspar concentrate and an unacceptably high iron content in the final product. It is concluded that the stock has poor potential for the production of feldspathic materials meeting industrial requirements.

Large dikes cut the syenite at the Similco Mines Limited mine site near Princeton (W. Epp, Mine Geologist, personal communication, 1987). These may be a potential source of feldspathic material but have not as yet been investigated.

NEPHELINE SYENITE

MOUNT KRUGER (MINFILE 082ESW106)

The Mount Kruger property (Figure 1; NS1) is located 10 kilometres west of the town of Osoyoos, and is accessible by gravel roads from Highway 3. The original Buck claims (1-3) were staked by Ken Butler in 1963. Selected grab samples were analysed by the British Columbia Research Council, International Minerals Chemical Corporation, and beneficiation tests were run by the federal Mineral Resources Branch of the Department of Energy. In 1972 Bethlehem Resources Corporation restaked claims which had lapsed in 1971 and dug several small test pits. The claims were restaked in 1984 by Denis Atkinson and in 1985 by Walter Bonin. The NEP claims are presently held by Nepheline Resources Limited of Vancouver.

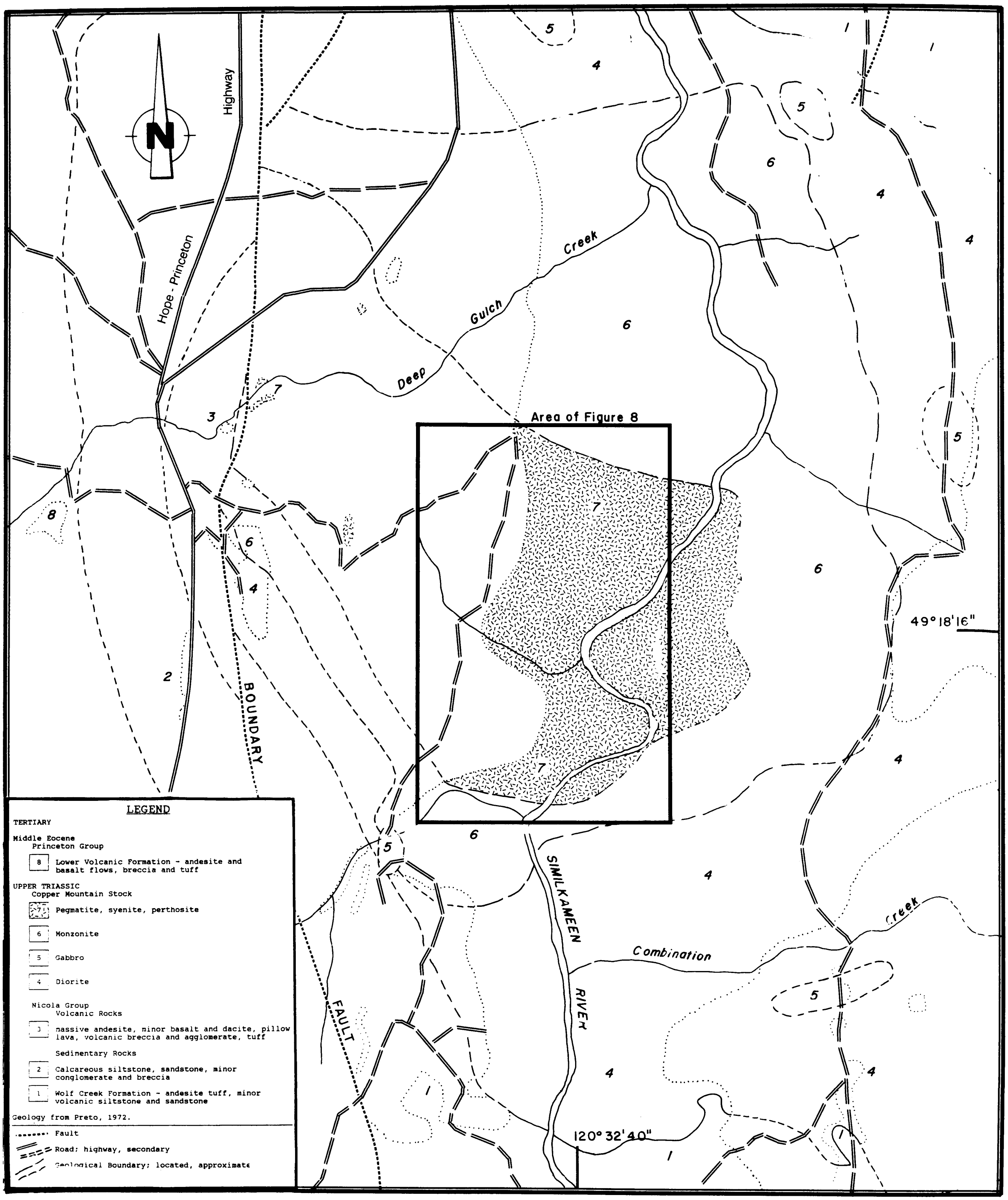


Figure 7. Geology of the Copper Mountain stock.

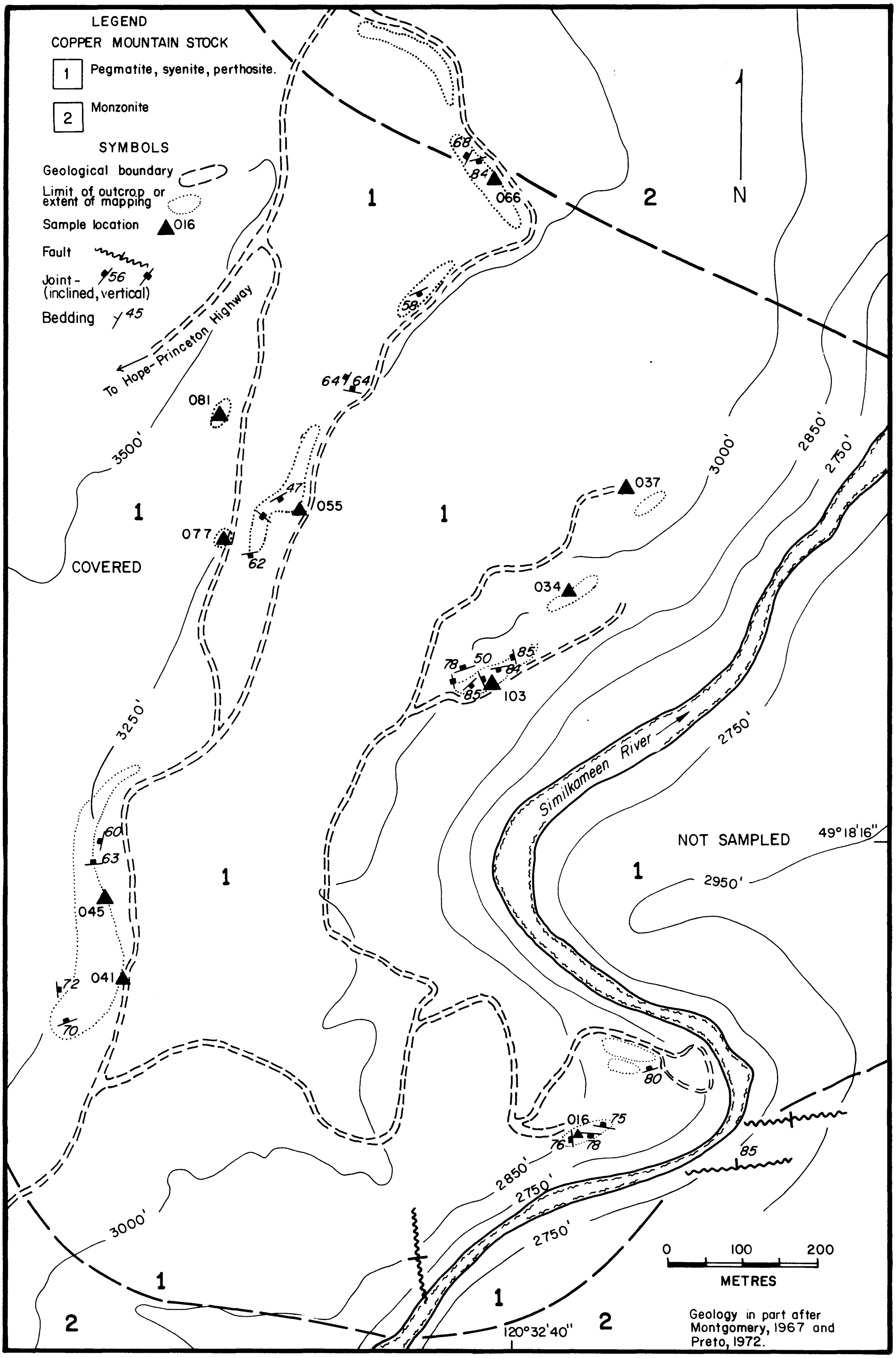


Figure 8. Geology and sample locations, Copper Mountain.

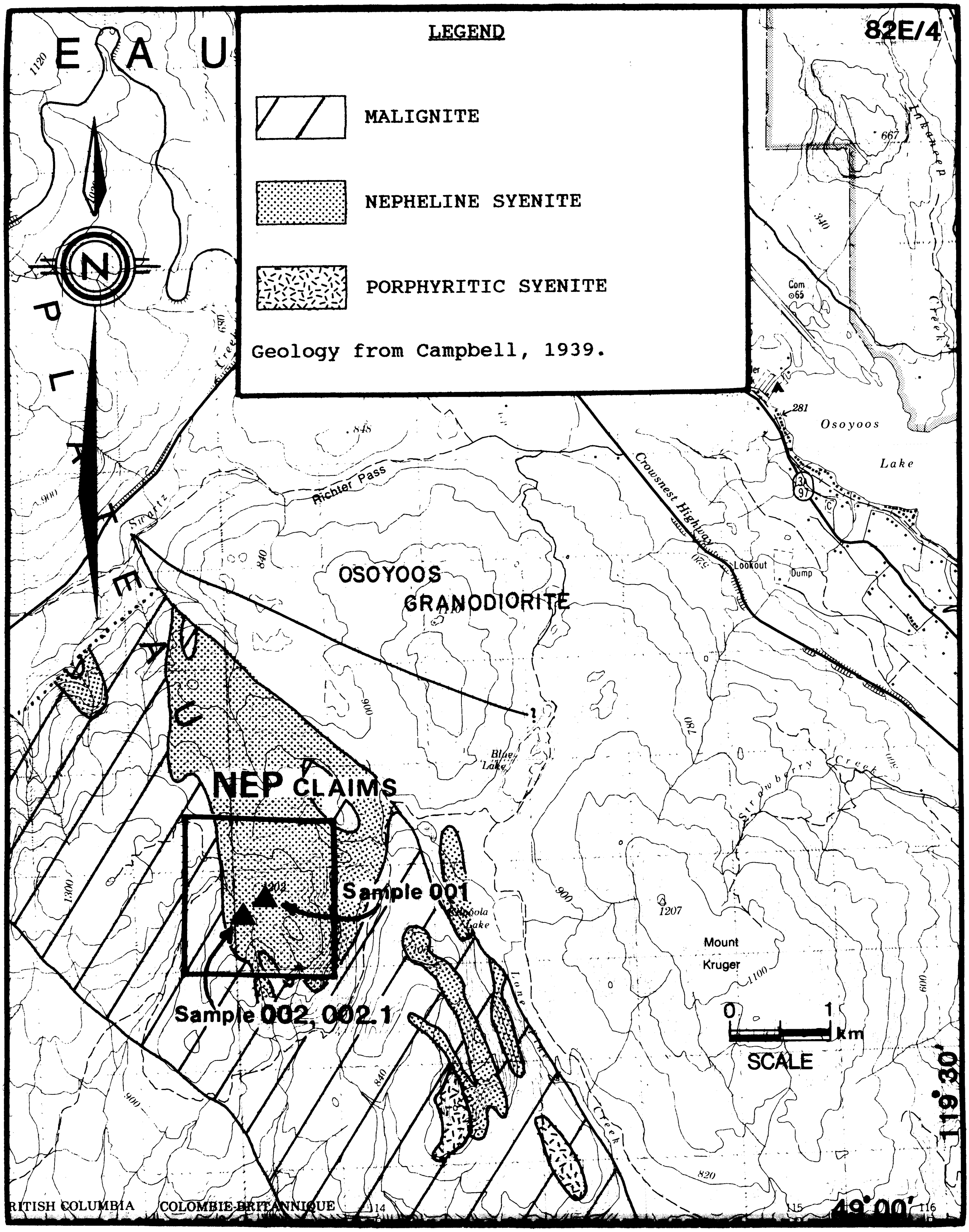


Figure 9. Geology and sample locations, Mount Kruger (NEP claims).

TABLE 19
RANGE OF MAJOR ELEMENT ANALYSES
KRUGER MOUNTAIN

Major oxides	Weight %
SiO_2	49.55 - 74.04
Al_2O_3	14.27 - 15.13
Fe_2O_3	0.65 - 11.33
CaO	0.87 - 9.16
Na_2O	2.91 - 3.86
K_2O	4.68 - 5.91

The area was mapped by the Geological Survey of Canada in 1961 by H.W. Little and by geologist J.R. Bellamy in 1972. During 1986, geologist J.G. Payne carried out detailed mapping for Nepheline Resources Limited, which was followed by a magnetometer survey, chemical analyses and diamond drilling.

REGIONAL GEOLOGY

The area is underlain by rocks of the Kobau Group and the Nelson plutonic suite. The Kobau Group is of Carboniferous age, and consists of metamorphosed siliceous sediments and intermediate volcanics, striking north and dipping west. A major fault along the Okanagan Valley juxtaposes the Kobau Group against paragneiss of the early Paleozoic Okanagan plutonic and metamorphic complex (formerly the Monashee Group). The Kobau Group is intruded by the Jura-Cretaceous Nelson plutonic suite, which includes Kruger Mountain alkaline rocks, a diorite batholith and stocks of monzonite with minor pegmatite.

The Mount Kruger alkaline bodies consist of four main sills of mostly nepheline syenite composition, which are conformable to foliation within themselves and in the Kobau Group.

LOCAL GEOLOGY

A large body of medium to coarse-grained nepheline syenite, several square kilometres in outcrop area is exposed between Keremeos and Osoyoos. Payne (1986) identified three main types of nepheline syenite: a hornblende zone (the finest grained along the borders of sills), an aegerine-augite zone and a biotite zone. Drilling of three holes totalling 330 metres in 1986, found the depth of the sills to be at least 170 metres (the depth of the deepest hole). An early map of the old Buck claims outlines areas of more salic and more mafic nepheline syenite.

Samples taken during field mapping for this project showed the mafic phases of the syenite to have a high iron content, present mainly as very fine grained (200 mesh) disseminated magnetite; samples for further testing were collected from the more favorable looking light-coloured rock.

TABLE 20
RESULTS AFTER DRY MAGNETIC SEPARATION
KRUGER MOUNTAIN

Mesh size	End fractions	Middle-range screen fractions	
		Magnetic	Nonmagnetic
		(Weight %)	
20	10.3	-	-
-20+28	-	4.1	11.2
-28+35	-	3.4	15.7
-35+140	-	5.5	37.5
-140	12.4	-	-
Totals	22.7	13.0	64.4

LABORATORY ANALYSES

Three samples were collected from a salic, light-coloured phase exposed on a hilltop west of Mount Kruger, approximately 9 kilometres west of Osoyoos (Figure 9). The range of major element analyses is given in Table 19. Complete chemical, spectrographic analyses and x-ray diffraction results are listed in Tables D1 and D2 in the Appendix. Twenty kilograms of the sample containing the least amount of iron (0.65%) was sent to CANMET for processing. It was crushed and middle-range screen fractions were passed through a dry magnetic separator; results are summarized in Table 20.

Moderate recovery (37.5%) of nonmagnetic material was realized and results of further analyses are given in Table 21.

TABLE 21
ANALYSIS OF NONMAGNETIC MATERIAL,
KRUGER MOUNTAIN

Major oxides	-20+28 mesh	-28+35 mesh	-35+140 mesh
		(Weight %)	
SiO_2	64.8	65.3	58.8
Al_2O_3	13.2	12.5	9.8
Fe_2O_3	0.15	0.12	0.09
CaO	0.76	0.75	0.68
Na_2O	4.08	4.02	3.59
K_2O	6.72	6.10	5.47

In thin section, microcline and albite average grain size is about 2 millimetres with up to 50 per cent aegerine-augite grains of equal or slightly larger size. The aegerine-augite does not appear to be intergrown with the feldspar, although the cores of some of the feldspar grains are altered and may be contaminated with iron. Augite and sphene are common accessory minerals, averaging 0.5 millimetre in size.

In a spectrographic report by W.R. Bacon (1969) microcline was identified as the most common feldspar, followed by andesine with minor orthoclase. The average composition was found to be 60 per cent feldspar, 16 per

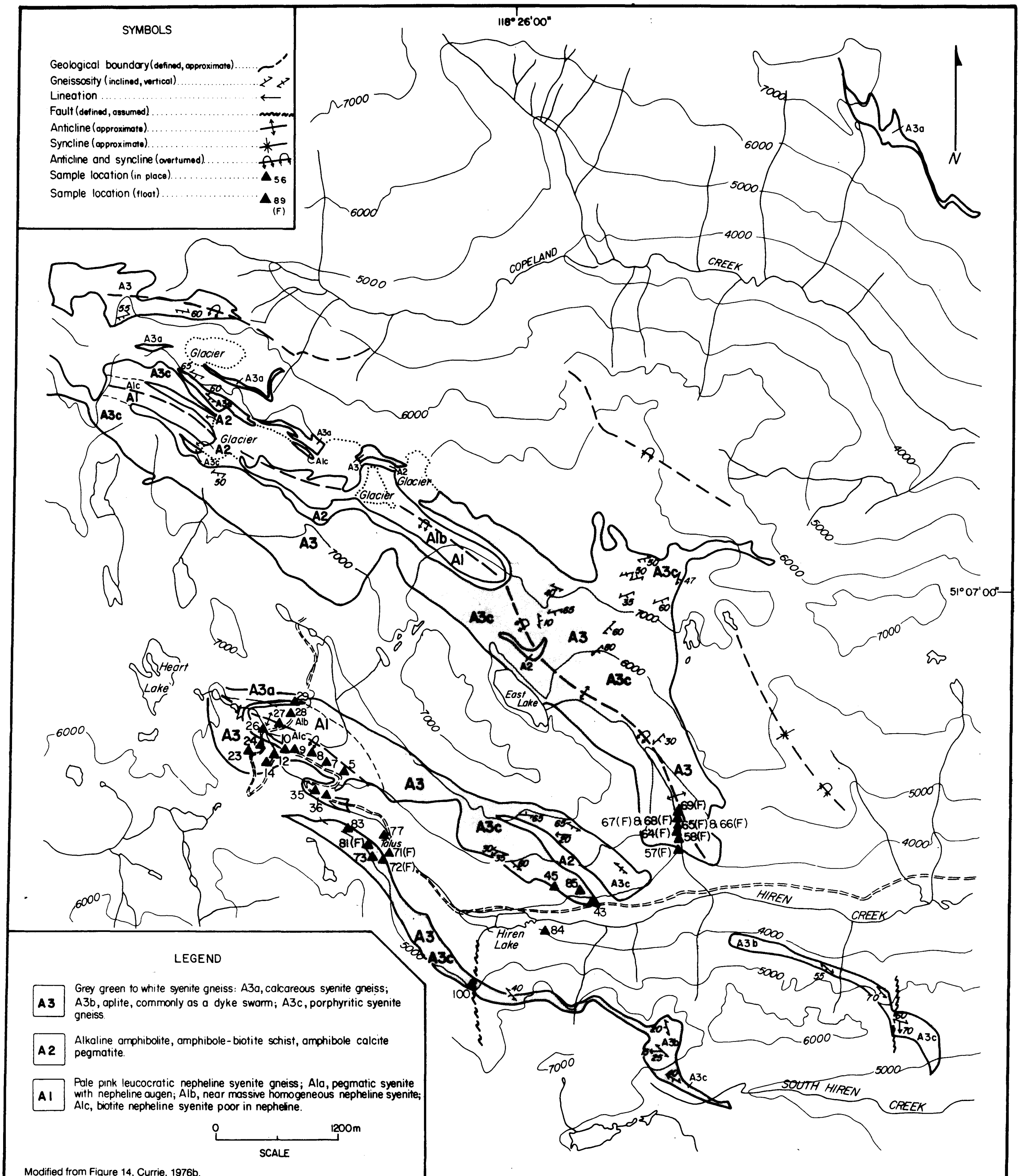


Figure 10. Geology of the Mount Copeland area.

cent nepheline, 11 per cent biotite, 6 per cent garnet, 7 per cent mafics and trace amounts of zircon and cancrinite.

Garnet (melanite), biotite, hastingsite and zircon occur in clusters up to 2 millimetres across, or separately in grains to 0.05 millimetre. Feldspar and nepheline grains range in size from 0.2 to 0.4 millimetre. Bacon observed that "A very fine grind (less than the smallest mafics in the rocks to free these particles from the nepheline-feldspar matrix) and a strong magnetic separator might possibly separate the iron-rich mafics and garnet and biotite from the rock."

