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A STUDY OF MARKETS FOR BRITISH COLUMBIA'S NEPHELINE SYENITE AND FELDSPATHIC MINERALS

prepared for the

PROVINCE OF BRITISH COLUMBIA

under the

CANADA/BRITISH COLUMBIA MINERAL DEVELOPMENT AGREEMENT

by

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EXECUTIVE SUMMARY

- The objective of this study is to evaluate potential markets for feldspar, nepheline syenite and other feldspathic materials to be produced in British Columbia, Canada.

- Feldspar, nepheline syenite and other feldspathic minerals are sources of alumina (Al_2O_3), which acts as a flux in the manufacturing of glass and fiberglass and in ceramics, such as whiteware for kitchens and bathrooms. About 60% is used in glass, another 35% in ceramics and 5% in small, miscellaneous uses.

- The only North American source, and the major world source of nepheline syenite, is in Ontario where one company produces approximately 500,000 tons per year. The major North American sources of feldspar are in the eastern United States, with North Carolina accounting for 70% of total production of about 700,000 tons per year. Other North American production occurs in some other eastern states, southern California and Mexico.

- Feldspar and nepheline syenite are freight sensitive, with freight from eastern suppliers to western consumers significantly exceeding the f.o.b. cost of the material at the producing plant. For example, the price of nepheline syenite is between US$21 - $30, per ton f.o.b. Ontario and freight to western provinces or states is about US$70.00 per ton.

Therefore, a producer of feldspar or nepheline syenite in British Columbia would enjoy a freight advantage in western markets over eastern producers of both materials and also over southern California or Mexican suppliers of feldspar.

- The regional market area coneisting pf Western Provinces, Pacific Northwest States and Northern California consumes approximately 25,000 short tons per year of nepheline syenite, all of which is derived from Ontario. A British Columbian source should attain the overwhelmingly largest share of this tonnage.

- Feldspathic sand, consisting of a silica sand and feldspar mixture, is used in large quantities in the western states for glass making. In order to supplant feldspathic sands there would have to be a eource of a relatively high grade silica sand and a source of alumina, such as feldspar or nepheline syenite. A large international company is evaluating the importation of silica sand to various west coast ports. If this movement commences it is estimated that about 33,000 tons per year of feldspar or 26,000 tons per year of nepheline syenite could be marketed in the Western Provinces, Pacific Northwest and Northern California.

- There is internationel trade for feldspar and nepheline syenite and other feldspathic minerals in the Pacific Basin. Due to the favorable location of British Columbia in relation to countries such as Japan and South Korea, it is estimated that about 26,000 tons per year could potentially be exported to Pacific Basin countries. If a portion of the consumption in

Japan of aplite, another form of feldspathic mineral, could be penetrated by British Columbia materials it is estimated another 45,000 tons per year could be penetrated.

- There are additional markets in southern California, other western states, Oklahoma and Texas. Given the correct technical characteristics, favorable freight rates and currency exchange rates, feldspathic materials from British Columbia could selectively attain some tonnage from these more remote market regions.

- British Columbia has at least ten deposits of feldspathic minerals that can potentially be used in the manufacturing of glass and ceramics.

- Depending on the technical characteristics of the deposits, establishment of freight rates and effective sales and marketing procedures, markets of 25,000 tons per year to over 100,000 tons per year are potentially attainable.

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OBJECTIVE

To evaluate potential markets for feldspar, nepheline syenite and other feldspathic materials to be produced in British Columbia, Canada.

DEFINITIONS

USES

Feldspar and nepheline syenite are used in the manufacture of container glass, fiberglass and specialty glass, for example dinner ware and souvenirs, however, it is not utilized in flat glass, such as window glass. It is also used in making ceramics, for instance whiteware for bathroom and kitchen fixtures and for wall and floor tiles. Other lower volume items are those produced by potters, schools and hobbyists.

PURPOSE Feldspar and nepheline syenite and other feldspathic materials contain alumina (Al_2O_3) which acts as a flux and lowers the temperature at which the glass or ceramic melt must be fired. They also stabilize the final products and may assist in removing deleterious chemicals from the raw materials batch.

FELDSPARS

The feldspars are a group of minerals that are composed of anhydrous aluminum silicates in combination with one or more chemical base elements (sodium, potassium, calcium, etc.). One of these base elements dominates the characteristics of any one feldspar and identifies its commercial importance.

The two most important feldspars from a commercial viewpoint are:

Potassium Feldspar - 10% or higher potash (K_2O) content

Sodium Feldspar - 7% or higher soda (Na_2O) content

Mineralogy:

Potassisum feldspar is also called K-spar. The two potassium feldspars are orthoclase, which crystallizes in the monoclinic form, and microcline, a triclinic form. Both have the theoretical composition of $KAlSi_3O_8$. Microcline grades into albite, a sodium feldspar (see below), through an intermedite phase, termed perthite.

Sodium feldspar is also called soda-spar. Calcium feldspar is of less importance commercially but is mineralogically associated with sodium feldspar. Sodium and calcium feldspar are members of the plagioclase family of feldspars. Albite, $NaAlSi_3O_8$, is the pure sodium plagioclase feldspar. Anorthite, $CaAl_2Si_2O_8$, is the pure calcium plagioclase feldspar. All plagioclase feldspars are triclinic.

In between these two members of the plagioclase family is a continuous series of other feldspars with varying percentages of

both sodium and calcium. Albite would consist of 100% albite and 0% anorthite. The other members of the family are: Oligoclase- 70% to 90% albite and 10% to 30% anorthite; Andesine - 50% to 70% albite and 30% to 50% anorthite; Labradorite - 30% to 50% albite and 50% to 70% anorthite; Bytownite - 30% to 10% albite end 70% to 90% anorthite and Anorthite with 0% albite and 100% anorthite.

NEPHELINE SYENITE

Syenite is a coarse- to medium-grained igneous rock resembling granite in appearance but it is different in composition. The greatest difference from granite is that syenite is crystallized from a magma deficient in silica, so, little or no quartz is present. It may contain minor amounts of muscovite mica. However, it is mainly composed of feldspar minerals and nepheline.

Nepheline is a feldspathoid mineral with the theoretical composition of $NaAlSiO_4$. However, almost always it has some potassium associated with it so a more realistic formula for the mineral is $(Na,K)AlSiO_4$. Its crystal form is hexagonal.

The combined term "nepheline syenite" identifies an igneous syenitic rock that has a particularly high content of the mineral nepheline. Therefore, nepheline syenite fits the category of being an "industrial mineral" but is, in fact, composed of a rock and a mineral. Commercial deposits of nepheline syenite contain at least 20% nepheline and at least 60% feldspar.

PHONOLITE

Phonolite is an extrusive igneous rock of the trachyte family that contains a large quantity of orthoclose feldspar and nepheline. It is the volcanic counterpart to the intrusive, nepheline syenite. The name comes from the fact that it has a ringing sound when struck.

ALASKITE

Alaskite is an intrusive igneous rock consisting of approximately the following composition: plagioclase feldspar-45%; microcline feldspar - 20%; quartz - 25% and muscovite mica-10%. Grain sizes average from 0.25 to 0.50 inches. The intrusive bodies are remarkably homogeneous and quite large, with individual bodies measuring up to two miles acroes. Production is confined to North Carolina in the United States and is extemely important commercially to that area.

APLITE

A generic term for a group of igneous rocks that are characteristically sugary in texture. The variety of importance commercially to this study is closely related to granite and consists mainly of sodium/calcium feldspars and quartz. Depending on the occurrence, alumina content can vary from just over 10% up to almost 20%. North American production is in the state of Virginia. Japan is the largest producer with several hundred thousand tons per year, although the grade is lower than that produced in the United Stetes.