ECONOMIC POTENTIAL

The samples contain low alumina (up to 13.2 per cent) and high iron (up to 0.15 per cent) which could not be reduced by processing tests, indicating the rock has limited potential to meet commercial specifications for glass and ceramic applications.

Earlier testing by CANMET in 1986 found the highest grade material to be 0.44 per cent iron and 20.2 per cent alumina with a low recovery rate of 27.8 per cent. This was considered unsuitable for clear glass but acceptable for amber glass and as filler material in fibreglass and foam glass (Andrews, 1986).

MOUNT COPELAND (MINFILE 082M002)

Nepheline syenite and syenite gneisses crop out in a 6-kilometre band on the southern flank of Mount Copeland, 15 kilometres northwest of Revelstoke (Figure 1, NS2; Figure 10).

REGIONAL GEOLOGY

The Mount Copeland area has been extensively mapped and studied by Fyles (1970), Currie (1976a, b) and Pell (1987). The descriptions and divisions of Currie are outlined below.

The Mount Copeland syenitic gneisses originate from the metamorphism of dikes and sills of compositions ranging from nepheline syenite to alkaline basalt which intruded quartzite, pelite and carbonate metasediments. All rocks were deformed during subsequent metamorphism, and anatectic melting resulted in aplitic syenite schlieren and dikes (Currie, 1976b).

Currie divided the Mount Copeland syenite complex into a basal nepheline syenite unit (A1), alkaline amphibolites (A2), and calcareous and saturated syenites (A3) (Figure 10).

The greatest percentage of nepheline is found in the augen-gneiss unit (A1a) of the basal nepheline syenite. This unit is mesocratic and faintly purple, with abundant cubic to subrounded nepheline porphyroblasts up to 2 centimetres across. Associated minerals are fine-grained biotite and feldspar, fluorite and cancrinite.

The core nepheline syenites (A1b) are more homogeneous and finer grained than Unit A1a.

Unit A1c shows the most pronounced gneissosity, with abundant biotite on parting faces. The unit may be transitional to Unit A3.

Grey syenitic gneisses (Unit A3) comprise a shell of rocks surrounding the more alkaline Units A1 and A2. Unit A3 rocks are a pale grey to greenish colour and medium to fine grained. They are quite heterogeneous, ranging from darkly banded gneiss to white aplitic leucosyenite to amphibolite. The predominant mineral is plagioclase feldspar, often totally replaced or rimmed by albite. Potassium feldspar forms large augen-shaped grains, and finer grained minerals include quartz, biotite, diopside and sphene. Magnetite occurs as large irregular grains in calcareous zones with accessory apatite, muscovite and zeolites.

Units A1 (nepheline syenite) and A3 (syenite gneiss) of Currie's divisions were sampled and analysed.

LABORATORY ANALYSES

Thirty-four samples from the deposit were analyzed (Figure 10). Chemical, spectrographic analyses and x-ray diffraction results are listed in Tables E1 to E6 in the Appendix. Major oxide analyses are summarized in Table 22. In thin section, the principal minerals are seen to be clinopyroxene and in biotite offering potential to produce a low-iron concentrate. Samples were therefore forwarded for laboratory studies.

TABLE 22
MAJOR OXIDE ANALYSES,
MOUNT COPELAND

Major oxides	Weight %
SiO_2	51.30 - 61.26
Al_2O_3	7.27 - 24.38
Fe_2O_3	0.84 - 8.21
CaO	0.04 - 9.61
Na_2O	2.74 - 8.76
K_2O	7.49 - 10.14

PROCESSING TESTS

For further evaluation, two 20-kilogram samples with low iron content were sent to CANMET for processing. The material was crushed, run through a dry magnetic separator (-10+100 mesh) and a mica-iron float. The nonmagnetic concentrates were then analysed. The results are summarized in Tables 23, 24 and 25.

ECONOMIC POTENTIAL

In tested samples, full liberation is achieved at less than 100 mesh. Concentrates processed by CANMET contain high levels of iron and titanium which could not be reduced below 0.19 per cent and 0.40 per cent respec-

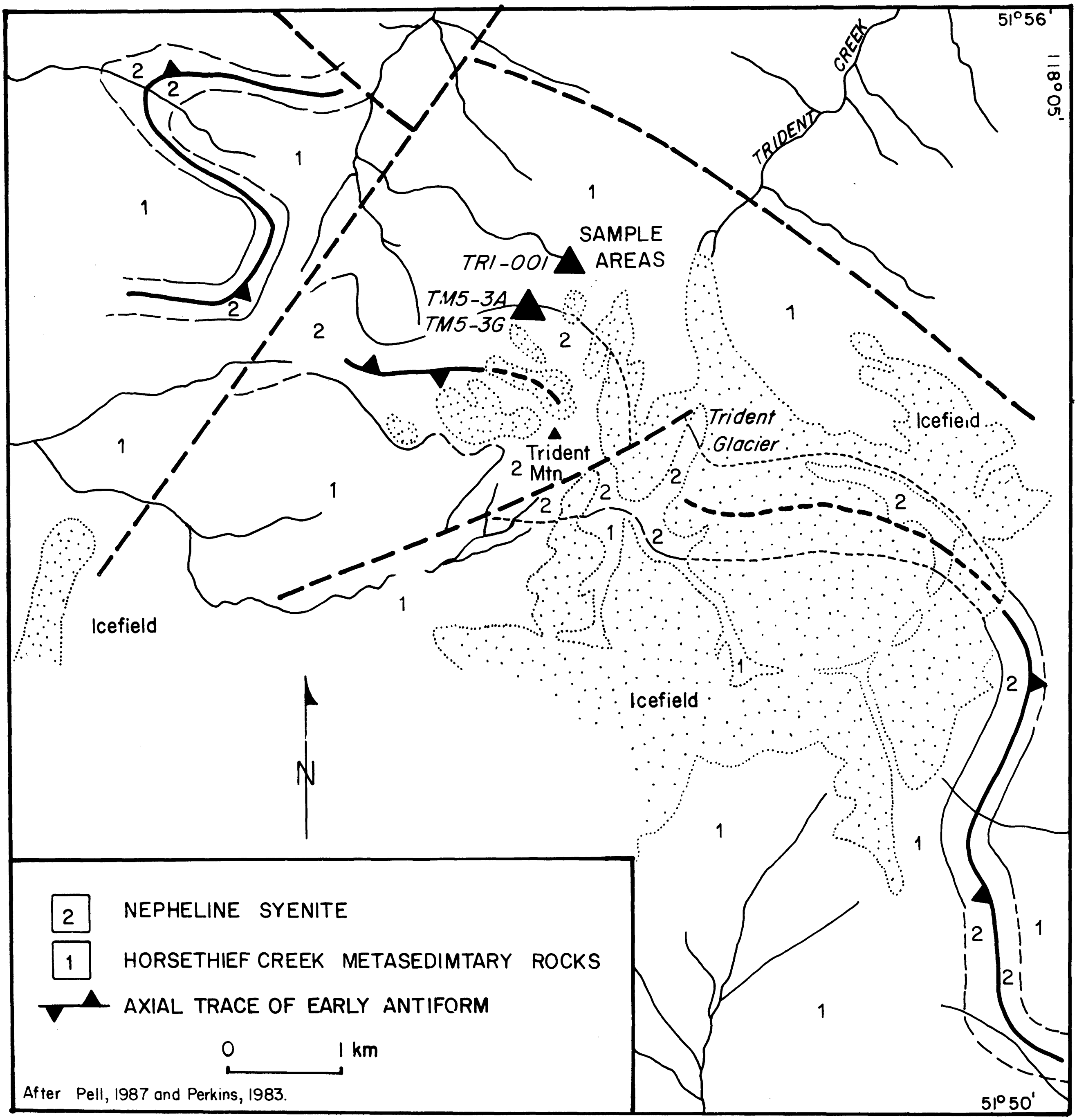


Figure 11. Geological sketch and sample locations, Trident Mountain.

TABLE 23
RESULTS OF MAGNETIC SEPARATION, MOUNT COPELAND

(Weight %)	Magnetic	Nonmagnetic	-100 Mesh
Sample 1	40.0	51.0	9.0
Sample 2	23.4	66.3	10.3

TABLE 24
ANALYSIS OF MICA-IRON FLOAT

Flotation			Concentrate/float tails	
(Weight %)	Slimes	Mica-iron	Magnetic	Nonmagnetic
Sample 1	15.6	27.9	19.1	36.5
Sample 2	20.0	3.8	28.6	46.6

TABLE 25
ANALYSIS OF NONMAGNETIC CONCENTRATES, MOUNT COPELAND

Major oxides (Weight %)	Separate 1	Separate 2	Flot'n 1	Flot'n 2
SiO_2	56.20	47.10	54.80	50.70
Al_2O_3	19.20	20.50	18.30	21.10
Fe_2O_3	0.50	1.23	0.19	0.41
CaO	1.27	1.60	0.98	0.80
Na_2O	6.58	6.02	6.44	5.48
K_2O	8.40	9.45	8.76	10.57

tively. Therefore it is not considered viable to produce nepheline syenite meeting market specifications from this locality.

TRIDENT MOUNTAIN (MINFILE 082M173)

REGIONAL GEOLOGY

Nepheline syenite gneiss occurs as a concordant lenticular mass at Trident Mountain, approximately 85 kilometres northeast of Revelstoke (Figure 1, NS3; Figure 11). The syenites were emplaced *circa* 380 Ma (dated by U-Pb isotope analyses on zircons), and intrude psammatic and kyanite-bearing pelitic schists (with rare calcsilicate bands) of the Hadrynian Horsethief Creek Group (Pell, 1987).

LOCAL GEOLOGY

The nepheline syenite is white to grey, medium (1 to 5 millimetres) to coarse grained (greater than 5 millimetres) and consists of microcline, albite and nepheline with minor biotite, ilmenite, sodalite, cancrinite, calcite, apatite, sphene, pyrochlore and zircon (Pell, 1987).

LABORATORY ANALYSES

The compositions of three samples and spectrographic results and x-ray diffraction analysis of one sample are given in Tables F1 to F3 in the Appendix. The range of major oxide values is given in Table 26. A 20-kilogram sample, sent to CANMET, was crushed and passed through a magnetic separator. Mesh analysis and analyses of the nonmagnetic concentrate are given in Tables 27 and 28.

TABLE 26
RANGES OF MAJOR OXIDES TRIDENT MOUNTAIN

Major Oxides	Weight %
SiO_2	55.59 - 63.70
Al_2O_3	20.73 - 24.69
Fe_2O_3	0.17 - 0.59
CaO	0.56 - 1.20
Na_2O	8.16 - 8.39
K_2O	3.12 - 8.22

TABLE 27
MESH ANALYSIS TRIDENT MOUNTAIN

Mesh	Magnetic concentrate (Weight %)	Nonmagnetic Concentrate
-10+35	4.1	67.7
-35 + 100	1.3	19.8
-100	0.5	6.6

TABLE 28
ANALYSES OF THE NONMAGNETIC CONCENTRATE, TRIDENT MOUNTAIN

Major oxides	-10+35 mesh	-35+10 mesh (Weight %)	0-100 mesh
SiO_2	56.6	58.0	62.0
Al_2O_3	16.8	17.3	18.5
Fe_2O_3	0.07	0.03	0.10
CaO	0.75	0.76	0.95
Na_2O	6.11	5.79	5.63
K_2O	7.59	8.05	8.31

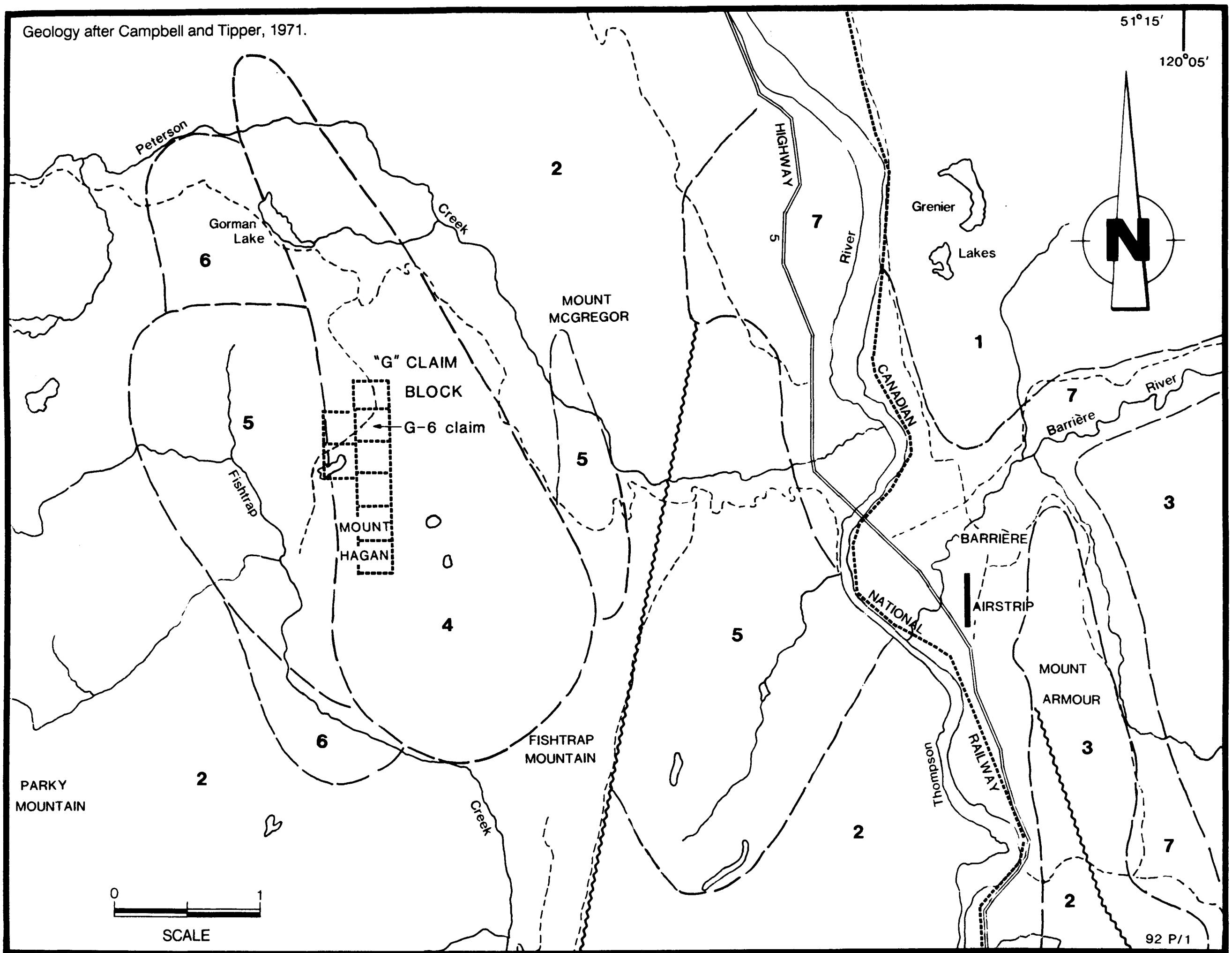
In thin section, albite and microcline are seen average 2 to 2.5 millimetres in size and are very uniform. Aegerine-augite and lesser amounts of augite average 0.5 to 1 millimetre. Accessory minerals include biotite (<2%) and sphene (<1%). There appears to be very little free iron; it is probably all contained in the biotite.

Ground nepheline syenite was tested in Clayburn Refractories Limited laboratories for potential glaze material, with good results after firing for 3 to 4 hours at 1250°C (Table 9). The glaze produced was white, translucent and glassy with a smooth unblemished surface.

ECONOMIC POTENTIAL

Processing results indicate the nepheline syenite has a high recovery rate of nonmagnetic materials very low in iron, and therefore a very good potential to produce commercial-grade nepheline syenite. Laboratory results indicate a product brightness of 85 per cent can be obtained.

Nepheline syenite concentrate obtained by laboratory-scale testing is comparable to nepheline syenite



LEGEND

Quaternary
Pleistocene and Recent

7	Till, gravel, clay, silt, alluvium.

Jurassic
Sinemurian to (?) Middle Jurassic

6	Hornblende andesite (may be all or partly intrusive)

Triassic or Jurassic
late Norian

5	Thuya and Takomkane batholiths and similar granitic rocks: hornblende-biotite quartz diorite and granodiorite, minor hornblende diorite, monzonite, gabbro, hornblendite.
4	Medium-grained, creamy buff, locally coarsely porphyritic (K-feldspar) syenite and monzonite.

Permian

3	Quartzite, quartz phyllite, quartz-granule conglomerate, argillite, phyllite, calcareous phyllite, marble, greenschist, greenstone.

Lower Pennsylvanian to upper Permian

2	Volcanic arenite, greenstone, argillite, phyllite; minor quartz-mica schist, limestone, basaltic and andesitic flows, amphibolite, conglomerate and breccia; includes small bodies of 6.

Mississippian and/or Later

Slide Mountain Group

1	Fennell Formation: pillow-lava flows,greenstone, foliated greenstone, greenschist,argillite, chert, minor amphibolite, limestone,breccia.

Symbols:
Geological boundary
Fault

Figure 12. Geology of the Barrière area.

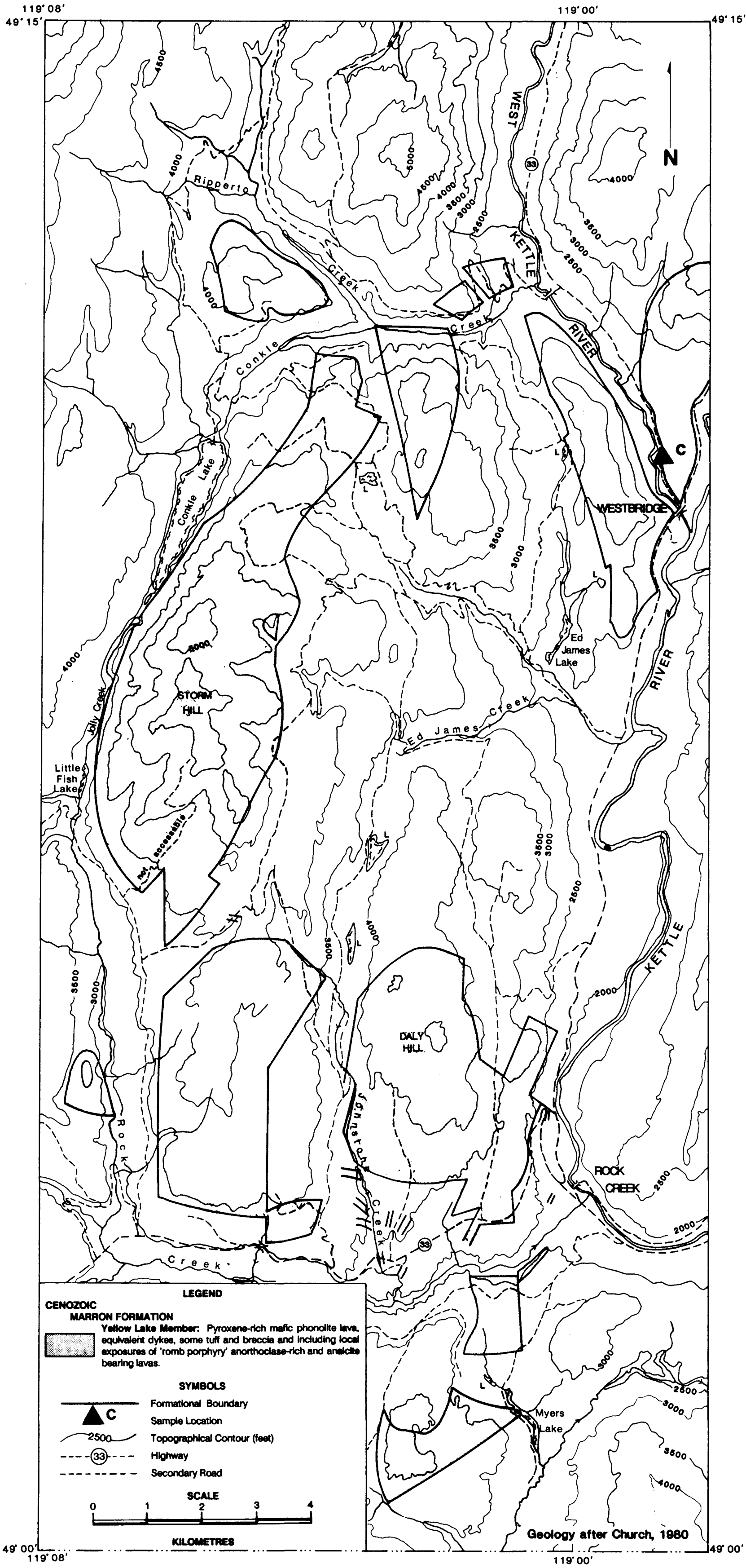


Figure 13. Geology of the Rock Creek Tertiary outlier.