LEUCOCRATIC

This is a term applied to igneous rocks consisting mainly of light-colored minerals, namely, quartz, feldspars and white micas.

FELDSPATHIC SAND

Feldspathic sands, as the name implies, are mixtures of feldspars and quartz. Because they are available locally and higher grade deposits of silica sand and feldspars are not available, they are used widely in western North America. However, the sands tend to be high in iron, a deleterious material when making glass. And, the alumina content is erratic, varying from less than 5% to over 10%, which makes the formulation of a standard glass batch extremely difficult.

Commercial operations of feldspathic sands in North America are almost entirely confined to the more westerly provinces and states. The state of Oklahoma produces these sands as does the province of Alberta. However, most feldspathic sand production is along the Pacific coast and extends from British Columbia through Washington and Oregon to southern California.

Utilization of feldspathic sands in this region is due to the fact that there are few high quality silica sand deposits near the west coast and relatively limited production of feldspars and no nepheline syenite production. In the United States, one high quality silica sand producer is in northern California and one in southern Nevada. There is also one relatively small producer of good quality silica sand in British

Columbia. Therefore, consumers purchase feldspathic sands because they are close to point of use and economical. The character of the sands are acceptable for the darker shades of container glass but cannot be used for making flat glass, such as window glass. Given any choice most glass manufacturers would prefer to use a high quality quartz sand for its high silica and low iron content and feldspars or nepheline syenite for the alumina source.

GLASS AND CERAMICS

As noted above under "Uses", nepheline syenite, feldspars and other feldspathics are used to make glass and ceramics. There are certain critical factors that affect the utilization of feldspathic minerals and rocks in the manufacture of glass and ceramics.

One factor that all manufacturers value highly is consistency of feed in their raw materials. Therefore, they will often pay a premium for matetials that do not fluctuate greatly. As noted above, the content of Al_2O_3 in feldspathic sands in the west is extremely variable and is difficult to batch in a glass plant. A reliable supply of consistent quality nepheline syenite or feldspars combined with a consistently low iron silica sand is the ideal feed for glass and ceramic batches.

At one time, feldspars were acquired by hand cobbing, i. e., hand sorting of relatively coarse-sized raw material. Now, all feldspars and aplite are processed and upgraded by crushing, grinding and flotation. Nepheline syenite is upgraded by

crushing, grinding, magnetic separation and milling. All materials are subjected to some form of classification to acquire the proper particle sizes.

Ceramics require a fine-sized particle. Therefore, feldspars and nepheline syenite are ground to minus 200 mesh for ceramic uses. Glass, on the other hand, requires coarser grain sizes with the top size being from minus 20 mesh to minus 40 mesh. There is also a minimum size for glass, usually in the range of 100 mesh to 140 mesh, with very minor quantities permitted below 200 mesh.

Substitution amongst the various alumina materials is common in the glass industry. The manufacturer can switch from feldspars to nepheline syenite to aplite to feldspathic sands, etc. This is not done casually because the glass batch must be adjusted to each new raw material. However, the glass producer will eventually use the lowest priced source of alumina that will meet the required specificatons. In ceramics, the varions aluminas that are the subject of this report also compete in some instances with clays. But, for the most part, substitution amongst the various aluminas is less common in ceramics than in glass.

CONVERSION OF WEIGHTS AND MEASURES

In any study involving international commodities, such as feldspar and nepheline syenite, and production/consumption in various countries the problem arises as to whether to use English or metric measurements. The practice of giving preference to one

measurement and placing the alternative immediately following in parentheses has proven cumbersome and distracting. Therefore, the format chosen for this report is to use the measurement that is appropriate to the information or data and provide for conversions by the reader as follows:

tonne = metric ton

ton = short ton

1 metric tonne = 1.1 short tons

1 long ton = 1.02 metric tonnes or 1.12 short tons

1 mile = 1.6 kilometers

mesh = number of openings in a one-inch screen

1 millimeter (mm) = 16 mesh

200 mesh = consistency of table sugar

325 mesh = consistency of body powder

MARKET AREAS

Feldspar and nepheline syenite are utilized throughout the world. However, as might be expected, principal usage is in the more developed countries and in particular those regions of developed countries that are most industrialized. As will be discussed in detail later, North American production is located in Ontario, in the eastern states of the United States, along with South Dakota, southern California and Mexico.

Feldspar and nepheline syenite are materials that are "freight sensitive", meaning that transportation costs are a significant portion of the delivered costs to consumers, with freight often exceeding the f.o.b. cost of the material. The product from a feldspar or nepheline syenite mine is, of course, most competitive when utilized nearer to the point of origin. Therefore, the further east and south the material is shipped, deposits in British Columbia will have more difficulty in competing. But, the deposits in British Columbia will enjoy advantages in the western provinces of Canada and the Pacific northwest states as well as some other western states. The deposits are also well-situated to compete in Pacific Basin markets.

With these factors in mind the following provinces, states and countries were identified as offering the best geographical potential for market penetration and comprise the "market areas"

of this report. The more industrialized entities within this geographical context are the best prospective areas.

Canada - British Columbia, Alberta, Saskatchewan and Manitoba.

United States - Washington, Oregon, California, Idaho, Montana, Utah, Colorado, New Mexico, Arizona, Oklahoma and Texas.

Countries - Japan, Korea, Taiwan, Thailand, Malaysia and Australia.

WORLD PRODUCTION AND SUPPLY

Feldspar is produced by at least 40 countries. In contrast, nepheline syenite is produced commercially only in Canada and Norway. The U.S.S.R. produces some nepheline syenite for domestic usage. There is the possibility of some smaller future production in the southeastern United States.

CANADA

As yet, Canada has no significant production of feldspar. But, there are potential producers, for example the deposits in British Columbia that are addressed in this study.

Canada is the world's largest producer of nepheline syenite. Production is derived from the Blue Mountain nepheline syenite mine near Nephton in Methuen Township, Peterborough County, some 110 miles northeast of Toronto, Ontario. Up until 1985 there were two operating companies at the site, Indusmin, a division of Falconbridge, Ltd. and International Mineral and Chemicals. IMC's operations were purchased by Indusmin in 1985 which gives them a monopoly on nepheline syenite production in North America.

The nepheline syenite is a uniform foliated fine- to medium-grained rock composed of 20% to 25% nepheline, 48 to 54% albite feldspar and 18% to 23% microcline feldspar. Characteristic accessory minerals, which rarely total more than 6%, include 0.2% to 0.6% magnetite, 0 to 4% biotite, 0 to 3% hastingsite and 0 to 2% muscovite.

After selective mining in an open pit, the nepheline syenite is upgraded to low-iron and high-iron glass grades and to ceramic grades by primary crushing, drying, screening, high-intensity magnetic separation and pebble-milling. For ultra-fine grades, used as a filler in paints, plastics, etc., fluid energy mills and air classification are used.

Annual production capacity at Nephton is 750,000 tons. Actual production rates in recent years have been between 60% and 75% of capacity, mainly due to slack market conditions in the glass industry. Tonnage and value for past production is shown in enclosed Table II.

UNITED STATES

There is no commercial production of nepheline syenite in the U.S.A at present. Production of feldspar exceeds 700,000 tons per year. Hand-cobbed ore is minimal and is not nearly as important as flotation concentrates, which contribute more than two-thirds of production. North Carolina produces about 70% of United States production and five other states contribute smaller quantities, mainly from the east. Production in the west is from southern California and South Dakota.

A feldspar and silica mixture, called feldspathic sand, is produced in the western states and as far east as Oklahoma. This product is a major source of feldspar equivalent in the west, particularly for container glass and fiberglass production and is discussed in more detail below under "Western North American-Markets - Feldspathic Materials".