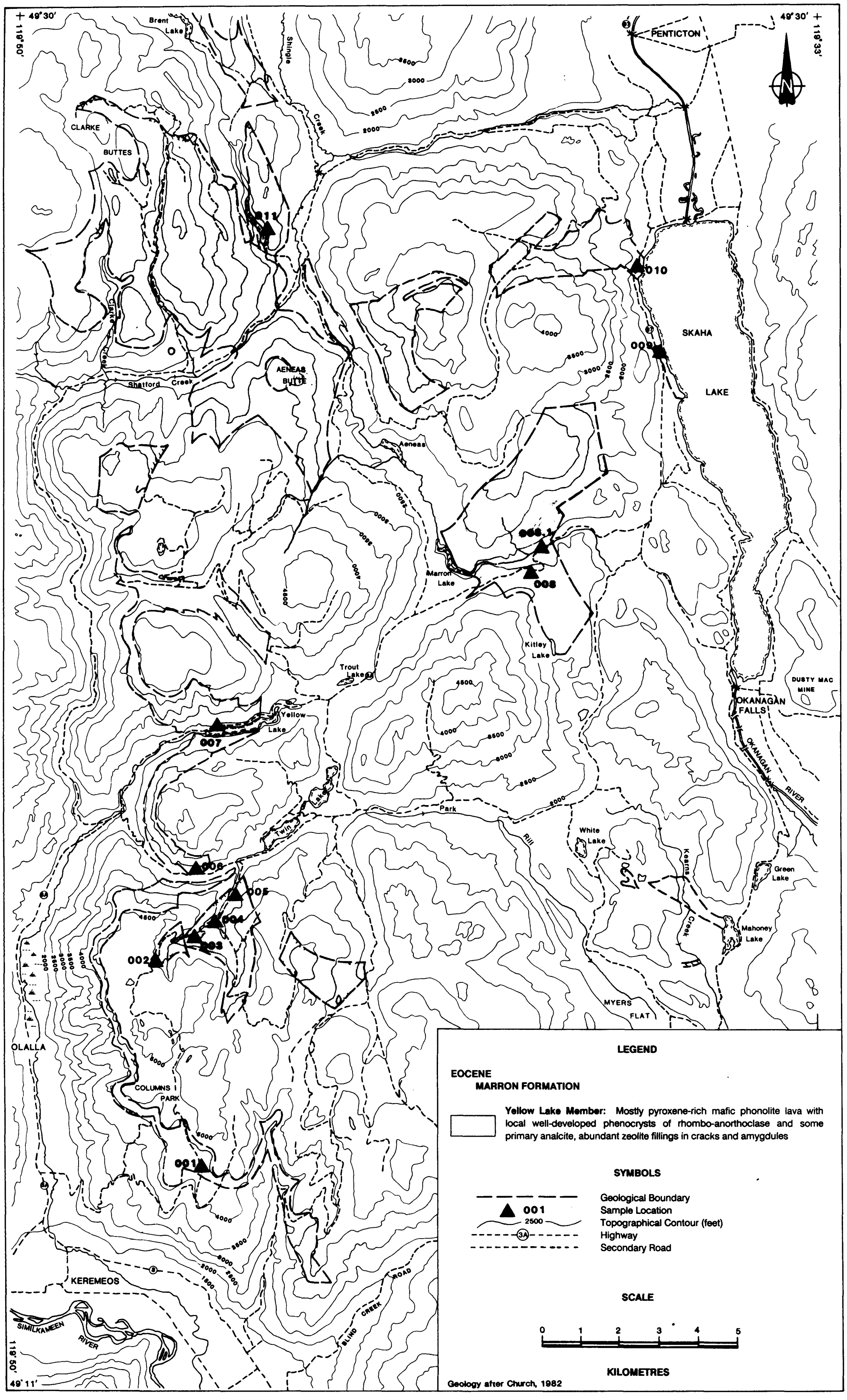


Figure 14. Geology of the Penticton Tertiary outlier.

currently imported into western Canada from Ontario. Geological mapping by Pell (1987) documented large lenticular bodies of nepheline syenite over a strike length of 7 kilometres at Trident Mountain. This large body has excellent potential to contain an economic nepheline syenite deposit.

BARRIÈRE (MINFILE 092P 159)

The Barrière feldspar prospect is located about 16 kilometres west of Barrière, B.C. Highway 5, the Canadian National Railway and an airstrip service the town (Figure 1, NS4; Figure 12).

REGIONAL GEOLOGY

The host intrusion is one of a series of small bodies, all of similar syenitic composition, that trend southeast from Barrière toward Kamloops (V.A. Preto, personal communication, 1989). Mount Lolo, just northeast of Kamloops, has been studied in detail and is found to be zoned, with natrolite-nepheline syenite comprising the core (Kwak, 1964).

LOCAL GEOLOGY

The 'G' claims, owned by Michael Resources Limited, are accessible by logging roads. Work during 1989 consisted of trenching, sampling of test pits and diamond drilling. Drilling totalled 457 metres in thirteen holes and outlined 3.6 million tonnes of potassium feldspar material, according to an October 5, 1989 press release (Michael Resources Ltd.). Timber from the centre of the deposit (on the G-6 claim) has been removed and overburden is being stripped in preparation for a test quarry (Figure 12).

In trench exposures, a basaltic to andesitic dike 3 metres wide crosscuts coarse syenite. The syenite is pinkish-grey in colour and commonly has iron oxide stain on weathered surfaces (Z.D. Hora, personal communication, 1987). Potassium feldspar crystals grow up to 6 centimetres in length and interstitial calcite and iron sulphides are present.

LABORATORY AND PETROGRAPHIC ANALYSES

In thin section, potassium feldspar shows microperthitic and some mesoperthitic textures. Iron oxides can be seen corroding the feldspar grains and contaminants this intimately intergrown are not easily removed and may pose difficulty in reducing Fe_2O_3 to acceptable commercial levels (<0.1% for coloured glass).

The aluminum oxide (Al_2O_3) level is within the range of commercial flux material (14-24%) and potash (K_2O) was also within commercial grades (8-12%). A typical assay from within a proposed quarry area is given in Table 29.

TABLE 29
TYPICAL ASSAY FROM WITHIN THE PROPOSED QUARRY, BARRIÈRE

Major Oxides	Weight %
SiO_2	61.21%
Al_2O_3	19.10%
K_2O	8.96%
Na_2O	4.44%
Fe_2O_3	1.30%
CaO	1.96%
MgO	0.38%

ECONOMIC POTENTIAL

Initial testing by Ore Sorters (North America) Inc. of Colorado, to reduce the iron to less than 0.1 per cent Fe_2O_3 by magnetic separation was not successful, indicating limited economic potential.

PHONOLITE

YELLOW LAKE (MINFILE 082ESW200)

Phonolite lava flows in the Yellow Creek member of the Eocene Penticton Group (Church, 1980, 1982; Figure 1, PH1; Figures 13 and 14) outcrops north of Keremeos and Rock Creek.

LOCAL GEOLOGY

The rock is fine-grained pyroxene-rich mafic lava with locally well-developed plagioclase and aegerine-augite phenocrysts. Twelve samples collected from various outcrops (Figures 13 and 14) were analysed to evaluate the lava as a potential source of feldspathic product meeting industrial standards for amber glass products.

SAMPLE DESCRIPTIONS

Sample C: A fine-grained medium-grey rock with pink, often rectangular phenocrysts of white to pink plagioclase up to 1 centimetre across. X-ray diffraction indicates albite, orthoclase and quartz are present with minor amounts of chlorite, aegerine-augite and trace calcite. Partial oxide analyses indicate a higher than average SiO_2 and Fe_2O_3 content of 64.67 and 3.3 per cent respectively and a lower than average Al_2O_3 content of 16.01 per cent.

Sample 001: A brown to black, fine to coarse-grained rock consisting of sanidine, clinopyroxene and aegerine-augite with minor zeolites [analcite and phillipsite(?)], phlogopite and traces of chlorite, vermiculite, orthoclase and tridymite(?). Iron (Fe_2O_3) content is high at 6.70 per cent.

Sample 002: A fine-grained black to dark brown rock with small (up to 2 millimetres) phenocrysts of white feldspar with zeolites filling cracks and cavities. The primary constituents are sanidine, aegerine-augite, analcite and minor alkali amphibole, phlogopite, albite and phillipsite(?).

Sample 003: A fine-grained grey to reddish brown rock with white zeolite filling cavities and phenocrysts of feldspar up to 3 millimetres across. Minerals identified include sanidine, analcite, nontronite (of the montmorillonite group), minor aegerine-augite, orthoclase and traces of mica and phillipsite.

Sample 005: A fine-grained reddish grey rock with rusty coloured phenocrysts of feldspar 1 to 6 millimetres long and flakes of biotite 1 to 2 millimetres long. Minerals present include sanidine, albite, quartz, carbonate, minor biotite and kaolinite with traces of hematite, calcite and siderite. In places the lava weathers white and cavities are filled with white zeolites.

Sample 006: A dark brown to black, fine-grained rock consisting of sanidine, orthoclase, aegerine-augite, analcite, minor tetranatrolite, biotite and traces of chlorite and albite. Zeolites commonly fill vesicles.

Sample 007: A medium-grey fine-grained porphyry consisting of analcite, orthoclase, sanidine, aegerine-augite, minor biotite and traces of tetranatrolite, chlorite and albite. White to pink zeolites fill vesicles up to 2 centimetres in diameter. Black tabular blades of pyroxene up to 6 millimetres in length by 3 millimetres in width form 5 to 10 per cent of the total volume.

Sample 008: A fine to medium-grained porphyry consisting of orthoclase, sanidine, albite, minor analcite, aegerine-augite and traces of calcite, smectite and chlorite. The phenocrysts are black pyroxenes 1 to 2 millimetres long which form 5 to 10 per cent of the volume.

Sample 009: A fine-grained, medium to dark grey porphyry consisting of orthoclase, albite, calcite, chlorite and minor to trace smectite, quartz, augite, apatite and siderite. Phenocrysts of feldspar, forming 10 to 20 per cent of the volume, are orange and up to 1 centimetre by 5 millimetres in size. White zeolites commonly fill cavities and cracks.

Sample 010: A light to medium-grey fine-grained porphyry. Minerals include albite, orthoclase, calcite, minor chlorite, augite and trace biotite, apatite and siderite. Orange phenocrysts of feldspar, 3 to 4 millimetres long, constitute 5 per cent of the volume. White zeolites (3 to 5%) fill cracks and some of the abundant vesicles.

Sample 011: A fine-grained, light to medium-grey porphyry consisting of albite, orthoclase, augite, minor hematite and smectite with traces of biotite and calcite. Phenocrysts of augite up to 7 millimetres long form 15 to 20 per cent of the volume. White zeolite-filled vesicles constitute 1 to 2 per cent of the total volume.

LABORATORY ANALYSES

Tables G1 to G3 in the Appendix list complete chemical, spectrographic analyses and x-ray diffraction results. The range of values for major oxides is given in Table 30.

TABLE 30
RANGE OF VALUES FOR MAJOR OXIDES, YELLOW LAKE

Major Oxides	Weight %
SiO_2	50.07 - 64.67
Al_2O_3	13.63 - 19.49
Fe_2O_3	3.30 - 6.93
CaO	1.46 - 8.47
Na_2O	3.05 - 5.86
K_2O	4.42 - 6.97

All samples tested showed high iron content. The samples with the least iron were sent to CANMET which was unable to carry out mineral separation studies due to the fine-grained nature of the material.

ECONOMIC POTENTIAL

Based on field observations, chemical analyses and evaluation by CANMET, the material studied cannot meet the specifications for amber glass.

LEUCOCRATIC GRANITE/APLITE
BOUNDARY CREEK (MINFILE 082ESE224)

GEOLOGY

Several bodies of leucocratic granite of the Jura-Cretaceous Nelson plutonic suite are known in the vicinity of Greenwood. One site, located 13.5 kilometres north of Greenwood near Boundary Creek (Figure 1, LG1; Figure 15) was sampled to assess the feldspar potential. The rock is white to medium grey, medium to coarse grained, and contains quartz, plagioclase, potassium feldspar, minor biotite and traces of chlorite. Iron stains are concentrated along microfractures in feldspar. In thin section, biotite grains ($<3\%$) occur generally as single crystals about 0.2 millimetre in size and occasionally as slightly larger clusters (up to 0.4 millimetre). The grain sizes of quartz and feldspar range from 0.25 to 5 millimetres, averaging 1.25 millimetres.

LABORATORY ANALYSES

Chemical, spectrographic analyses and x-ray diffraction results from two samples are listed in Tables H1 to H3 in the Appendix, the range of major oxide analyses is given in Table 31.

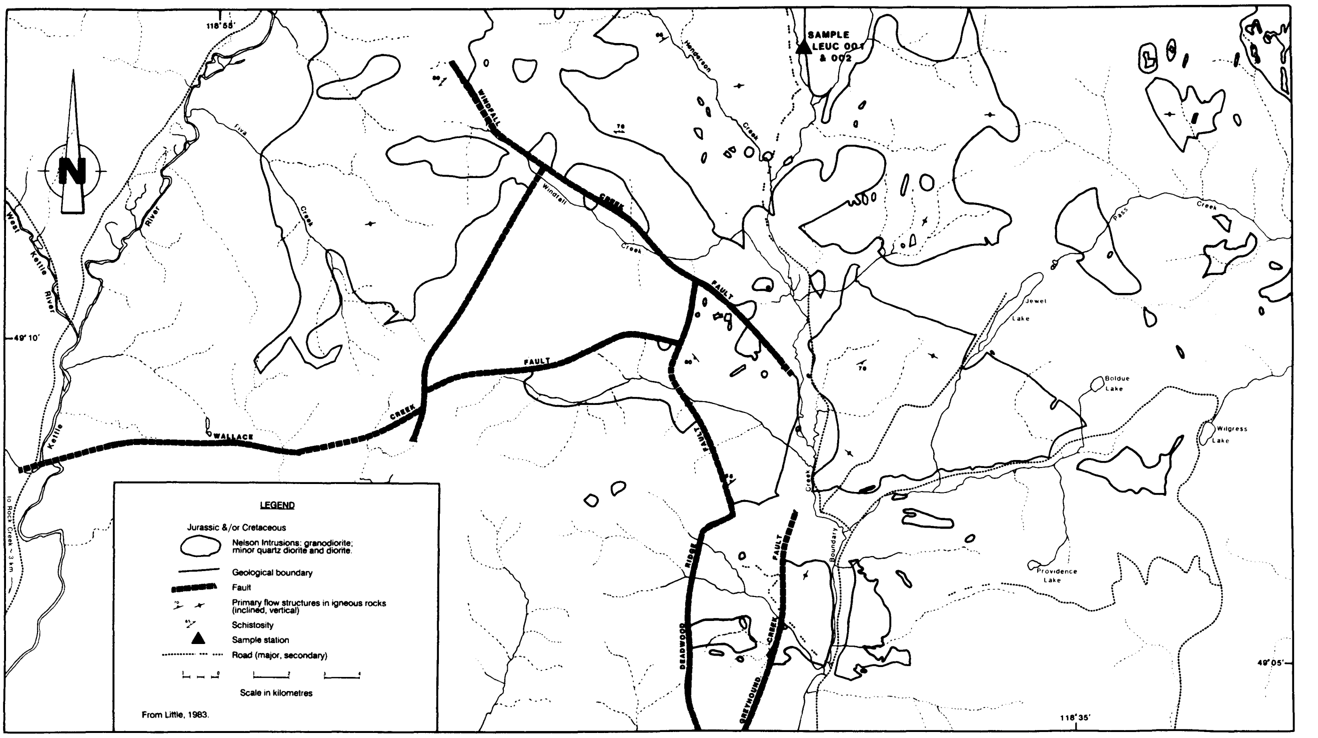


Figure 15. Distribution of the Nelson intrusions, Greenwood.

TABLE 31
MAJOR OXIDE ANALYSES
BOUNDARY CREEK

Major Oxides	Weight %
SiO_2	69.31 - 72.00
Al_2O_3	15.44 - 16.87
Na_2O	4.01 - 4.35
K_2O	3.07 - 4.45
CaO	1.80 - 1.89
Fe_2O_3	1.12 - 2.00

ECONOMIC POTENTIAL

The sample was not tested further, however, this type of rock might become an alternative feldspar source, similar to aplite or alaskite from North Carolina or Virginia.

SUMAS MOUNTAIN (MINFILE 092GSE037)

The Sumas Mountain prospect is located about 9 kilometres northeast of Abbotsford, 65 kilometres east of Vancouver (Figure 1, A1). The main line of the Canadian National Railway follows the Fraser River just north of the mountain. The property is easily accessible by gravel roads which lead to Sumas Mountain Provincial Park on the summit.

The property consists of three claims, comprising 13 units (Figure 16). Several branches of Wade Creek cross the forest-covered property; the area has been and is being extensively logged. Parts of feldspar-rich bodies have been quarried for aggregate for logging-road construction; the material is strongly fractured and easily broken into angular fragments.

REGIONAL GEOLOGY

The area is underlain by pale green volcanics of the Early to Middle Jurassic Harrison Lake Formation. Granite and granodiorite of the Coast plutonic suite (dated at 160 Ma) cut the volcanics (J.W.H. Monger, personal communication, 1990). The Harrison Formation is unconformably overlain by Eocene sediments (Payne, 1989).

LOCAL GEOLOGY

A body of felsic rock trends generally northeast over an area of a few square kilometres between the granites and volcanics. It is aplitic in appearance, consisting mainly of albite and quartz with trace chlorite. It is described as having a porphyritic dacite phase and a fine-grained dacitic phase (Payne, 1989). The porphyritic dacite contains 10 to 25 per cent plagioclase phenocrysts with fewer quartz crystals in an aphanitic pale to medium-green groundmass of actinolite, chlorite, lesser titanium oxide and local minor pyrite. A variation on this phase contains 20 per cent medium to dark green, aphanitic andesite inclusions.

The second phase is very fine grained leucocratic dacite with very fine grained plagioclase and quartz phenocrysts. The groundmass is creamy white feldspar and quartz with minor mafics (magnetite, chlorite and actin-

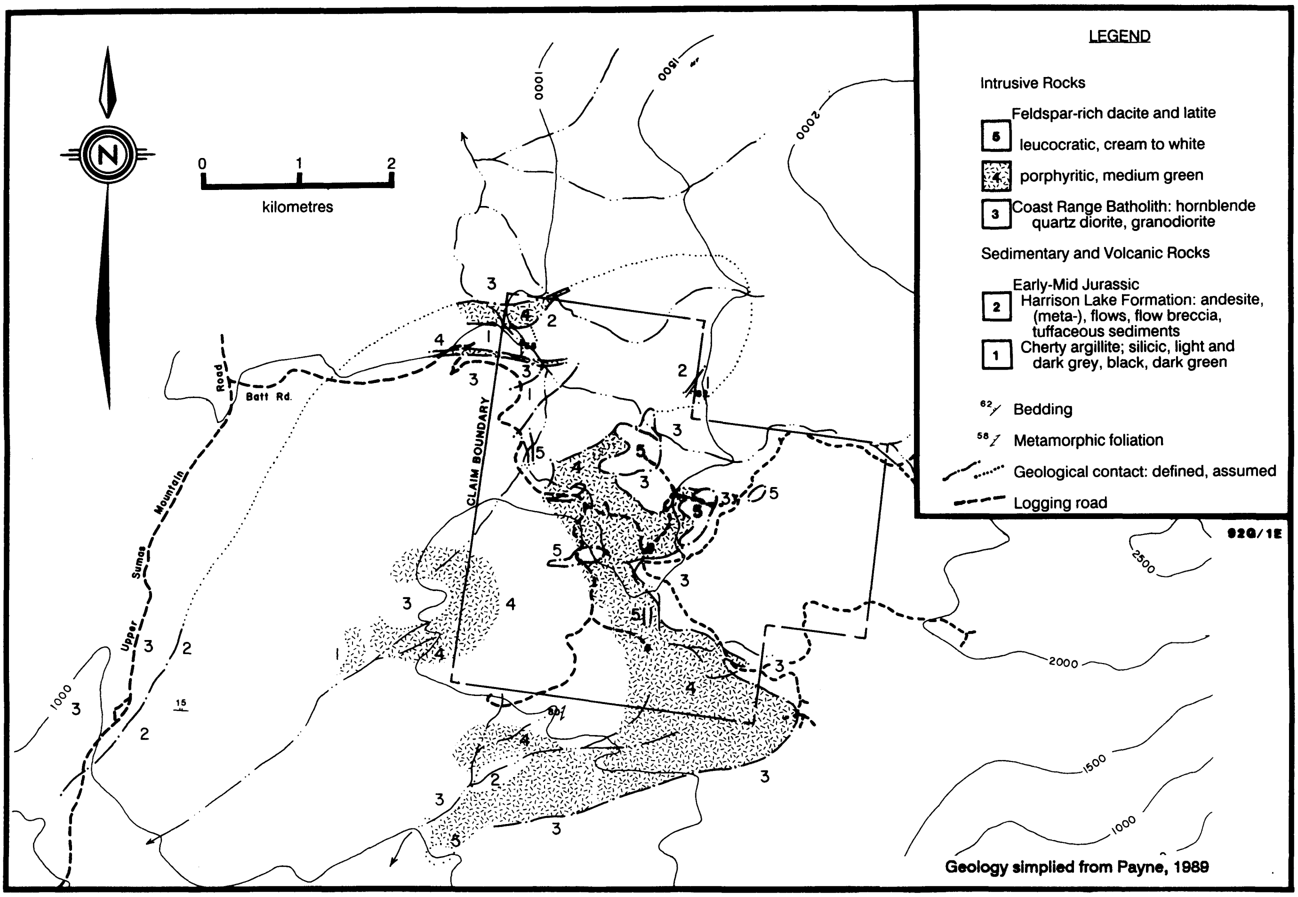


Figure 16. Geology of Sumas Mountain.

olite), titanium oxide and locally 1 per cent pyrite. A flow-banded white and grey latite occurs in border phases.