North Carolina

The major source of feldspar production in the state is in the Spruce Pine District covering parts of Avery, Mitchell and Yancey counties. Production is based on alaskite, a granitic rock characterized by alkali feldspars, quartz and mica. A typical composition is:

Oligoclase feldspar	40%
Microcline feldspar	20%
Quartz	25%
Muscovite mica	15%

Feldspar mining in the Spruce Pine District began with the exploitation of pegmatites, but, alaskite has the advantage of massive reserves with uniform mineralogy which lends itself to large-scale mining techniques and flotation processing. Flotation allows three products to be derived from alaskite-feldspar, silica and mica. There is little waste.

The three basic co-products are each further processed into various grades. Because all the operations are based on alaskite ore, the three producers - Feldspar Corp., IMC Corp. and Indusmin, Inc. - all employ similar processing technology and produce similar grades of the three co-products.

Feldspar Corp. is the largest producer of feldspar in the United States with major production facilities in North Carolina as well as in Connecticut, Georgia and Virginia. Combined capacity is 300,000 tons per year of soda/potash feldspar (180,000 tons per year capacity), silica sand and mica from the Chalk Mountain Mine and the Wiserman Mine in Mitchell County, which feeds two processing plants with a combined capacity of

265,000 tons per year. The difference between mine and plant capacity is primary processing at the mine.

Unimin Corp. has feldspar production in the Spruce Pine District based at the Hawkins Mine in Mitchell County. Capacity is thought to be about 125,000 tons per year. Unimin Corp. also bought the Harris Mining Co's. mine and plant near Spruce Pine. This operation, based on the weathered portion of the alaskite, produces kaolin, mica and silica sand. Of importance from the feldspar standpoint is that the company has shown indications that they are exploring for feldspar reserves.

Indusmin Ltd., a subsidiary of Falconbridge of Canada, bought Lawson United Feldspar and Mineral Co. in 1977. The company operates the Pine Mountain Mine and Buna Mine, both in Mitchell County. Capacity appears to be around 125,000 tons per year. The operations producing feldspar in North Carolina coupled with their massive production of nepheline syenite in Ontario enables Indusmin to effectively supply feldspathic materials in the large consuming areas of southern, northeastern and midwestern markets of the United States as well as the eastern provinces of Canada. Because they are the only producer of nepheline syenite in North America, they also sell some of this material to western Canada and western United States.

The balance of feldspar production in North Carolina comes from the pegmatites in the Kings Mountain District. In this area, Foote Minerals Co., recently purchased from Newmont Mining Corp. by Cyprus Industrial Minerals Co., produces around 100,000

tons per year of feldspar as a byproduct of lithium production. Lithium Corporation of America, purchased in 1985 by FMC Corp. from Gulf Resources and Chemical Corp. apparently ceased production in 1987. KMG Minerals Corp. (a combination of U. S. Mica Co., English Mica Co., and Kings Mountain Mica Co.) has a processing capacity of approximately 25,000 tons per year of feldspar. Raw ore is selectively mined from the weathered section of quartz monzonite and separated into kaolin, mica, silica sand and feldspar.

Georgia

Feldspar Corp. operates a mine and plant at Monticello, Georgia, with a combined capacity of 120,000 tons per year of which high-potash feldspar accounts for 50,000 tons per year. The remainder is silica sand.

Virginia

Feldspar Corp. operates an aplite mine, with 200,000 tons per year capacity, at Montpelier, Virginia. This is the sole surviving aplite deposit in North America. Its success is based on its pivotal geographical location between the nepheline syenite production in Ontario and the feldspar operations in North Carolina.

Connecticut

Feldspar Corp. operates a mine and plant at Middletown, Conn., with a 200,000 tons per year combined capacity of soda and potash feldspar (100,000 tons per year) plus silica sand and mica.

South Dakota

Pacer Corp. mines pegmatite minerals at operations in Custer and Keystone, South Dakota, with both surface and underground mines. They also have a surface mine at Custer, Wyoming. Processing is ddne in South Dakota. Capacity is sbout 50,000 tons per year, although it is not known if they normally work up to capacity. Products are high grade potash feldspar finely ground to minus 180, 200 and 325 meshes for the ceramics industry. A 30 mesh glass grade is also produced and marketed.