Strong fracturing forming sheeted joint sets occurs with one set locally subparallel to a poorly developed, subhorizontal flow banding. Pyrite grains are locally disseminated and fracture surfaces have limonite and lesser hematite staining.

LABORATORY ANALYSES

Samples analysed by Acme Laboratories in Vancouver contained 0.19 to 1.5 per cent Fe_2O_3 with most samples between 0.5 and 1.0 per cent Fe_2O_3 (Payne, 1989). Results of whole rock analyses of 10 samples are summarized in Table 32.

Much of the iron is contained in chlorite and actinolite, and lesser amounts in pyrite and hematite staining. A moderate amount of the iron is in magnetite which could be magnetically separated, however, the other iron-bearing minerals are intimately intergrown with feldspar and difficult to separate (Payne, 1989).

Analyses of grab samples of the leucocratic phase by the British Columbia Geological Survey Branch laboratory showed Fe_2O_3 ranging from 0.15 to 0.40 per cent (Table I1 in the Appendix). Complete spectrographic results are shown in Table I2. Samples sent to CANMET were too fine grained for processing tests.

Other work on the property has included a magnetometer survey which was not helpful in mapping geological boundaries.

TABLE 32
RESULTS OF WHOLE ROCK ANALYSES OF TEN SAMPLES, SUMAS MOUNTAIN

Major Oxides	Range (Weight %)
SiO_2	71.1 - 81.7
Al_2O_3	11.3 - 17.8
Fe_2O_3	0.19 - 2.33
MgO	0.01 - 0.35
CaO	0.26 - 0.78
Na_2O	4.20 - 8.92
K_2O	0.10 - 2.65
TiO_2	0.10 - 0.24
P_2O_5	0.01 - 0.09
LOI	0.3-1.0

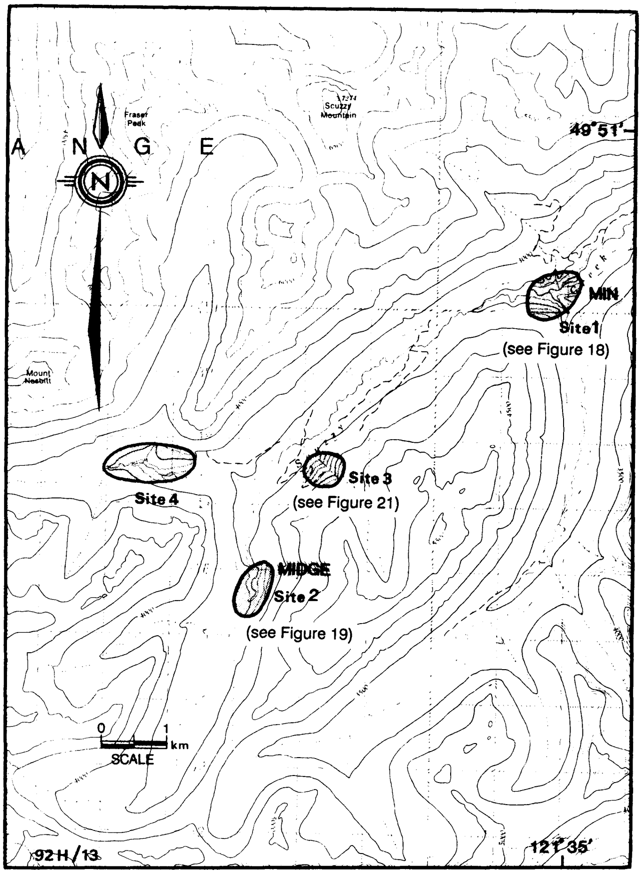


Figure 17. Location of sample sites, Scuzzy Creek.

ECONOMIC POTENTIAL

Preliminary results indicate that the Sumas Mountain rock does not meet glass industry specifications. Further work will be required to assess if some parts of the felsic body might produce a marketable product.

FELDSPATHIC SAND

SCUZZY CREEK (MINFILE 092HNW052)

Large sand deposits, of probable glaciolacustrine origin, are located along Scuzzy Creek and one of its tributaries, approximately 12 kilometres south of North Bend on the west side of the Fraser Canyon (Figure 1, FS1; Figure 17).

GEOLOGY

The feldspathic sand consists of unconsolidated material 0.66 to 2.0 millimetres in grain size. The main constituents are plagioclase and quartz with minor mica and amphibole. The sand ranges in colour from white to light grey or dark brown. The individual deposits may be up to 1800 by 400 metres in area and up to 60 metres thick. They are underlain by the Scuzzy pluton which consists predominantly of massive coarse-grained biotite granodiorite (Roddick *et al.*, 1979). The intrusion is white weathering and generally devoid of inclusions and veins. The composition is commonly coarse-grained feldspar and quartz with much finer grained biotite and even finer grained muscovite. The mafic content is distinctly lower than in associated quartz diorites (Roddick and Hutchison, 1969).

DEPOSIT DESCRIPTIONS

Site 1: This site (Figures 17 and 18) saw limited production during 1966 when North West Silica Limited dried, screened and bagged 120 tons of sand for Vancouver and Kamloops markets (McCammon and Waterland, 1967).

The deposit is approximately 1800 metres in length, 440 metres at its maximum width and up to 60 metres thick. Scuzzy Creek runs through the length of the deposit, and has exposed a section of unconsolidated sand and till. The sediments are divided into four distinct units based on grain size (Figure 18). A brief description of each unit (in descending stratigraphic order) follows.

The uppermost unit, Unit 1, consists of white to light grey, fine to coarse-grained unconsolidated sand which contains less than 2 per cent rounded to subangular granitic pebbles between 2 and 4 centimetres in diameter. The unit is undisturbed and sorted, containing thin laminated bands (up to 2 centimetres) of mafic minerals (biotite and amphibole) and pebbles. A 4-centimetre band of pebbles up to 10 centimetres long distinguishes Unit 1 from underlying Unit 2. Using this marker, Unit 1 is approximately 2.5 metres thick.

Unit 2 is basically similar to Unit 1 with the exception that pebbles consistently range from 2 to 10 centimetres in diameter.

Unit 3 has pebbles 2 to 10 centimetres in size occupying up to 10 per cent of the total volume. Large cobbles and small boulders of quartz diorite up to 50 centimetres across are common. The contact between Units 2 and 3 is gradational. A section measured along the Scuzzy Creek mainline logging road exposes 20 to 25 metres of Units 2 and 3 combined.

Unit 4 is a till deposit consisting of coarse, unsorted feldspathic sand, pebbles, cobbles and quartz diorite boulders up to 6 metres across. At one measured section, exposed on the Scuzzy Creek mainline logging road, the unit is 30 metres thick.

Site 2: The site is 7 kilometres southwest of Site 1 (Figures 17 and 19). The sand deposit extends 1.6 kilometres along Scuzzy Creek and is up to 0.6 kilometre wide with an estimated thickness of 30 metres.

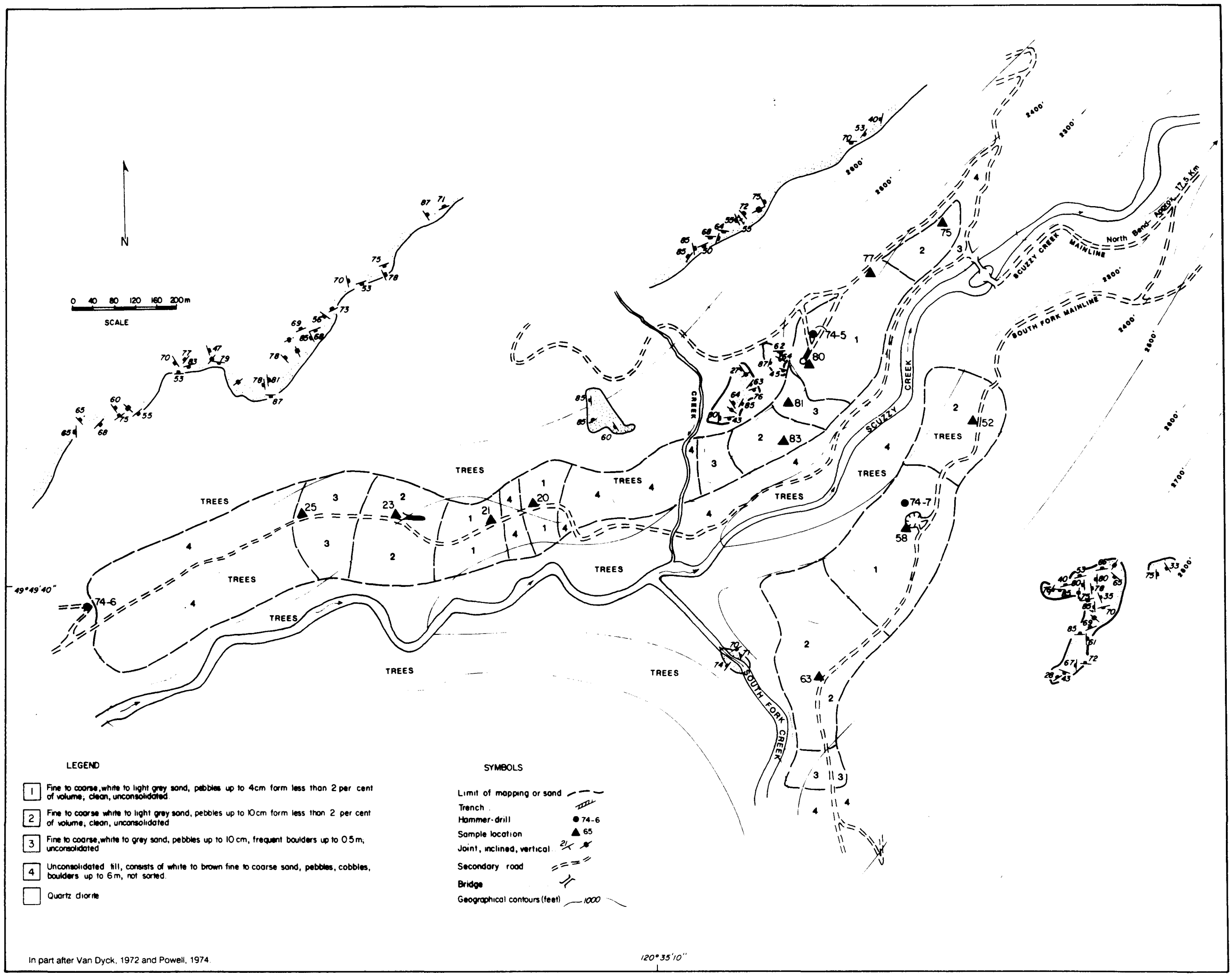


Figure 18. Geology of Scuzzy Creek, Site 1.

TABLE 33
RANGE OF MAJOR OXIDE ANALYSIS, SCUZZY CREEK

Major Oxides	Weight %
SiO_2	73.75 - 76.90
Al_2O_3	14.43 - 15.40
Fe_2O_3	0.53 - 0.76
CaO	2.77 - 3.05
Na_2O	4.44 - 4.84
K_2O	0.44 - 0.49

TABLE 34
RESULTS OF SCREEN ANALYSIS, SCUZZY CREEK

Screen Analysis

Mesh	Weight %
14	1.5
-14+28	17.1
-28+48	41.5
-48+100	28.1
-100+200	9.2
-200	2.6

TABLE 35
RESULTS OF FLOTATION TESTS, SCUZZY CREEEK

Flotation Test	Test #1	Test #2 (Weight %)
+20 Mesh	-	4.40
Mica-iron concentrate	1.0	1.20
Feldspar concentrate 1	17.60	19.60
Feldspar concentrate 2	26.50	-
Cleaner tails	3.20	5.0
Tails	35.90	65.30
Slimes, losses	15.80	4.50

TABLE 36
RESULTS OF MAGNETIC SEPARATION TESTS

Magnetic Separation

Major Oxides	Test 1 Concentrate 1	Test 1 Concentrate 2 (Weight %)	Test 2
SiO_2	55.80	59.60	58.90
Al_2O_3	20.90	21.90	22.0
Fe_2O_3	0.084	0.084	0.94
CaO	5.52	5.53	4.53
Na_2O	8.41	8.39	8.43
K_2O	0.52	0.45	0.53

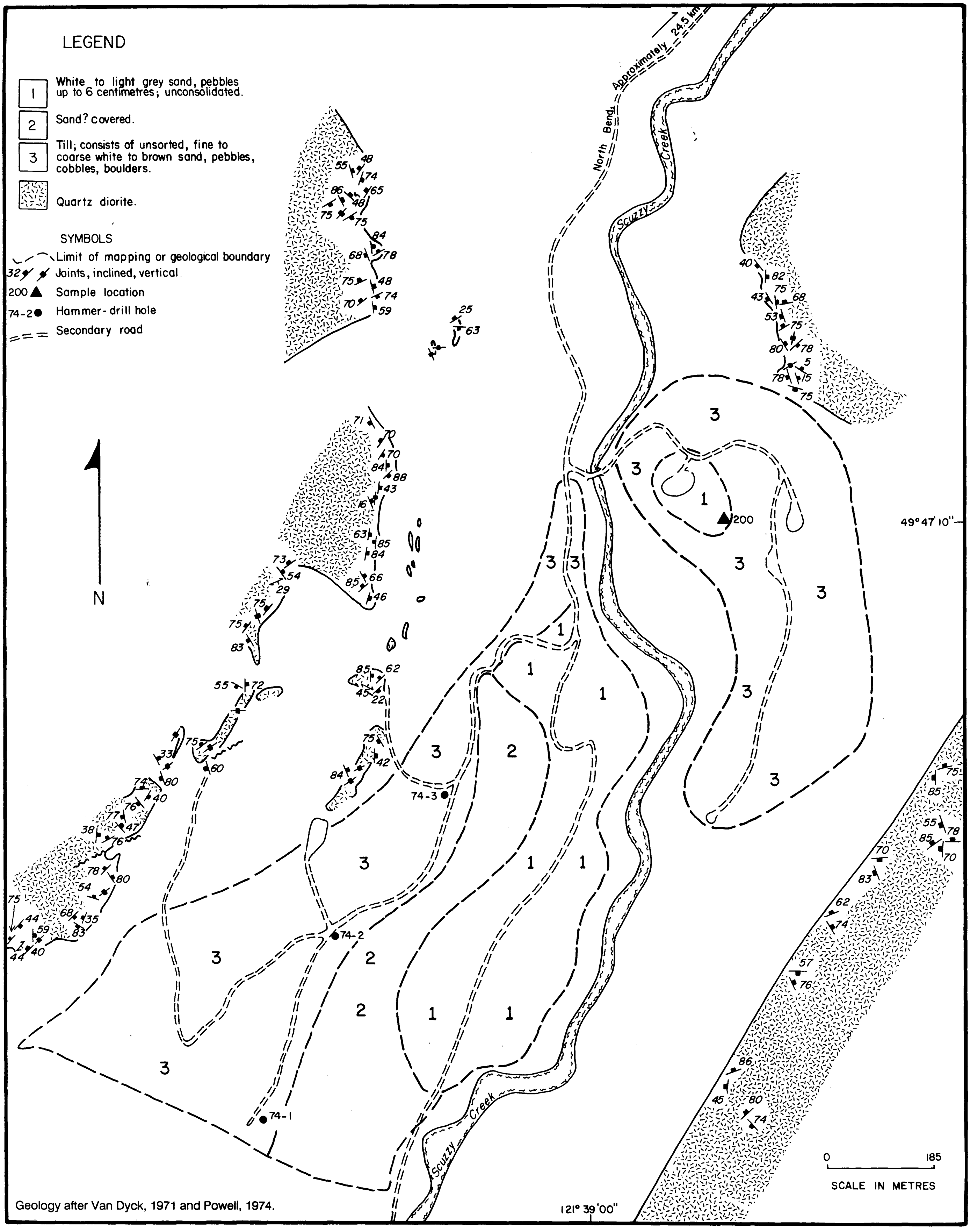


Figure 19. Detailed geology of Site 2, Scuzzy Creek.

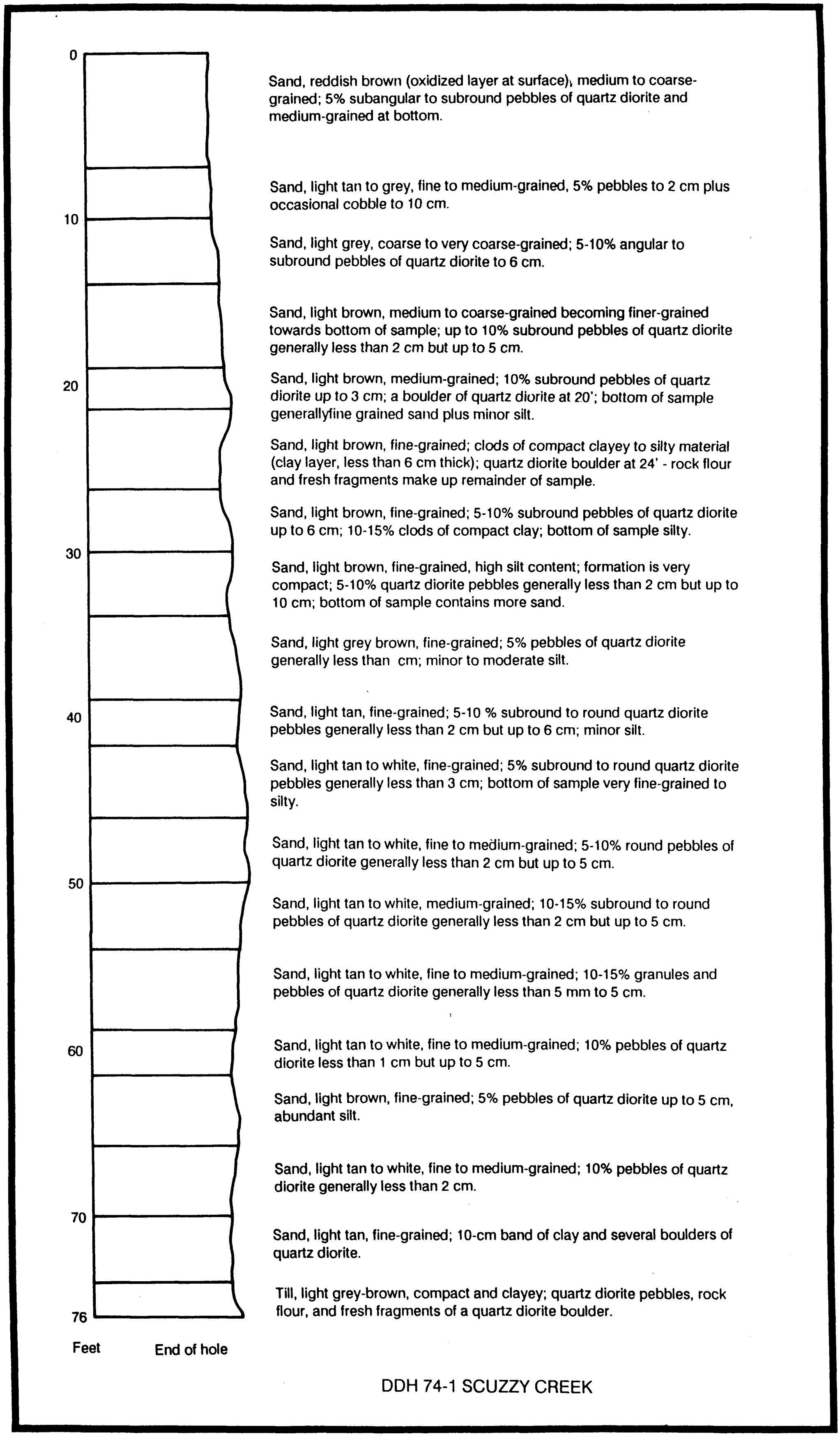


Figure 20. Diamond-drill hole 74-1, Scuzzy Creek.

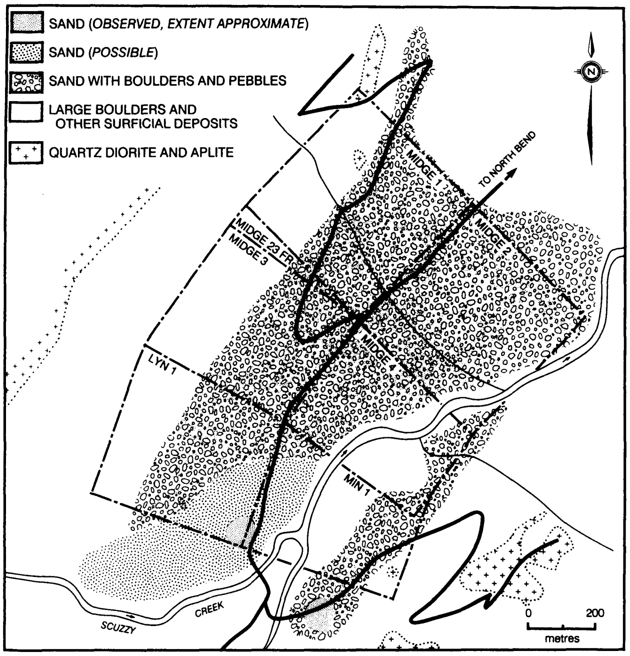


Figure 21. Detailed geology of Site 3, Scuzzy Creek.

Two distinct mappable units are recognized. Unit 1 consists of fine to coarse-grained, sugary, white to light brown sand. Estimated percentages are: quartz, 45 to 55; plagioclase (albite), 40 to 50; minor potassium feldspar, mica and amphibole. Up to 10 per cent (by volume) consists of rounded to angular quartz diorite pebbles.

Unit 2, which underlies Unit 1, is a till deposit consisting of unsorted pebbles, cobbles and quartz diorite boulders in a coarse sand matrix; similar to Unit 4 at Site 1. Both units are exposed along an access road and beside Scuzzy Creek. The deposit was drilled by Indusmin Limited in 1974; Figure 20 is a graphic log of one of seven holes totalling 134 metres.

Site 3: The third site is located at the confluence of Scuzzy Creek and one of its tributaries (Figures 17 and 21). Indusmin Limited describes "15 feet of buff-coloured, stratified, medium to coarse-grained quartzo-feldspathic sand" overlying "20 feet of lake silts". The company drilled one 66-foot hole (percussion drilling) to determine deposit thickness and encountered glacial till at 30 feet depth. No samples were processed for this report.

Site 4: Site 4 is 2 kilometres west of Site 3, on the north bank of an unnamed tributary to Scuzzy Creek (Figure 17). An area 30 by 90 metres was recently (1987) cleared of overburden to stockpile clean, fine to coarse-grained, white to golden brown feldspathic sand. Exposed sections show 11 metres of clean sand with minor quartz diorite pebbles averaging 4 centimetres in diameter and boulders up to 50 centimetres across.

DEPOSITION OF SAND DEPOSITS

Till was deposited along Scuzzy Creek and its tributaries by glaciers retreating from the valley. Ice dams may have formed along the creeks, blocking stream flow and creating large settling ponds which collected sands eroded from the Scuzzy pluton. Once the ice dams broke, sedimentation ceased and Scuzzy Creek resumed its flow, eroding away portions of the deposits.

LABORATORY ANALYSES

Chemical, spectrographic analyses and x-ray diffraction tests were completed on samples from Sites 1, 2 and 4 (Tables J1 to J3 in the Appendix). The range of major oxide analyses is given in Table 33.

Analyses indicate the sand is potentially suitable for glass applications. On this basis, one sample was sent to CANMET for beneficiation. Results of the first process step, screen analysis, are summarized in Table 34. Approximately 70 per cent of the grains are between 28 and +100 mesh, a size considered acceptable by glass manufacturers.

The sample was next scrubbed, deslimed and a mica-iron and feldspar float produced. The feldspar concentrate was run over a dry magnetic separator. Results are presented in Tables 35 and 36. Recovery rates in feldspar concentrates are low. After magnetic separation, tested samples are high in alumina and calcium and contain less than 1 per cent iron.

ECONOMIC POTENTIAL

Although recovery rates for feldspar are low (up to 26.5%), tests indicate the Scuzzy Creek deposits contain material meeting glass manufacturers' requirements. Large indicated volumes of sand available and relatively easy access give the site good potential to produce material for the glass industry.

Two samples of ground feldspar concentrate were tested for potential glaze material by Clayburn Refractories Limited. Being calcium rich, the ground feldspar is quite refractory and did not melt after firing for 3 to 4 hours at 1250°C.

After the second firing at 1300°C for 3 hours, one of the two concentrates produced an acceptable glaze material; an opaque creamy colour with no visible impurities. The second concentrate was white and free from impurities but remained grainy in appearance.

CONCLUSIONS

As a result of a marketing study by Mineral Marketing Inc. in 1988, it is recognized that there is significant market potential for good quality feldspathic materials produced in British Columbia. There is, at the present time, a slow growth demand for feldspar of about 1 per cent annually, mainly because of the competition from the plastics industry and increased recycling of glass. The demand growth for potassium feldspar in special uses and ceramics is somewhat better, at about 2 per cent annually (Agricola Mineralia, 1986).

The operating costs to a producer may include some or all of the following: labour, drying, grinding, mineral separation, screening, fine sizing, maintenance, loading, trucking to rail and loading on board. The operating profit to a producer is calculable as the delivered price minus freight, handling, marketing costs, discount adjustments, possible tariffs, and production costs and royalties.

The evaluation of a feldspathic resource should include the following considerations: the uniformity of the deposit; the uniformity of the product in physical, chemical and mineralogical composition; the presence of sedimentary inclusions or mafic dikes; the presence of iron alteration on joints; the inclusion of any deleterious minerals such as corundum, zircon or any other refractory minerals; and, the amenability of the material to beneficiation (*i.e.* the ease of removal of magnetic minerals; Hewitt, 1961). Most of these considerations can be applied to any feldspar deposit. Competition in the feldspar industry discourages the development of pegmatites from which only feldspar is produced; byproduct operations show the most promise, for example, lithium mineral concentrate.

Another factor to consider in the development of a feldspar or nepheline syenite deposit is the effect on the environment. Large dumps may be avoided by considering byproduct sales of, for example, quartz, sand, mica or feldspar-silica mixtures. Because of the nature of the material, no acidic waters will be generated as there should be no concentrations of sulphides, and reservoir waters would be relatively clear.

Dust production is a potential problem when a dry-milling circuit is used; especially quartz dust which causes silicosis, a chronic respiratory illness (Agricola Mineralia, 1986). Dust and tailings may find alternate uses as discussed in the section on fillers (paint, plastics and rubber).

The required uniformity of composition and amenability to low-cost beneficiation make suitable deposits rare. In any deposit evaluation, microscopic examination is essential to determine if the material can be beneficiated. If the feldspar grains look clean, and iron-bearing minerals are large enough to be separated with the glass sand size *i.e.* -20 + 100 mesh, then beneficiation tests to determine attainable grain size and purity should be the next step.

To develop a deposit in British Columbia, the quantity and consistency in composition of the feldspathic material must be well established, and a good marketing strategy is necessary to compete with products already available. The sites considered to have the most potential in British Columbia at this time are Lumby, Hellroaring Creek, Scuzzy Creek and Trident Mountain.

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APPENDIX I

APPENDIX I
TABLE A1
MAJOR ELEMENT XRF RESULTS, HELLROARING CREEK
(per cent)

Field No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
HELL-012	64.86	0.01	19.00	0.05	0.02	0.03	0.05	2.94	12.45	0.17	0.27	99.86
HELL-014.5	88.46	0.02	6.60	0.20	0.02	0.00	0.06	1.60	1.70	0.03	0.45	99.14
HELL-015	74.58	0.02	14.43	1.01	0.08	0.00	0.34	6.25	1.51	0.11	0.56	98.90
HELL-033	71.76	0.03	16.79	1.56	0.05	0.13	0.42	6.44	0.45	0.10	0.69	98.42
HELL-043	73.45	0.01	15.27	0.58	0.04	0.00	0.37	5.31	2.92	0.11	0.62	98.68
HELL-046	75.88	0.02	14.90	0.77	0.02	0.03	0.41	4.63	2.55	0.08	0.78	100.07
HELL-048	75.98	0.01	12.61	0.21	0.01	0.00	0.19	5.32	2.03	0.10	0.47	96.95
HELL-049	81.22	0.02	12.02	0.39	0.02	0.02	0.17	2.49	2.16	0.04	1.18	99.73
HELL-054	73.73	0.01	14.12	0.07	0.01	0.00	0.07	2.05	9.07	0.11	0.30	99.54
HELL-056	71.84	0.01	15.14	0.05	0.01	0.00	0.05	1.97	9.89	0.13	0.34	99.43
HELL-065	76.72	0.01	13.65	0.51	0.03	0.00	0.45	5.68	1.54	0.10	0.33	99.03
HELL-070	69.71	0.01	16.31	0.06	0.01	0.01	0.07	1.95	11.35	0.15	0.31	99.93
HELL-072	71.45	0.03	15.98	4.24	1.07	0.11	0.48	4.49	0.79	0.07	0.64	99.36
HELL-073	74.92	0.02	14.26	0.65	0.03	0.01	0.54	5.50	2.52	0.09	0.48	99.00
HELL-077	97.95	0.01	0.17	0.04	0.01	0.00	0.01	0.00	0.00	0.00	0.16	98.35
HELL-080	72.57	0.01	14.77	0.27	0.04	0.00	0.25	4.19	3.92	0.10	0.70	96.82
HELL-086	70.69	0.01	15.77	0.11	0.02	0.01	0.07	2.20	10.11	0.15	0.38	99.52
HELL-087	71.88	0.01	15.23	0.08	0.02	0.02	0.10	2.20	9.35	0.14	0.41	99.44
HELL-094	97.42	0.01	0.05	0.08	0.01	0.00	0.01	0.00	0.00	0.00	0.07	97.65
HELL-100	73.82	0.02	14.94	0.97	0.09	0.06	0.42	4.75	3.42	0.09	0.44	99.03
HELL-120	73.49	0.02	15.14	1.49	0.17	0.03	0.64	6.31	0.48	0.15	0.39	98.31
HELL-148	73.16	0.02	15.14	0.61	0.03	0.08	0.24	3.27	6.15	0.10	0.75	99.55
HELL-156	73.07	0.02	14.79	0.79	0.04	0.02	0.58	5.15	2.35	0.08	0.54	97.43

PROCESSING TESTS

Processing tests by CANMET on one representative potassium feldspar sample from Hellroaring Creek produced:

Product	Weight (%)
Slimes	14.2
Mica concentrate	3.2
Iron concentrate	0.2
Feldspar concentrate (magnetic)	1.4
Feldspar concentrate (non-magnetic)	59.9
Clean tails	1.9
Tails	19.4
Total	100.0

Chemical analysis of the non-magnetic feldspar concentrate is:

Major Oxides	Sample as Received (weight %)	Felspar Concentrate (weight %)
Fe_2O_3	0.06	0.05
MnO	<0.01	<0.01
Cr_2O_3	<0.01	<0.01
TiO_2	<0.01	<0.01
CaO	0.12	0.13
Na_2O	2.18	2.43
K_2O	9.67	12.82
P_2O_5	0.12	0.13
SiO_2	65.0	58.9
Al_2O_3	12.7	16.0
MgO	<0.05	<0.05
LOI	0.28	0.82

DISCUSSION

Processing tests indicate potential to produce mica and feldspar concentrates that meet industry standards with full liberation at 50 mesh.

TABLE A2
SPECTROGRAPHIC RESULTS, HELLROARING CREEK
(per cent)

Sample No.	Si	Al	Hg	Ca	Fe	Pb	Cu	Zn	Mn	Ag	V	Ti
HELL-012	>10	8.0	<0.1	<0.1	<0.1	-	0.03	-	<0.01	-	T	<0.01
HELL-014.5	>10	3.0	<0.1	<0.1	0.1	-	T	-	<0.01	-	T	<0.01
HELL-015	>10	7.0	<0.1	0.1	0.6	-	T	-	0.05	-	T	0.01
HELL-033	>10	7.5	0.1	0.12	1.1	-	T	-	0.03	-	T	0.02
HELL-043	>10	7.0	<0.1	0.15	0.3	-	T	-	0.02	-	T	0.01
HELL-046	>10	7.0	<0.1	0.15	0.5	-	T	-	<0.01	-	T	0.01
HELL-048	>10	7.0	<0.1	0.1	0.1	-	T	-	<0.01	-	T	<0.01
HELL-049	>10	6.5	<0.1	0.1	0.25	-	T	-	0.01	-	T	0.01
HELL-054	>10	7.0	<0.1	<0.1	<0.1	-	T	-	<0.01	-	T	<0.01
HELL-056	>10	7.5	<0.1	0.25	0.6	-	T	-	0.02	-	T	0.01
HELL-070	>10	5.5	<0.1	<0.1	<0.1	T	-	-	<0.01	-	-	<0.01
HELL-072	>10	8.0	0.25	0.3	2.0	-	T	-	0.35	-	T	0.03
HELL-073	>10	7.0	<0.1	0.25	0.25	-	T	-	<0.01	-	T	0.01
HELL-077	>>10	0.1	<0.1	<0.1	<0.1	-	-	-	<0.01	-	-	T
HELL-080	>10	7.0	<0.1	0.1	0.15	-	T	-	0.02	-	T	<0.01
HELL-086	>10	6.0	<0.01	<0.1	<0.1	-	T	-	<0.01	-	T	<0.01
HELL-087	>10	5.5	<0.1	<0.1	<0.1	T	T	-	<0.01	-	T	<0.01
HELL-094	>10	<0.1	<0.1	<0.1	<0.1	-	-	-	<0.01	-	-	T
HELL-100	>10	10.0	0.1	0.3	0.6	-	T	-	0.12	-	-	0.01
HELL-120	>10	8.5	<0.1	0.4	1.3	-	-	-	0.15	-	-	0.01
HELL-148	>10	9.0	0.1	0.15	0.4	T	T	-	0.01	-	-	0.01
HELL-156	>10	>10.0	<0.1	0.5	0.5	-	-	-	0.04	-	-	0.01

Sample No.	Ni	Co	Na	K	Ga	Zr	Sr	Y	Be	B	Mo	Sn	Cr	Yb
HELL-012	T	T	>2.0	>5.0	T	-	-	-	-	T	T	-	-	-
HELL-014.5	-	T	1.0	0.5	T	-	-	-	T	T	-	T	-	-
HELL-015	-	T	>2.0	0.8	T	-	-	-	T	0.25	-	-	-	-
HELL-033	-	T	>2.0	0.3	T	-	-	-	T	>0.5	-	T	-	-
HELL-043	-	T	>2.0	1.2	T	-	-	-	T	0.2	-	T	-	-
HELL-046	-	T	2.0	0.7	T	-	-	-	T	0.5	-	T	-	-
HELL-048	-	T	>2.0	1.0	T	-	-	-	T	T	-	T	-	-
HELL-049	-	T	1.5	0.8	T	-	-	-	T	T	T	T	T	-
HELL-054	-	T	>2.0	>5.0	T	-	-	-	-	T	-	T	-	-
HELL-056	-	T	>2.0	>5.0	T	-	-	-	-	T	-	T	-	-
HELL-065	T	T	>2.0	0.7	T	-	-	-	T	0.3	T	-	T	-
HELL-070	-	T	>2.0	>5.0	T	-	T	-	-	T	-	T	-	-
HELL-072	-	T	>2.0	0.5	T	T	-	T	T	>0.5	-	T	-	T
HELL-073	-	T	>2.0	>2.0	T	-	-	-	T	0.3	-	-	-	-
HELL-077	-	T	T	T	-	-	-	-	-	-	-	-	-	-
HELL-080	-	T	>2.0	>2.0	T	-	-	-	T	0.01	-	T	-	-
HELL-086	-	T	>2.0	>5.0	T	-	-	-	-	T	-	T	-	-
HELL-087	-	T	>2.0	>5.0	T	-	-	-	-	T	-	-	-	-
HELL-094	-	T	T	T	-	-	-	-	-	-	-	-	-	-
HELL-100	-	T	>2.0	>2.0	T	-	-	-	T	0.5	T	T	-	-
HELL-120	-	T	>2.0	<0.3	T	-	-	-	T	>0.5	-	-	-	-
HELL-148	-	T	2.0	>5.0	T	-	T	-	T	0.25	-	T	-	-
HELL-156	-	T	>2.0	>2.0	T	-	-	-	T	0.4	-	T	-	-

TABLE A3
X-RAY DIFFRACTION RESULTS, HELLROARING CREEK

Field No.	Minerals Identified
HELL-012	Microcline > albite
HELL-014.5	Quartz > > albite > > microcline > muscovite
HELL-015	Albite ~ quartz > > microcline > minor muscovite and tourmaline
HELL-033	Albite > quartz > > tourmaline (Fe-rich?) minor muscovite and K-feldspar
HELL-043	Albite > quartz > microcline > > minor muscovite and tourmaline
HELL-046	Albite ~ quartz > microcline > > minor muscovite and tourmaline
HELL-048	Albite > quartz > > microcline > > minor muscovite
HELL-049	Quartz > albite > > muscovite±trace K-feldspar
HELL-054	Microcline > quartz > albite > > trace illite and/or muscovite
HELL-056	Microcline > quartz > albite > > trace muscovite
HELL-065	Albite > quartz > microcline > > minor tourmaline and muscovite
HELL-070	Microcline > quartz > albite > > trace muscovite
HELL-072	Albite > quartz > > tourmaline > minor muscovite and trace K-feldspar
HELL-073	Albite > quartz > > microcline > > tourmaline > > trace muscovite
HELL-077	Quartz with trace feldspars±smectite
HELL-080	Albite ~ quartz > microcline > > muscovite
HELL-086	Microcline > quartz > albite > > trace muscovite
HELL-087	Microcline > quartz > albite > > trace muscovite
HELL-094	Quartz
HELL-100	Albite ≃ quartz > microcline > > tourmaline > minor muscovite
HELL-120	Albite > quartz > > tourmaline > minor muscovite±trace K-feldspar
HELL-148	Quartz ~ albite ~ microcline > > minor muscovite and tourmaline
HELL-156	Albite ~ quartz > > microcline > minor tourmaline and muscovite

Remarks:

(1) Tourmaline detected in this suite of rocks appears to be iron-rich.

TABLE B1
MAJOR ELEMENT XRF RESULTS, LUMBY (BEARCUB CLAIMS)

Field No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
BLUE-004	74.66	0.11	14.58	0.93	0.01	0.14	1.54	3.14	4.25	0.02	0.50	99.89
BLUE-012	73.13	0.02	16.23	0.60	0.10	0.03	2.93	4.31	2.34	0.03	0.28	99.99
BLUE-016	75.58	0.05	14.20	0.42	0.01	0.07	0.99	3.00	5.22	0.03	0.53	100.10
BLUE-022	74.04	0.05	14.81	0.47	0.04	0.11	0.91	2.86	5.49	0.02	0.51	99.30
BLUE-033	73.89	0.01	14.29	0.13	0.02	0.02	0.19	1.35	9.72	0.04	0.24	99.90
BLUE-034	75.33	0.05	13.86	0.51	0.02	0.11	1.07	2.76	5.86	0.03	0.26	99.86
BLUE-041	70.63	0.02	15.90	0.20	0.01	0.05	0.09	1.75	10.88	0.02	0.26	99.81
BLUE-043	77.47	0.02	13.48	0.26	0.00	0.01	3.80	3.21	0.18	0.05	0.38	98.86
BLUE-044	74.35	0.08	14.86	0.77	0.02	0.13	1.25	3.51	4.61	0.02	0.42	100.02
BLUE-047	71.60	0.01	16.09	2.03	0.53	0.06	1.66	4.70	2.83	0.03	0.22	99.76
BLUE-050	72.39	0.02	14.41	0.14	0.01	0.05	0.27	1.71	9.52	0.03	0.30	98.85
BLUE-052	74.77	0.06	15.34	0.74	0.05	0.09	1.94	4.74	1.39	0.03	0.50	99.53
BLUE-055	75.58	0.05	14.52	0.29	0.01	0.08	2.37	3.62	2.43	0.02	0.37	99.33
BLUE-057	74.68	0.15	14.90	0.94	0.02	0.21	1.41	3.22	2.92	0.02	0.85	99.32
BLUE-058	71.36	0.03	15.50	0.30	0.01	0.07	0.23	1.86	10.27	0.02	0.28	99.93
BLUE-062	71.89	0.03	15.60	0.42	0.05	0.06	0.41	2.44	8.60	0.03	0.27	99.80
BLUE-065	74.14	0.02	15.01	0.25	0.03	0.03	0.90	3.39	5.91	0.02	0.34	100.04
BLUE-095	72.83	0.03	15.81	0.19	0.01	0.03	0.47	2.24	8.00	0.02	0.52	100.16
BLUE-099	72.96	0.04	15.28	0.62	0.06	0.07	1.76	4.86	2.29	0.02	0.29	98.26
BLUE-106	73.52	0.05	15.50	0.49	0.01	0.12	0.95	3.30	5.00	0.04	0.59	99.57
BLUE-109	72.38	0.05	15.53	0.43	0.01	0.10	1.40	3.81	4.89	0.03	0.32	98.96
BLUE-111	73.89	0.08	15.67	0.65	0.01	0.10	4.31	3.35	1.06	0.01	0.71	99.84
BLUE-113	72.93	0.04	14.91	0.72	0.05	0.05	1.21	3.25	5.72	0.03	0.34	99.21
BLUE-117	74.20	0.08	15.13	0.57	0.02	0.12	0.97	2.74	5.38	0.02	0.58	99.81
BLUE-119	66.26	0.01	18.33	0.07	0.01	0.04	0.16	1.88	12.64	0.04	0.39	99.83
BLUE-127	82.37	0.04	10.65	0.13	0.00	0.03	4.26	0.85	0.10	0.02	0.54	98.99
BLUE-130	70.68	0.04	16.72	0.56	0.01	0.03	3.13	3.49	3.77	0.03	0.48	98.92
BLUE-137	72.93	0.03	14.32	0.65	0.01	0.04	0.40	2.42	8.21	0.04	0.38	99.43
BLUE-142	73.09	0.03	14.99	0.28	0.02	0.07	0.71	2.66	7.70	0.03	0.26	99.84
BLUE-146	72.37	0.03	14.96	0.25	0.01	0.06	0.13	1.61	10.04	0.03	0.47	99.96
BLUE-190	74.15	0.05	14.60	0.49	0.02	0.13	1.23	3.07	5.57	0.04	0.41	99.76
BLUE-191	76.30	0.05	15.09	0.83	0.11	0.12	1.10	2.40	2.72	0.03	0.83	99.59
BLUE-193	72.35	0.01	15.48	0.38	0.06	0.03	0.24	2.00	9.08	0.05	0.36	100.04
BLUE-196	74.03	0.06	15.41	0.60	0.01	0.11	1.16	3.49	4.59	0.03	0.60	100.09
BLUE-198	72.96	0.01	14.95	0.22	0.01	0.03	0.15	2.16	9.16	0.04	0.28	99.97
BLUE-215	71.40	0.01	15.42	0.14	0.01	0.03	0.14	1.61	10.35	0.02	0.25	99.38
BLUE-221	71.99	0.01	15.19	0.04	0.01	0.02	0.07	1.44	10.71	0.02	0.28	99.78
BLUE-224	75.22	0.03	15.21	0.43	0.08	0.04	1.57	4.55	2.54	0.02	0.38	100.07
BLUE-231	75.77	0.02	14.45	0.22	0.01	0.01	1.78	3.98	3.07	0.06	0.43	99.80
BLUE-234	75.24	0.05	15.25	0.78	0.09	0.08	1.45	4.48	2.05	0.02	0.64	100.13
BLUE-237	73.15	0.04	15.06	0.50	0.04	0.08	0.28	2.14	8.14	0.04	0.67	100.14
BLUE-239	73.99	0.07	15.40	0.90	0.05	0.12	1.50	4.61	2.80	0.03	0.48	99.95
BLUE-242	71.46	0.02	15.31	0.24	0.02	0.08	0.23	2.13	9.40	0.04	0.25	99.17
BLUE-263	77.72	0.05	11.86	0.39	0.01	0.09	1.37	2.74	3.59	0.05	0.40	98.27

PROCESSING TESTS

Processing tests by CANMET on one representative sample from Lumby produced:

Product	Weight (%)
+20 mesh	3.5
Slimes	14.0
Mica concentrate	5.3
Feldspar concentrate (magnetic)	0.4
Felspar concentrate (non-magnetic)	55.6
Tails	21.2
Total	100.0

The non-magnetic feldspar concentrate was analyzed with the following results:

Major Oxides	Sample as Received (weight %)	Feldspar Concentrate (weight %)
Fe_2O	0.14	0.06
MnO	<0.01	<0.01
Cr_2O_3	0.07	<0.01
TiO_2	<0.01	<0.01
CaO	0.21	0.25
Na_2O	2.03	2.60
K_2O	10.7	12.9
P_2O_5	0.02	0.02
SiO_2	65.1	62.2
Al_2O_3	13.9	17.5
MgO	<0.05	<0.05
LOI	0.21	0.19

DISCUSSION

Low iron content and acceptable potassium and alumina content indicate the Lumby pegmatite has good to very good potential to produce a high-quality potash feldspar with liberation of 20 mesh.

TABLE B2
X-RAY DIFFRACTION RESULTS, LUMBY

Field No.	Minerals Identified
BLUE-004	Quartz > plagioclase > > K-feldspar (20%?) > > minor biotite (≤5%)
BLUE-012	Quartz > plagioclase > > K-feldspar (15-20%?)
BLUE-014	Plagioclase > quartz > K-feldspar (20%?) > > trace biotite (3%?)
BLUE-016	Quartz > K-feldspar ~ plagioclase > > trace biotite (2%?)
BLUE-022	Quartz ~ K-feldspar > plagioclase > > minor biotite and muscovite (2-3% each?)
BLUE-033	K-feldspar (orthoclase?) ~ quartz > > minor plagioclase (10%?)
BLUE-034	Quartz > plagioclase ~ K-feldspar > > minor biotite (4%?)
BLUE-041	K-feldspar ~ quartz > plagioclase > > minor biotite (3%?)
BLUE-043	Quartz (60-65%?) > plagioclase (35-40%?) (oligoclase with An 25-30?)
BLUE-044	Quartz ~ K-feldspar > plagioclase > > minor biotite (5%?)
BLUE-047	Plagioclase ~ quartz > K-feldspar > > trace mica (≤2%)
BLUE-050	K-feldspar ~ quartz > > plagioclase (10%?) > > trace muscovite and/or illite (≤2%)
BLUE-052	Plagioclase > quartz > > minor K-feldspar, biotite (5% each?) trace muscovite
BLUE-055	Quartz > plagioclase > > K-feldspar (15%?) > > minor biotite (4%?)
BLUE-057	Quartz > plagioclase > > mica (~10% with muscovite > > biotite) > minor K-feldspar (5%?)
BLUE-058	K-feldspar (orthoclase) > quartz > > plagioclase (10-15%) > > trace biotite (2%?)
BLUE-062	Plagioclase > quartz > K-feldspar > > minor mica (mainly biotite) and chlorite (3% each?)
BLUE-065	Quartz > K-feldspar ~ plagioclase > > trace mica (mainly biotite) (2%?)
BLUE-095	Quartz > K-feldspar > plagioclase > > minor muscovite > trace biotite±amphibole
BLUE-099	Quartz > plagioclase > > K-feldspar > > minor biotite > trace muscovite (≤2%)
BLUE-106	Quartz > plagioclase > K-feldspar > > minor muscovite > trace biotite (≤2%?)
BLUE-109	Quartz > plagioclase K-feldspar > > minor biotite (3%?)
BLUE-111	Quartz > plagioclase > > minor K-feldspar (5-10%) > trace biotite, amphibole and chlorite (≤5% total)
BLUE-113	Quartz > K-feldspar ~ plagioclase > > minor biotite (â3%?)
BLUE-117	Quartz > plagioclase > K-feldspar > > minor muscovite (5%?) trace biotite (2%?)
BLUE-119	K-feldspar (orthoclase) > > minor plagioclase, quartz (≤10% each?) > > trace mica (%)
BLUE-127	Quartz > > plagioclase > > minor K-feldspar (5-10%) > trace calcite and illite (≤3% each?)
BLUE-130	Quartz > plagioclase > K-feldspar
BLUE-137	K-feldspar ~ quartz > plagioclase > > trace biotite (≤2%?)
BLUE-142	K-feldspar ~ quartz plagioclase > > trace biotite (2%?)
BLUE-146	K-feldspar > quartz > > plagioclase (10-15%) > > trace biotite (2%?)
BLUE-190	Quartz > plagioclase > K-feldspar > > minor biotite (5%?)±trace amphibole
BLUE-191	Quartz > plagioclase > > K-feldspar > minor muscovite, sillimanite (5% each?) > trace biotite and chlorite
BLUE-193	K-feldspar (orthoclase?) ~ quartz > > plagioclase (15-20%?) > > trace mica±chlorite (≤2% total)
BLUE-196	Quartz > plagioclase > K-feldspar > > minor biotite (4%) > trace muscovite±chlorite
BLUE-198	K-feldspar ~ quartz > plagioclase > > trace mica (with biotite > muscovite, total ~3%?)
BLUE-215	K-feldspar ~ quartz > > plagioclase (~10-15%) > > trace mica (mainly muscovite), amphibole±mixed-layer clay (≤5% total)
BLUE-221	K-feldspar (orthoclase?) > quartz > > plagioclase (~10%)±trace smectite
BLUE-224	Plagioclase (oligoclase?) > quartz > > K-feldspar (15-20%?) > > minor mica (mainly muscovite, 4%?)
BLUE-231	Quartz > plagioclase > K-feldspar > > trace mica (mainly muscovite, 2%?)±chlorite±mixed-layer clay
BLUE-234	Quartz ~ plagioclase > > K-feldspar (10-15%?) > minor muscovite (7%?)±trace illite
BLUE-237	K-feldspar ~ quartz > plagioclase > > trace muscovite, biotite and chlorite (2% each?)
BLUE-239	Plagioclase ~ quartz > > K-feldspar (15%?) > > minor biotite (4%?)
BLUE-242	K-feldspar (orthoclase) > quartz > > plagioclase (15-20%) > > trace biotite±illite±smectite (≤5 total)
BLUE-263	Quartz > plagioclase > K-feldspar > > trace mica±chlorite (≤2% total)

TABLE B3
SPECTROGRAPHIC RESULTS, LUMBY
(per cent)

Sample No.	Si	Al	Hg	Ca	Fe	Pb	Cu	Zn	Mn	Ag	V	Ti	Ni
BLUE-004	>10	9.0	0.1	1.2	1.0	T	-	-	0.01	-	T	0.08	-
BLUE-012	>10	7.0	0.03	2.5	0.5	T	T	-	0.1	-	T	0.01	-
BLUE-014	>10	7.0	0.1	1.2	0.5	T	T	-	<0.1	-	T	0.01	-
BLUE-016	>10	6.0	0.07	0.3	0.4	T	-	-	<0.1	T	T	0.02	-
BLUE-022	>10	8.0	0.07	1.0	0.45	T	T	-	0.03	-	T	0.05	-
BLUE-033	>10	7.0	0.1	<0.1	<0.1	T	T	-	0.03	-	T	0.01	-
BLUE-034	>10	8.0	0.1	0.5	0.6	T	T	-	0.01	-	T	0.03	-
BLUE-041	>10	5.0	0.02	<0.1	0.2	T	-	-	0.01	-	T	0.01	-
BLUE-043	>10	9.0	<0.1	3.0	0.25	-	T	-	0.01	-	T	0.01	-
BLUE-044	>10	8.0	0.12	1.0	0.8	T	T	-	0.01	-	T	0.06	-
BLUE-047	>10	8.5	0.1	1.5	2.5	T	T	-	0.2	-	T	<0.01	-
BLUE-050	>10	7.0	<0.1	0.1	0.1	T	T	-	0.01	-	T	<0.01	-
BLUE-052	>10	7.5	0.1	1.4	0.2	T	T	-	0.01	-	T	0.02	-
BLUE-057	>10	8.0	0.2	1.2	0.8	T	T	-	0.02	-	T	0.07	T
BLUE-058	>10	8.0	<0.1	<0.1	0.15	T	T	-	0.01	T	T	0.01	-
BLUE-062	>10	8.5	0.15	1.4	0.7	T	T	-	0.02	-	T	0.05	-
BLUE-065	>10	7.0	<0.1	0.25	0.15	T	T	-	0.04	-	T	0.01	-
BLUE-095	>10	7.0	0.03	0.2	0.2	T	T	-	<0.01	-	T	0.01	-
BLUE-099	>10	6.5	0.05	2.0	0.6	T	T	-	0.07	-	T	0.04	-
BLUE-106	>10	8.0	0.1	1.0	0.5	T	-	-	0.01	-	T	0.05	-
BLUE-109	>10	7.5	0.04	0.9	0.4	T	-	-	<0.01	-	T	0.03	-
BLUE-111	>10	7.0	0.04	6.0	0.5	T	T	-	<0.01	-	T	0.06	T
BLUE-113	>10	6.5	0.03	0.8	0.5	T	T	-	0.04	-	T	0.02	-
BLUE-117	>10	7.0	0.1	0.8	0.5	T	-	-	0.02	-	T	0.06	-
BLUE-119	>10	7.5	<0.01	<0.01	<0.01	0.02	T	-	<0.01	T	T	0.01	T
BLUE-127	>10	6.5	0.03	4.5	0.15	-	T	-	<0.01	-	T	0.02	-
BLUE-130	>10	7.0	0.01	3.5	0.5	T	T	-	<0.01	-	T	0.03	-
BLUE-137	>10	7.5	0.1	0.15	0.7	T	T	-	<0.01	-	T	0.01	-
BLUE-142	>10	8.5	0.1	0.3	0.3	T	T	-	0.01	-	T	0.01	-
BLUE-146	>10	7.5	0.1	<0.1	0.2	T	T	-	<0.01	-	T	0.01	-
BLUE-190	>10	8.0	<0.1	1.0	0.3	T	T	-	<0.01	-	T	0.01	-
BLUE-191	>10	9.0	0.1	1.0	0.7	-	T	-	0.12	-	T	0.02	-
BLUE-193	>10	8.0	<0.1	0.1	0.25	T	T	-	0.08	-	T	<0.01	-
BLUE-196	>10	10.0	0.1	1.0	0.35	T	T	-	0.01	-	T	0.03	-
BLUE-198	>10	7.0	<0.1	<0.1	0.1	T	T	-	<0.01	-	T	<0.01	-
BLUE-215	>10	9.0	<0.1	<0.1	0.1	T	T	-	0.02	-		0.01	-
BLUE-221	>10	7.5	<0.1	<0.1	<0.1	T	T	-	<0.01	-	T	<0.01	-
BLUE-224	>10	8.5	<0.1	1.2	0.25	T	T	-	0.1	-	T	0.02	-
BLUE-231	>10	8.0	<0.1	1.5	0.1	T	T	-	<0.01	-	T	0.01	-
BLUE-234	>10	9.0	0.1	1.2	0.5	T	T	-	0.09	-	T	0.02	-
BLUE-237	>10	8.0	<0.1	0.1	0.3	T	T	-	0.04	T	T	0.02	-
BLUE-239	>10	7.5	0.1	1.3	0.6	T	T	-	0.05	0	T	0.03	-
BLUE-242	>10	7.0	<0.1	0.12	0.1	T	T	-	0.01	-	T	<0.01	-
BLUE-263	>10	7.5	<0.1	1.0	0.15	T	T	-	<0.01	-	T	0.01	-

Sample No.	Co	Na	K	W	Ba	Ga	Zr	Sr	Y	Be	B	Mo	Yb	Th
BLUE-004	T	1.5	2.0	-	0.05	T	T	T	-	-	-	-	-	-
BLUE-012	T	>2.0	>2.0	-	T	T	T	T	T	T	-	-	-	-
BLUE-014	T	>2.0	>2.0	-	T	T	T	T	T	T	-	-	-	-
BLUE-016	T	1.5	>2.0	-	T	T	-	T	-	-	T	-	-	-
BLUE-022	T	1.7	>2.0	-	T	T	-	T	T	T	-	-	T	-
BLUE-033	T	1.5	>2.0	-	T	T	-	T	-	-	-	-	-	-
BLUE-034	T	2.0	>2.0	-	T	T	-	T	T	T	-	-	T	-
BLUE-041	T	1.6	2.0	-	0.03	T	-	T	-	-	-	-	-	-
BLUE-043	T	1.8	<0.3	-	-	T	T	0.06	-	T	-	-	-	-
BLUE-044	T	2.0	2.0	-	T	T	T	T	T	T	-	-	T	-
BLUE-047	T	>2.0	2.0	-	T	T	T	0.04	0.02	T	-	-	0.01	T
BLUE-050	T	2.0	>2.0	-	T	T	-	T	-	-	-	-	-	-
BLUE-052	T	>2.0	0.7	-	-	T	T	T	-	T	-	-	T	T
BLUE-055	T	>2.0	1.2	-	T	T	T	T	T	-	-	-	-	-
BLUE-057	T	1.9	1.0	-	T	T	-	T	T	-	-	-	-	-
BLUE-058	T	1.7	>2.0	-	0.03	T	-	T	-	-	-	-	-	-
BLUE-062	T	>2.0	>2.0	-	-	T	T	T	T	T	-	-	-	-
BLUE-065	T	1.9	>2.0	-	T	T	-	T	T	T	-	-	-	-
BLUE-095	T	1.5	>2.0	-	T	T	-	T	-	-	-	-	-	-
BLUE-099	T	>2.0	>2.0	-	T	T	-	T	T	T	-	-	-	-
BLUE-106	T	>2.0	>2.0	-	T	T	-	T	-	T	-	-	-	-
BLUE-109	T	2.0	>2.0	-	-	T	-	T	T	T	-	-	-	-
BLUE-111	T	>2.0	2.0	-	T	T	T	T	-	T	-	-	-	-
BLUE-113	T	>2.0	>2.0	-	0.02	T	T	-	T	T	-	-	-	-
BLUE-117	T	>2.0	>2.0	-	T	T	T	T	-	-	-	-	-	-
BLUE-119	T	>2.0	>2.0	-	T	T	-	T	-	-	-	-	-	-
BLUE-127	T	0.8	<0.3	-	-	T	-	T	T	-	-	-	T	-
BLUE-130	T	>2.0	>2.0	-	0.1	T	T	T	T	T	-	-	T	-
BLUE-137	T	1.7	>2.0	-	-	T	-	T	-	-	-	T	-	-
BLUE-142	T	2.0	>2.0	-	T	T	-	T	-	T	-	-	-	-
BLUE-146	T	1.5	>2.0	-	T	T	-	T	-	-	-	-	-	-
BLUE-190	T	>2.0	1.8	-	T	T	T	T	-	T	-	-	-	-
BLUE-191	T	>2.0	1.3	-	0.03	T	T	T	-	T	-	-	-	-
BLUE-193	T	2.0	>2.0	-	T	T	T	T	-	-	-	-	-	-
BLUE-196	T	>2.0	2.0	-	T	T	T	T	T	T	-	-	T	-
BLUE-198	T	>2.0	>2.0	-	-	T	-	T	-	T	-	-	-	-
BLUE-215	T	>2.0	>2.0	-	T	T	-	T	-	-	-	T	-	-
BLUE-221	T	1.8	>2.0	-	T	T	-	T	-	-	-	-	-	-
BLUE-224	T	>2.0	1.5	-	-	T	-	-	T	T	-	-	T	-
BLUE-231	T	>2.0	2.0	-	-	T	-	T	T	T	-	-	T	-
BLUE-234	T	2.0	1.0	-	-	T	-	T	T	T	-	-	T	-
BLUE-237	T	1.8	>2.0	-	-	T	-	T	T	T	-	-	T	-
BLUE-239	T	>2.0	1.2	-	-	T	T	T	T	T	-	-	T	-
BLUE-242	T	2.0	>2.0	-	-	T	-	T	-	-	-	-	-	-
BLUE-263	T	2.0	1.5	-	0.03	T	-	T	-	T	-	-	-	-

TABLE C1
COPPER MOUNTAIN - SPECTROGRAPHIC REPORT

Sample/ Element	016	034	037	041	045	055	066	077	081	103
Si	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10
Al	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10
Mg	<0.1	0.1	0.1	0.1	0.1	<0.1	0.2	0.1	0.1	0.1
Ca	0.1	1.2	0.1	0.2	0.3	0.1	0.35	0.2	0.1	0.25
Fe	0.9	0.4	0.2	0.2	0.3	0.15	0.2	0.2	0.4	0.2
Cu	T	T	T	T	T	T	T	0.02	0.03	T
Zn	T	-	-	-	-	-	-	-	-	-
Mn	0.06	0.02	0.01	0.01	0.02	0.01	0.02	<0.01	<0.01	0.01
Ag	T	-	-	-	-	-	-	-	-	-
V	T	T	T	T	T	T	T	T	-	T
Ti	0.03	0.1	0.03	0.05	0.09	0.03	0.15	0.1	0.1	0.1
Co	T	T	T	T	T	T	T	T	T	T
Na	>2	>2	>2	>2	>2	>2	T	>2	>2	>2
K	>2	1.9	1.8	>2	>2	2	>2	>2	>5	>2
Ba	T	0.04	T	0.12	0.12	T	1.0	0.1	0.15	0.05
Ga	T	T	T	T	T	T	T	T	T	T
Zr	T	T	T	T	T	T	T	T	T	0.05
Sr	-	T	-	T	T	-	T	0.05	0.03	T
Be	T	T	-	T	T	-	T	-	-	T
B	T	T	T	T	T	T	T	T	T	T
Mo	T	-	-	-	-	-	-	-	-	-

TABLE C2
MAJOR ELEMENT XRF RESULTS, COPPER MOUNTAIN

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
CUMT-016	62.49	0.17	19.67	1.19	0.06	0.09	0.29	5.72	7.55	0.01	1.12	98.35
CUMT-034	61.70	0.33	19.71	0.43	0.04	0.12	1.93	6.57	5.41	0.06	2.26	98.56
CUMT-037	64.06	0.38	20.05	0.22	0.01	0.06	0.49	6.21	6.56	0.00	1.05	99.10
CUMT-041	64.52	0.24	19.70	0.34	0.02	0.09	0.49	4.25	9.94	0.00	1.27	100.86
CUMT-045	64.24	0.32	20.33	0.26	0.01	0.07	0.38	5.17	7.91	0.00	1.18	99.89
CUMT-055	65.29	0.32	20.18	0.21	0.01	0.00	0.40	6.55	6.47	0.00	0.81	100.25
CUMT-066	63.27	0.47	20.98	0.30	0.03	0.13	0.74	8.49	2.80	0.02	1.37	98.60
CUMT-077	62.52	0.27	19.35	0.31	0.02	0.03	0.39	6.48	6.21	0.01	0.81	96.40
CUMT-081	64.74	0.32	19.86	0.51	0.02	0.08	0.18	4.54	9.02	0.01	1.05	100.32
CUMT-103	64.05	0.27	20.38	0.36	0.01	0.05	0.50	6.89	5.62	0.00	1.22	99.34
DOL-1*	62.86	0.35	20.41	0.35	0.01	0.20	1.20	4.87	7.35	0.35	0.59	-
DOL-2*	61.84	0.10	19.35	1.03	0.03	0.54	1.06	6.07	7.12	0.17	0.76	-
MON-1**	64.29	0.45	19.44	0.16	0.02	0.37	0.65	2.72	9.51	0.00	1.41	-

**Adapted from Dolmage (1934)*

***Adapted from Montgomery (1967)*

TABLE C3
MINOR ELEMENT XRF RESULTS, COPPER MOUNTAIN

Sample No.	Cr ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm
CUMT-016	15±9	126±6	303±4	23±2	184±3	10±4
CUMT-034	17±9	81±6	1075±15	27±2	212±3	12±4
CUMT-037	10±9	91±6	1080±15	182	1433	2±4
CUMT-041	19±9	163±6	984±13	222	1503	7±4
CUMT-045	19±9	122±6	1370±19	202	1433	6±4
CUMT-055	16±9	86±6	1457±21	202	1336	4±4
CUMT-066	13±9	30±6	1507±22	19±2	39±2	-4±4
CUMT-103	15±9	75±6	1010±15	15±2	255±4	-4±4

TABLE C4
X-RAY DIFFRACTION RESULTS, COPPER MOUNTAIN

CUMT-077	Albite > > K-Feldspar > > minor to trace Quartz and Muscovite
CUMT-081	Albite ~ = K-Feldspar (Microcline?) > > minor to trace Quartz and Muscovite

TABLE D1
X-RAY DIFFRACTION RESULTS, KRUGER MOUNTAIN

NEP-001	K-Feldspar > Albite ≃ Amphpbole (Ferrohastingsite?) > minor Biotite
NEP-002	Albite ≃ Quartz > K-Feldspar (Microcline)
NEP-002.1	Albite > Quartz > K-Feldspar (Microcline?) > minor Amphibole (Ferrohastingsite)±trace Biotite

TABLE D2
SPECTROGRAPHIC RESULTS, KRUGER MOUNTAIN

Sample/ Element	NEP-001	NEP-002	NEP-002.1
Si	>10	>10	>10
Al	9.0	6.5	7.5
Mg	2.0	0.1	0.2
Ca	7.0	0.1	1.2
Fe	8.0	0.4	2.5
Cu	T	-	-
Mn	0.2	0.01	0.08
V	T	-	T
Ti	0.2	0.01	0.1
Ni	T	-	-
Co	T	T	T
Na	>2.0	2.0	>2.0
K	>2.0	>2.0	>2.0
Ba	0.2	-	T
Ga	T	T	T
Zr	T	-	T
Sr	0.5	T	0.01
Y	T	-	-
Be	-	T	-
B	T	T	T
Sc	T	-	-

TABLE D3
MAJOR ELEMENT XRF RESULTS, KRUGER MOUNTAIN

SAMPLE NO.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
NEP-001	49.55	0.94	15.13	11.33	0.24	3.65	9.16	2.91	4.68	0.75	0.79	99.13
NEP-002	74.04	0.08	14.27	0.65	0.02	0.07	0.87	3.71	5.91	0.02	0.21	99.86
NEP-002.1	69.77	0.25	14.31	2.44	0.08	0.60	2.02	3.86	4.79	0.08	0.21	98.40

TABLE E1
SPECTROGRAPHIC REPORT, MOUNT COPELAND
UNIT A1

Sample/ Element	005	007	008	009	010	026	027	028
Si	10	10	10	10	10	10	10	10
Al	8.0	9.0	10.0	10	10.0	10.0	8.0	9.0
Mg	0.5	0.6	0.2	0.8	0.6	0.3	0.15	0.2
Ca	1.9	1.5	1.7	1.2	1.8	1.8	1.3	1.7
Fe	5.0	3.2	2.2	3.8	3.5	3.2	3.0	3.0
Pb	-	-	-	T	-	-	-	-
Cu	-	-	-	T	T	T	-	-
Zn	-	T	T	T	T	T	T	T
Mn	0.2	0.2	0.09	0.19	0.11	0.07	0.09	0.08
Ag	-	-	-	-	-	-	-	-
V	0.01	0.01	0.01	0.01	0.01	T	T	T
Ti	0.25	0.02	0.02	0.18	0.22	0.20	0.19	0.22
Ni	-	-	T	T	-	T	-	T
Co	T	T	T	-	-	-	T	-
Na	2.0	2.0	5.0	5.0	2.0	5.0	5.0	5.0
K	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
W	-	-	-	-	-	-	-	-
Ba	0.08	0.06	0.06	0.09	0.1	0.03	T	T
Ga	T	T	T	T	T	T	T	T
Zr	0.04	0.04	0.06	0.04	0.03	0.04	0.03	0.07
Sr	0.04	0.08	0.07	0.04	0.05	0.07	0.02	0.05
Y	T	T	0.01	T	0.01	0.03	0.02	0.03
Be	T	T	T	T	T	T	T	T
B	-	-	-	-	-	-	-	-
Mo	-	-	-	-	T	-	-	-
Yb	-	-	T	-	T	T	T	T
Nb	-	-	-	-	T	T	T	T
Th	-	-	-	-	-	T	T	T
La	-	-	-	-	-	T	T	T
Nd	-	-	-	-	-	0.02	-	0.02
Ce	-	-	-	-	-	0.06	T	0.06

TABLE E2
MOUNT COPELAND - SPECTROGRAPHIC REPORT
UNIT A3

Sample Element	012	014	023	024	029	035	036	043	045	057	058	064	065
Si	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10
Al	>10	9.0	7.0	>10	9.0	9.0	>10	9.5	>10	10.0	10.0	10.0	>10
Mg	0.15	0.3	0.1	0.2	0.4	0.1	0.3	0.15	0.4	0.4	0.25	0.4	0.7
Ca	<1	0.1	1.1	1.5	2.4	0.3	2.0	1.6	1.7	1.5	1.0	1.2	1.6
Fe	2.7	3.5	1.5	1.7	3.5	0.4	1.9	1.8	2.7	2.0	1.8	2.6	2.4
Pb	-	T	-	-	-	T	T	-	-	T	T	T	T
Cu	-	-	T	0.02	-	-	-	-	-	-	-	-	-
Zn	T	T	T	T	T	T	T	T	T	T	T	T	T
Mn	0.08	0.25	0.08	0.08	0.1	0.01	0.13	0.05	0.12	0.15	0.06	0.12	0.17
Ag	-	-	-	-	-	-	-	-	-	-	-	-	-
V	T	T	T	T	0.01	T	T	T	T	T	T	T	T
Ti	0.1	0.2	0.17	0.19	0.2	0.01	0.24	0.23	0.21	0.09	0.07	0.17	0.15
Ni	-	T	-	-	T	-	T	T	T	T	T	T	T
Co	T	-	T	T	T	T	T	T	T	T	T	T	T
Na	>2.0	2.0	>5.0	>5.0	>5.0	>2.0	>5.0	>5.0	>5.0	>5.0	>2.0	>5.0	>2.0
K	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0
W	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	0.1	0.04	T	0.03	T	0.02	T	T	0.05	0.05	0.05	0.05	0.05
Ga	T	T	T	T	T	T	T	T	T	T	T	T	T
Zr	0.02	0.05	0.02	0.03	0.05	T	0.06	0.08	0.03	0.04	0.05	0.04	0.05
Sr	0.04	0.06	T	0.06	0.05	T	0.15	0.07	0.2	0.2	0.07	0.12	0.15
Y	T	T	T	0.02	0.03	-	0.02	0.01	T	T	T	T	T
Be	T	T	-	T	T	-	-	-	T	T	T	T	T
B	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	-	-	-	-	-	-	-	-	-
Yb	-	-	-	T	T	-	T	T	-	T	-	-	T
Nb	T	T	T	-	T	-	-	-	-	-	-	-	-
Th	-	-	-	T	T	-	T	T	T	-	-	-	-
La	-	-	-	T	T	-	T	T	T	T	T	T	T
Nd	-	-	-	0.01	0.02	-	T	-	-	-	-	-	-
Ce	-	-	-	0.03	0.12	-	T	T	-	-	-	-	-

Sample/ Element	066	067	068	069	071	072	073	077	081	083	084	085	100
Si	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10
Al	9.5	>10	10.0	10.0	10.0	>10	9.0	>10	10.0	>10	>10	>10	5.5
Mg	0.4	0.1	0.6	0.3	0.2	0.5	0.3	0.25	0.9	0.2	0.6	0.4	3.5
Ca	1.3	1.2	1.9	1.3	1.7	1.6	2.0	1.8	1.0	1.5	2.0	2.0	>10
Fe	2.8	2.2	2.5	2.4	2.5	2.4	2.6	2.5	2.7	2.7	4.0	3.0	7.0
Pb	T	-	T	T	-	-	-	-	T	-	T	T	T
Cu	T	T	T	T+	-	-	-	T	T	-	-	-	-
Zn	T	T	T	T	T	T	T	T	T	T	-	T	T+
Mn	0.16	0.11	0.12	0.17	0.06	0.04	0.08	0.07	0.1	0.07	0.15	0.1	0.3
Ag	-	-	-	-	-	-	-	-	-	-	-	-	-
V	-	T	T	T	T	T	T	T	T	T	T	T	T
T	-	-	-	-	-	-	-	-	-	-	-	-	-
Ti	0.22	0.2	0.22	0.19	0.22	0.22	0.23	0.21	0.24	0.20	0.17	0.18	0.24
Ni	T	T	T	T	T	T	T	T	T	T	-	T	T
Co	T	T	T	T	T	T	T	T	T	T	T	T	T
Na	>5.0	>5.0	>2.0	>5.0	>2.0	>2.0	>5.0	5.0	>2.0	>5.0	>2.0	>5.0	>2.0
K	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	>5.0	5.0	>5.0	>5.0	>5.0	>5.0	>2.0
W	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	0.06	T	0.15	0.1	T	T	T	T	0.2	T	0.4	0.01	0.03
Ga	T	T	T	T	T	T	T	T	T	T	T	T	T
Zr	0.04	0.12	0.02	0.06	0.05	0.07	0.08	0.06	0.06	0.05	0.02	0.17	0.018
Sr	0.19	0.07	0.25	0.18	0.08	0.24	0.16	0.15	0.25	0.15	0.12	0.15	T
Y	T	T	T	T	0.01	T	0.02	0.02	T	0.02	0.01	0.01	T
Be	T	T	T	T	-	T	T	T	T	T	T	-	T
B	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	-	-	-	-	-	-	T	-	-
Yb	T	-	-	-	T	-	T	T	-	T	T	T	T
Nb	-	-	-	-	-	-	-	-	-	-	-	-	-
Th	-	-	-	-	T	T	T	T	-	T	-	-	-
La	T	T	T	T	T	T	T	T	-	T	T	-	-
Nd	-	-	-	-	T	T	T	T	-	T	-	-	-
Ce	-	-	-	-	T	T	T	T	-	T	-	-	-

TABLE E3
X-RAY DIFFRACTION REPORT, MOUNT COPELAND
UNIT A1

COPE-005	Orthoclase > > Albite ≃ Aegirine-Augite > Nepheline > minor Amphibole trace Mica, Chlorite±Magnetite
COPE-007	Orthoclase > > Albite > Nepheline >/= Amphibole > minor Biotite, Analcite and trace Magnetite
COPE-008	Orthoclase > > Nepheline > Albite > Amphibole > > trace Magnetite
COPE-009	Orthoclase > Albite ≃ Biotite > Nepheline > minor Analcite > trace Amphibole±Magnetite
COPE-010	Orthoclase > > Albite ≃ Nepheline > Aegirine-Augite > minor Analcite and trace Magnetite and Amphibole
COPE-026	Orthoclase > > Albite > Analcite > Muscovite > Minor Aegirine-Augite and Calcite
COPE-027	Orthoclase > Nepheline > Albite > minor Aegirine-Augite and Andradite(?)
COPE-028	Orthoclase > Analcime > Albite ≃ Muscovite > minor Aegirine-Augite and Calcite

TABLE E4
MOUNT COPELAND - X-RAY DIFFRACTION REPORT AND COMMENTS
UNIT A3

COPE-012	Orthoclase > Albite > > Muscovite > trace Magnetite. Minor amorphous alteration product appears to be present also
COPE-014	Orthoclase > > Albite > > Muscovite > minor Geothite and amorphous alteration material
COPE-023	Orthoclase > > Nepheline > Albite > > minor Aegerine-Augite and Titanium-bearing Andradite(?)
COPE-024	Orthoclase > Nepheline >/= Albite > minor Aegirine-Augite and trace Analcite±Cancrinite
COPE-029	Orthoclase > Nepheline > Albite/Oligoclase >/= minor Aegirine-Augite and Andradite(?)
COPE-035	Orthoclase ≃ Albite > > minor Biotite
COPE-036	Orthoclase > > Albite > Nepheline > minor Biotite, Calcite > trace Aegerine-Augite and Magnetite
COPE-043	Orthoclase > > Nepheline > Albite >/= Aegirine-Augite > > trace Titanium-rich Andradite(?)
COPE-045	Orthoclase >Albite > Nepheline >/= Analcite minor Aegirine-Augite, Hornblende > trace Magnetite and Illite
COPE-057	Orthoclase >/= Albite > > Nepheline > minor Hornblende (Sodium and Iron rich)
COPE-058	Orthoclase ≃ Albite > Biotite±trace Aegirine-Augite
COPE-064	Orthoclase > Albite > Hornblende >/= Nepheline
COPE-065	Orthoclase > > Albite >/= Biotite > minor Nepheline and Calcite
COPE-066	Orthoclase > > Albite > Hornblende > Nepheline > > trace Biotite
COPE-067	Orthoclase > Albite > Nepheline > Aegerine-Augite > trace Chlorite
COPE-068	Orthoclase > Albite > Nepheline ≃ Hornblende > > trace Andradite(?)
COPE-069	Orthoclase > Albite > > Nepheline > Aegirine-Augite > > trace Hornblende
COPE-071	Orthoclase > > Nepheline >/= Albite >/= Aegirine-Augite > > trace Magnetite and Titanium-rich Andradite(?)
COPE-072	Orthoclase > > Albite >/= Analcite > Muscovite >/= Aegirine-Augite and Calcite
COPE-073	Orthoclase > > Nepheline > Albite > minor Aegirine-Augite, Titanium-bearing Andradite±trace Scapolite(?)
COPE-077	Orthoclase > > Albite >/= Nepheline > Aegirine-Augite minor Titanium-bearing Andradite, Analcite, Biotite±Cancrinite
COPE-081	Orthoclase > Albite > Biotite > > minor Calcite
COPE-083	Orthoclase > > Nepheline > Albite > minor Aegirine-Augite and Titanium-rich Andradite(?)
COPE-084	Orthoclase > > Albite > Nepheline ≃ Hornblende > > trace Analcite±Augite
COPE-085	Orthoclase > Albite > Nepheline > Biotite ≃ Calcite > > trace Analcite
COPE-100	Aegirine-Augite ≃ Orthoclase ≃ Albite > > minor Hornblende±trace Sphene

TABLE E5
MAJOR ELEMENT XRF RESULTS, MOUNT COPELAND
UNIT A1

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
COPE-005	53.89	0.84	17.27	8.21	0.24	0.53	2.66	4.39	9.67	0.01	0.67	98.37
COPE-007	57.11	0.50	19.88	4.33	0.21	0.45	1.51	4.56	9.19	0.02	1.16	98.92
COPE-008	54.95	0.45	21.67	3.42	0.09	0.25	1.76	6.21	9.18	0.01	0.74	98.73
COPE-009	51.30	0.47	24.38	4.98	0.21	0.75	1.06	6.76	8.02	0.02	2.11	100.05
COPE-010	53.99	0.58	20.84	5.42	0.15	0.46	1.97	5.52	9.00	0.05	1.27	99.27
COPE-026	53.04	0.59	23.24	3.67	0.10	0.25	2.84	3.35	8.92	0.00	4.17	100.17
COPE-027	52.61	0.66	23.16	3.62	0.10	0.21	2.17	8.76	8.23	0.00	0.39	99.92
COPE-029	52.20	0.71	23.07	3.91	0.10	0.26	1.99	5.16	7.94	0.00	4.71	100.04

TABLE E6
MAJOR ELEMENT XRF RESULTS, MOUNT COPELAND
UNIT A3

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
COPE-012	57.95	0.20	23.77	3.07	0.08	0.12	0.04	2.94	10.14	0.00	1.71	100.02
COPE-014	57.49	0.52	20.93	5.18	0.28	0.25	0.13	2.74	9.53	0.01	2.18	99.24
COPE-023	54.09	0.55	23.11	2.26	0.09	0.12	2.48	7.72	9.02	0.01	0.64	100.10
COPE-024	53.79	0.54	23.00	2.28	0.07	0.21	1.81	7.85	9.30	0.00	0.61	99.45
COPE-029	53.33	0.86	21.35	3.37	0.10	0.19	3.26	7.88	8.79	0.00	0.56	99.70
COPE-035	63.53	0.10	20.52	0.84	0.04	0.15	0.88	4.06	9.23	0.01	0.39	99.75
COPE-036	53.33	0.64	20.57	4.18	0.17	0.27	3.64	5.52	7.77	0.03	2.27	98.39
COPE-043	53.32	0.62	22.06	3.54	0.08	0.21	2.31	8.26	8.42	0.00	0.78	99.60
COPE-045	55.85	0.53	20.52	4.53	0.16	0.29	2.26	6.20	7.97	0.05	1.33	99.70
COPE-057	56.65	0.49	20.59	4.37	0.20	0.18	1.84	6.60	8.03	0.03	0.67	99.64
COPE-058	61.26	0.27	20.65	2.54	0.14	0.29	1.03	4.48	8.56	0.01	0.81	100.05
COPE-064	57.02	0.52	20.35	4.63	0.24	0.37	1.55	6.47	7.84	0.02	0.47	99.47
COPE-065	55.46	0.38	20.23	4.48	0.30	0.86	2.39	4.60	8.42	0.03	2.49	99.63
COPE-066	56.43	0.69	19.94	5.42	0.29	0.29	1.90	6.19	7.69	0.02	1.06	99.23
COPE-067	55.48	0.39	21.59	3.82	0.19	0.16	1.87	7.57	7.49	0.01	0.71	99.27
COPE-068	56.43	0.56	19.16	4.96	0.23	0.37	2.50	5.39	7.85	0.04	1.01	98.50
COPE-069	57.42	0.47	20.07	4.42	0.26	0.19	1.50	6.61	8.13	0.03	0.48	99.58
COPE-071	54.16	0.68	20.06	4.96	0.14	0.31	3.20	7.06	8.20	0.00	0.55	99.33
COPE-072	53.43	0.61	22.87	3.63	0.08	0.29	2.22	3.88	8.69	0.00	3.47	99.17
COPE-073	53.65	0.77	20.98	3.57	0.11	0.16	3.20	7.90	8.73	0.01	0.51	99.59
COPE-077	53.64	0.68	21.08	3.35	0.12	0.19	2.91	6.31	8.84	0.00	2.28	99.41
COPE-081	59.34	0.88	19.23	4.41	0.22	0.52	1.50	4.46	7.98	0.07	1.00	99.62
COPE-083	52.40	0.61	22.72	3.81	0.11	0.32	2.72	8.38	8.20	0.00	0.38	99.64
COPE-084	57.45	0.65	19.66	5.10	0.22	0.34	2.46	4.27	8.77	0.06	0.66	99.62
COPE-085	51.36	0.48	21.99	3.53	0.14	0.19	3.53	6.71	8.29	0.04	3.22	99.49
COPE-100	56.63	0.76	7.61	9.27	0.67	5.48	9.61	4.57	3.38	0.06	0.77	98.81

TABLE F1
MAJOR ELEMENT XRF RESULTS, TRIDENT MOUNTAIN

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
TRI87-001	63.70	0.05	20.73	0.52	0.01	0.08	1.20	8.35	3.12	0.03	0.24	98.03
TM5-3A*	56.66	0.02	24.36	0.17	0.01	0.05	0.59	8.16	8.22	0.00	0.99	99.23
TM5-3G*	55.59	0.04	24.69	0.59	0.01	0.07	0.56	8.39	7.98	0.02	1.55	99.49

**Sampling and analysis by Pell (1986).*

TABLE F2
TRIDENT MOUNTAIN - SPECTROGRAPHIC REPORT

Element	TRI-001
Si	>10
Al	8
Mg	0.1
Ca	1.0
Fe	0.4
Pb	T
Cu	-
Zn	-
Mn	0.01
Ag	-
V	T
Ti	0.02
Ni	-
Co	T
Na	>5
K	>2
W	-
Ba	0.1
Ga	-
Zr	-
Sr	0.02
Y	-
Be	T
B	-
Mo	-

TABLE F3
X-RAY DIFFRACTION REPORT, TRIDENT MOUNTAIN

TRI-001 Albite > > K-Feldspar > > minor Biotite

TABLE G1
YELLOW LAKE PHONOLITE - SPECTROGRAPHIC REPORT

Sample/ Element	C	001	002	003	004	005	006	007	008	008.1	009	010	011
Si	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10
Al	10	9.0	9.5	10.0	>10	>10	>10	10	9.0	>10	10.0	10.0	8.0
Mg	0.5	1.4	1.0	1.2	1.3	0.6	1.0	2.0	0.7	1.2	2.5	1.3	2.8
Ca	0.7	2.6	1.6	1.4	2.0	2.5	2.4	2.8	1.0	2.0	7.0	3.0	5.0
Fe	2.5	5.0	4.0	4.5	3.5	3.7	3.4	4.0	3.5	3.5	6.0	4.0	6.0
Pb	T	T	T	T	T	T	T	T	T	T	T	T	T
Cu	T	T	T	T	T	T	T	T	T	T	T	T	T
Zn	-	-	-	-	-	T	-	-	-	-	-	-	-
Mn	0.09	0.1	0.12	0.07	0.1	0.09	0.08	0.1	0.08	0.08	0.09	0.1	0.1
Ag	-	-	-	-	-	T	T	-	-	-	T	T	-
V	T	T	T	T	T	T	T	T	T	T	T	T	T
Ti	0.1	0.18	0.17	0.16	0.18	0.17	0.18	0.2	0.16	0.18	0.2	0.2	0.25
Ni	-	T	-	T	T	-	T	T	-	T	T	T	T+
Co	T	T	T	T	T	T	T	T	T	T	T	T	T
Na	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0
K	>5.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0
W	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	0.12	0.2	0.25	0.3	0.25	0.2	0.35	0.25	0.25	0.3	0.25	>0.25	>0.25
Ga	T	T	T	T	T	T	T	T	T	T	T	T	T
Zr	T	T	T	T	T	T	T	T	T	T	T	T	T
Sr	0.08	0.15	0.12	0.1	0.12	0.07	0.25	0.2	0.18	0.18	0.25	0.5	0.5
Y	T	T	T	T	T	T	T	-	T	T	T	T	T
Be	T	T	T	T	T	T	T	T	T	T	T	T	-
Sn	T	-	-	-	-	-	-	-	-	-	-	-	-
Cr	-	T	-	T	T	T	T	-	-	T	-	T	T
La	-	-	-	-	-	-	-	-	-	-	-	T	T
Nd	-	-	-	-	-	-	-	-	-	-	-	-	T
Se	-	-	-	-	-	-	-	-	-	-	-	T	T
P	-	-	-	-	-	-	-	-	-	-	-	T	T

TABLE G2
YELLOW LAKE PHONOLITE - MAJOR ELEMENT XRF RESULTS

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_20 %	P_2O_5 %	LOI %	SUM %
C	64.67	0.58	16.01	3.30	0.09	0.86	1.46	4.23	6.27	0.14	1.20	98.81
001	50.72	0.86	17.21	6.70	0.12	2.99	5.46	4.22	4.58	0.83	3.63	97.33
002	52.99	0.81	18.88	5.39	0.13	2.01	3.78	4.14	4.76	0.49	4.58	97.96
003	53.06	0.87	17.74	6.02	0.07	2.49	2.39	4.74	4.95	0.69	7.16	100.18
004	52.30	0.87	18.04	5.96	0.12	2.41	2.89	5.86	4.74	0.69	4.85	98.72
005	54.56	0.77	17.47	5.91	0.10	1.39	4.17	3.19	5.25	0.44	5.24	98.46
006	53.00	0.82	18.42	5.13	0.09	2.11	3.61	4.34	6.97	0.56	3.46	98.84
007	49.41	0.93	16.26	6.65	0.11	3.60	4.82	3.68	5.52	0.90	4.64	96.50
008	53.61	0.79	19.49	5.40	0.11	1.60	2.26	4.44	4.46	0.41	5.29	97.85
008.1	52.32	0.74	18.61	5.48	0.10	2.35	4.12	3.21	5.42	0.53	4.76	97.64
009	48.95	0.88	14.55	6.42	0.10	4.79	8.47	3.05	4.64	0.97	6.88	99.70
010	52.92	0.86	18.06	5.90	0.09	2.64	4.41	4.43	4.92	0.82	3.97	98.93
011	50.07	0.96	13.63	6.93	0.11	5.11	6.43	3.37	5.24	1.02	1.79	94.66

TABLE G3
YELLOW LAKE PHONOLITE - X-RAY DIFFRACTION RESULTS

C	Albite > / = Orthoclase > / = Quartz > > minor Chlorite±Aegirine-Augite±trace of Calcite
001	Sanidine > > Aegirine-Augite > minor Analcite, Phillipsite(?), Phlogopite±trace Chlorite/Vermiculite, Orthoclase and Tridymite(?)
002	Sanidine (Sodium rich) > > Aegirine-Augite > / = Analcite > minor Alkali Amphibole, Phlogopite,±Albite±Phillipsite(?)
003	Sanidine > / = Analcite > > Nontronite > / = minor Aegirine-Augite, Orthoclase > trace Mica and Phillipsite
004	Analcite > / = Sanidine > > â Aegirine-Augite, > / = minor Orthoclase > Biotite±trace Amphibole and Albite
005	Sanidine > Albite > Quartz > / = Fe Dolomite > minor Biotite, Kaolinite > trace Hematite, Calcite and Siderite
006	Sanidine > Orthoclase > Aegirine-Augite > / = Analcite > minor Tetranatrolite $[Na_2(Al_2Si_3)O_{10} \cdot 2H_2O]$ > Biotite > trace Chlorite and Albite; Amorphous material is probably also present
007	Analcite > / = Orthoclase > / = Sanidine > Aegirine-Augite > minor Biotite > trace Tetranatrolite, Chlorite±Albite; Amorphous material is probably also present
008	Albite > > Orthoclase > Smectite (Nontronite?) > minor Illite, Calcite±Hematite
008.1	Orthoclase > / = Sanidine = Albite > minor Analcite, Aegirine-Augite > trace Calcite, Smectite±Chlorite; Amorphous material is also present
009	Orthoclase = Albite > = Calcite > Chlorite > minor to trace Smectite, Quartz, Augite, Apatite and Siderite
010	Albite > Orthoclase > > Calcite > / = minor Chlorite±Augite > trace Mica, Apatite and/or Siderite
011	Albite > / = Orthoclase > Augite > / = minor Hematite, Smectite > trace Biotite and Calcite; Amorphous material is probably present

TABLE H1
BOUNDARY CREEK, MAJOR ELEMENT XRF RESULTS

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
LEUC-001	72.00	0.11	15.44	1.12	0.08	0.18	1.80	4.01	3.07	0.03	0.57	98.41
LEUC-002	69.31	0.42	16.87	2.00	0.01	0.55	1.89	4.35	4.45	0.09	0.41	100.35

TABLE H2
SPECTROGRAPHIC ANALYSES

Sample No.	Si	Al	Hg	Ca	Fe	Pb	Cu	Zn	Mn	Ag	V	Ti	Ni	Co	Na	K	W	Ba	Sr	Be	Mo	Cr
LEUC-001	>10	7.5	0.15	1.8	1.0	-	T	-	0.1	T	T	0.05	-	T	>2.0	>2	-	0.2	0.01	T	T	T
LEUC-002	>10	7.5	0.5	1.9	1.8	-	-	-	0.01	-	T	0.13	-	T	>2	>2	-	0.25	0.1			

TABLE H3
X-RAY DIFFRACTION REPORT

LEUC-001	Quartz > Plagioclase (Oligoclase?) > K-Feldspar > > minor Biotite ± trace Chlorite
LEUC-002	Plagioclase > Quartz > K-Feldspar > > minor Biotite > trace Chlorite

TABLE I1
SUMAS MOUNTAIN - MAJOR ELEMENT XRF RESULTS

Oxides	Weight %
Al_2O_3	15-18
Na_2O	~8
Fe_2O_3	0.15-0.40

TABLE I2
SUMAS MOUNTAIN - X-RAY DIFFRACTION RESULTS

Sumas-041	Quartz > Albite; trace Chlorite
Sumas-042	Quartz > Albite; trace Chlorite

TABLE I3
SUMAS MOUNTAIN - SPECTROGRAPHIC RESULTS

Sample No.	Si	Al	Mg	Ca	Fe	Pb	Cu	Zn	Mn	Ag	V	Ti	Ni	Co	Na	K	W	Zr	Sr	Y
Sumas-041	>>10	8.5	0.2	0.5	0.4	-	T	-	0.06	-	-	0.12	-	T	>2.0	<0.3	-	T	-	T
Sumas-042	>>10	7.0	0.1	0.4	0.15	-	T	-	0.04	-	-	0.1	-	T	>2.0	<0.3	-	T	-	T

TABLE J1
MAJOR ELEMENT XRF RESULTS - SCUZZY CREEK

Sample No.	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	P_2O_5 %	LOI %	SUM %
Site 1												
023	76.90	0.10	14.53	0.70	0.10	0.21	2.77	4.44	0.49	0.02	0.52	100.69
058	74.65	0.09	14.59	0.63	0.01	0.16	2.89	4.60	0.44	0.02	0.42	98.50
080	74.09	0.10	15.40	0.60	0.01	0.16	3.05	4.84	0.48	0.03	0.50	99.28
Site 2												
200	46.60	0.08	14.43	0.53	0.02	0.17	2.81	4.59	0.46	0.02	0.48	100.18
Site 4												
004	73.75	0.12	14.74	0.76	0.01	0.25	2.87	4.69	0.49	0.02	0.71	98.43

TABLE J2
SCUZZY CREEK - SPECTROGRAPHIC RESULTS

Sample/	Site 1			Site 2	Site 4
Element	023	058	080	200	004
Si	>10	>10	>10	>10	>10
Al	>10	>10	>10	8.0	8.5
Mg	0.1	0.2	0.15	0.1	0.12
Ca	1.8	2.5	2.0	1.4	1.5
Fe	0.5	0.7	0.4	0.4	0.6
Pb	-	-	-	-	-
Cu	T	-	-	-	-
Zn	-	-	-	-	-
Mn	<0.1	<0.1	<0.1	<0.1	<0.1
Ag	-	-	-	-	-
V	T	T	T	-	-
Ti	0.04	0.05	0.03	0.02	0.3
Ni	-	-	-	-	-
Co	0.02	0.02	0.02	T	T
Na	>2.0	>2.0	>2.0	>2.0	>2.0
K	>0.3	>0.3	>0.3	>0.3	>0.3
W	-	-	-	-	-
Ba	0.03	0.1	0.06	T	T
Ga	T	T	T	T	T
Zr	T	T	T	T	T
Sr	T	T	T	0.04	0.05
Y	-	-	-	-	-
Be	-	-	-	-	T
B	-	-	-	-	-
Mo	-	-	-	-	-

TABLE J3
X-RAY DIFFRACTION RESULTS - SCUZZY CREEK

SITE 1	
023*	Plagioclase > Quartz > > trace Mica ± Amphibole and others
058*	Plagioclase > Quartz > > minor Mica and others
080*	Plagioclase > Quartz > > trace Mica and others
SITE 2	
200	Quartz > Albite ? (Oligoclase) > > minor K-Feldspar, Mica and Amphibole
SITE 4	
004	Albite? (Oligoclase) > Quartz > > trace Muscovite, Chlorite and Amphibole

**Plagioclase in these samples appears to be Oligoclase with An ~ = 24 mole per cent.*

APPENDIX II

APPENDIX II
LISTING OF FELDSPAR AND NEPHELINE SYENITE OCCURRENCES FROM MINFILE

MINFILE #	Name	NTS	Commodity
Pegmatites (feldspar as a commodity)			
082LSW109	Tappen Creek Little Shuswap Silver Star	82L/6E	feldspar
092B 111	Peg	92B/12W	beryl feldspar
092HSW127	Hope	92H/6W	feldspar
092HNW067	Coquihalla	92H/11E	mica feldspar silica
092ISW086	Lytton	92I/4E	feldspar
092P 153	Timothy Mtn.	92P/14E	feldspar mica silica
093K 094	Casey Pegmatite	93K/3E	feldspar mica silica
093N 189	Wolverine Range	93N/16W	feldspar mica garnet
094C 092	Jackpine Blackpine Lake	94C/6W	feldspar
Nepheline Syenite (as a commodity)			
082ENE066	Franklin Camp	82E/9W	neph. syen.
082M 170	Frenchmans Cap	82M/8W	neph. syen.
082N 080	Sullivan River	82N/13W	neph. syen.
082N 081	Solitude Mtn.	82N/13E	neph. syen.
082N 082	Bush River	82N/14W	neph. syen.
083D 027	Lempriere	83D/6E	neph. syen.
083D 043	Howard Creek Carbonatite	83D/7W	neph. syen. strontium zirconium rare earths phosphate
092INE164	Mt. Lolo	92I/16E	neph. syen.
092P 154	Rayfield River	92P/6E	neph. syen. feldspar
093L 261	Lewes River Gail GMGW	93L/1W	titanium neph. syen.
093L 262	Parrot Lake	93L/2E	neph. syen.

104B 123	Zippa Zip	104B/11W	neph. syen. feldspar titanium
Nepheline Syenite (as a lithology)			
082M 077	Trident Creek	82M/16E	niobium uranium thorium
082M 126	Mt Neptune	82M/16W	kyanite
082N 027	Bow Demon Moose Creek	82N/1W niobium	titanium thorium rare earths
082N 028	Waterloo Colti	82N/1W	silver lead zinc
093A 008	Cariboo-Bell Mount Polley Bootjack Lake	93A/12E gold	copper
093A 086	Bayshore B.I., Key	93A/12E	copper

APPENDIX III

APPENDIX III
GLOSSARY

adularia - potash feldspar ($KAlSi_3O_8$), low temperature, mixed crystallography.

aegirine - any pyroxene intermediate between augite and acmite which displays the characteristic green pleochroism.

alaskite - holocrystalline, granular, leucocratic granite containing orthoclase, microcline, subordinate quartz, few to no mafics, may contain plagioclase. In industry may refer to muscovite granite.

albite - plagioclase feldspar (0-10% An), triclinic.

alkali - referring to a rock sufficiently rich in sodium and potassium that it shows an agpaitic mineral, but contains no feldspathoid.

alkaline - applied to a rock containing either a modal or normative feldspathoid.

alumina - Al_2O_3, several crystalline forms, melts at 2040°C, insoluble in H_2O, native alumina - corundum; hydrated forms-gibbsite, diaspore, boehmite; silica combinations - clays, feldspars, kyanite; purified alumina, hydrated - native bauxites, laterites.

aluminum hydrate - $Al_2O_3 \cdot 3H_2O$, artificially produced, ~65% Al_2O_3, used in glass when low alkalis and low iron desired.

andesine - plagioclase feldspar (30-50% An), used in glass and ceramics.

anorthosite - plutonic rock composed almost wholly of plagioclase of anorthite composition.

aplite - commercially mined in Virginia as a low-cost alumina source, mixes easily and thoroughly (despite relatively high iron content).

beneficiation - any process by which valuable minerals are concentrated.

borolanite - melanite-rich nepheline syenite.

bytownite - plagioclase feldspar (70-90% An), triclinic, not used commercially.

clay - product of decomposition and alteration of feldspathic rocks.

comminution - crushing, grinding, screening and classifying to liberate mineral compounds.

corundum - natural crystalline oxide of aluminum, Al_2O_3 (ruby and sapphire are gem varieties).

cullet - crushed or powdered glass, collected and recycled with raw materials of new glass batch (10-30% used); promotes in melting, may affect viscosity.

devitrification - solid state transformation from a glass to a crystalline mineral.

elaeolite - (=elaeolith), obsolete name for nepheline.

essexite - nepheline-bearing mesocratic rock with subequal amounts of plagioclase and orthoclase. In the literature this term can be found to apply to nearly all intermediate to basic intrusive members of the alkali basalt family.

feldspar - most common mineral in crystalline rocks (*see* various types). The main groups are alkali feldspars: 'K-spar' or potassium feldspar; $KAlSi_3O_8$, and plagioclase feldspars: $NaAlSi_3O_8$ (albite) to $CaAl_2Si_2O_8$ (anorthite). Industrial mineral used as a source of aluminum and alkalis mainly in glass and ceramic industries.

feldspathoid - any alkali aluminosilicate with an O/Si ratio greater than 3:1, whether or not other ions are present.

fillers - finely ground, generally inert mineral substances used in the manufacture of many products to reduce the consumption of more costly raw materials and to modify physical properties.

flint - crystalline quartz, used in pottery to reduce shrinkage.

flux - any material that lowers the melting temperature of another material or material mixture (antonym of 'refractory').
- substance which promotes wetting and spreading or enhances fluidity and manipulative properties of material in joining, fusion and smelting operations.

frit - N.: material of which glass is composed; a semifused stoney mass.
V.: to partly fuse

fusion range - temperature range at which a material is in a liquid state.

glass enamel - vitrifiable glass colours - finely powdered mixtures of low-melting flux and calcined ceramic pigment.

glaze - homogeneous, thin silicate mixture fused on surface of clay body - 'glass' in physical and chemical nature.

glaze stain - prepared calcined ceramic pigments, mixed with glaze before applied to ware - gives uniform colour.

graphic texture - (syn: runic texture), regular intergrowth of quartz and feldspar.

haüyne - the sulphatic member of the sodalite group, approximately $(Na,Ca)AlSiO_4(Na_2S,Na_2SO_4)$. Typically a volcanic mineral.

ijolite - a plutonic rock consisting of approximately equal amounts of nepheline and pyroxene.

iron oxides - Fe ferrous oxide, Fe_2O_3 ferric oxide (hematite, Fe_3O_4 ferrous ferric oxide (magnetite); in glass raw materials, iron produces yellow, green or blue colours, used in whiteware glazes and body stains in the production of tan and brown colours, in porcelain enameling iron oxide scale on base metals produces blisters and shivering and can cause severe defects.

juvite - nepheline syenite with potash feldspar very predominant over soda feldspar.

kaolin (china clay) - type of clay, fires to white colour pyrometric cone equivalent (PCE) 34-35.

kyanite - $Al_2O_3 \cdot SiO_2$, ~50-60% Al_2O_3, source of alumina, but high iron content restricts use to low-alkali glasses.

labradorite - lime soda feldspar, approximately 53% SiO_2, 30% Al_2O_3, 13% CaO, 4% Na_2O, tr. H_2O.

Lasca-grade - high purity silica.

leucite - $KAlSi_2O_6$, psuedo-isometric, found in potassium-rich volcanic rocks (phonolite).

leucocratic - containing 0-30% dark minerals, colour index between 0 and 30; light coloured, usually igneous rocks.

litchfieldite - a nepheline syenite composed of albite with smaller amounts of potassium feldspar, nepheline, biotite, cancrinite and sodalite. Name by Bayley, 1892 from Litchfield, Maine; use not recommended.

malignite - iron-rich nepheline syenite with colour index between 50 and 90.

melanocratic - mela-, colour index between 60 and 100 for the rock; containing between 60 and 100% dark minerals; dark coloured, especially of igneous rocks.

mesh - grain size measurement, = number of openings in a 1" screen (18 mesh = 1 mm = boundary between very coarse and coarse sand on Wentworth scale).

mesocratic - intermediate in colour between leucocratic and melanocratic, containing between 30 and 60% dark minerals.

microcline - K-feldspar ($KAlSi_3O_8$), triclinic.

monzonite - granular plutonic rock intermediate between syenite and diorite (approximately equal amounts of orthoclase and plagioclase), quartz % by volume, hornblende, diopside, mica common with accessory apatite, zircon, sphene, opaque oxides.

nepheline - feldspathoid, ideally $NaAlSiO_4$, but all natural nepheline contains potassium in solid solution. Nepheline from plutonic rocks has more potassium, whereas that from volcanic rocks is richer in sodium.

nephelinite - a volcanic rock essentially composed of roughly equal amounts of nepheline and mafic silicate minerals.

nosean - a feldspathoid mineral of the sodalite group $Na_8Al_6Si_6O_{24}(SO_4)$, grey, blue or brown, related to haüyne, syn noselite.

oligoclase - triclinic soda-lime feldspar.

orthoclase - potassium feldspar ($KAlSi_3O_8$), monoclinic.

pegmatite - exceptionally coarse grained irregular dikes found especially at the margins of a batholith, being usually the last and most hydrous portion of magma to crystallize, may contain unusual mineral assemblages.

perthite - exsolution of potassium and sodium feldspar in a crystal (50% Or).

phonolite - extrusive equivalent of nepheline syenite, principal mineral is soda orthoclase or sanidine.

pyrometric cone equivalent (PCE) - test of refractory properties of a material, a method of designating fusion points.

sanidine - potassium feldspar ($KAlSi_3O_8$), monoclinic, high temperature.

shonkinite - melanocratic syenite, augite and orthoclase are principal minerals, often contains small amount of nepheline.

sillimanite - $Al_2O_3 \cdot SiO_2$, 50-60% Al_2O_3, source of alumina but high iron content restricts use to low-alkali glasses.

sodalite - $NaAlSiO_4 \cdot NaCl$, a feldspathoid often distinguished by blue or green colour but may be grey. Common in nepheline syenite, less so in phonolite and certain basic rocks. Generally the 'sodalite' group consists of sodalite, nosean, haüyne and lazurite.

sussexite - nepheline syenite porphyry with nepheline phenocrysts.

syenite - a rock composed essentially of potash feldspar and lacking quartz.

vitrification - formation of a glass, syn: vitrifaction.

Source of glossary:

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