California

In 1985, Steelhead Resources Inc., purchased Calspar Corp., which owned a feldspar mine near Barstow, California. Processing facilities were in Santa Fe Springs, California. Their acquisition also included an inactive feldspar mine at Kingman, Arizona. It has been reported in early 1988 that Steelhead has purchased a mineral processing plant in Victorville, California, from Pfizer Inc. Plans are to cease feldspar processing at the Santa Fe Springs facility and to produce feldspar, and other minerals, at Victorville. Sodium feldspar production is stated at about 7,000 tons per year. Potash feldspar production in the future will exceed sodium feldspar output.

California Silica Products Co., a subsidiary of Oglebay Norton Co., operates a feldspathic sand mine and plant at Mission Viejo, California. The flotation process produces 2,500 tons per year of feldspar. Portions of this production is processed and marketed through Steelhead Resources.

NORWAY

This has the only commercially significant nepheline syenite production outside of Ontario. Production is in the hands of one company, Norsk Nefelin, a part of Elkem A/S, which operates an underground mine and processing plant at Stjernoy in the Alta Fjord in the North Cape of Norway. This is some 250 miles north of the Arctic Circle and 40 miles southwest of Hammerfest.

After mining, ore is crushed underground to a minus 30 mesh. Further processing at the surface consists of crushing, magnetic separation and screening to form glass and ceramic grades. Glass grade material is 100% minus 0.5 mm, and ceramic grade is 50% minus 0.01 mm and 99.5% minus 0.044 mm. Another grade, known as amber grade, has a 0.4% Fe_2O_3 content and is the magnetic fraction of the final high intensity magnetic step in the process. The glass grade is by far the most important, accounting for 220,000 tonnes of their 270,000 tonnes per year capacity.

As in Canada, actual production capacity utilization has been below nameplate capacity for several years. Output in 1983 was 219,565 tonnes and 238,170 tonnes in 1984. Reserves are on the order of 300 million tonnes.

MEXICO

Mexico produces over 120,000 tons per year of feldspar, most of which is controlled by the two subsidiaries of Vitro SA- Primas Minerales de Ahuazotepec SA and Materias Primas de San Jose SA. The latter has a capacity of 70,000 tons per year of

potash feldspar from operations et San Jose de Iturbide, Guanajuato, in central Mexico. Grades include M-20 (10% passes 140 mesh) and M-40 (13% passes 200 mesh). Both are used in ceramics. Some of the feldspar is exported to the western United States. Primas Minerals de Ahuazotepec SA, the smaller producer, produces soda feldspar in the state of Pueblo.

BRAZIL

There has been a great deal of speculation recently over the possibility of Brazil becoming a nepheline syenite producer. Austral Mineracao e Servicos Ltda. is planning to exploit the Canaan deposit, 25 miles from Rio de Janeiro. The deposit, in the municipality of Duque de Caxias in the foothills of the Petropolis Range, is made up of a nepheline syenite virtually identical in texture and similar in composition to the Blue Mountain deposit in Ontario. Measured reserves are 1.6 million tons, indicated reserves are 5.7 million tons and inferred 25.4 million tons.

Glass grade material has been produced on a pilot plant scale with typical specifications as follows:

SiO_2	58.8 %
Al_2O_3	23.0 %
Fe_2O_3	0.1 %
Na_2O_3	10.3 %
K_2O	6.2 %

100% minus 0.5 mm and 8% minus 200 mesh.

Some sales were recorded in 1981 and plans were announced that full-scale production would begin with 36,000 tons per year and expansion to 72,000 tons per year. However, no news of a

startup has been received in the press and it appears the company is having some problems.

USES OF NEPHELINE SYENITE AND FELDSPATHIC MATERIALS

The major, fundamental use of feldspars, nepheline syenite and other feldspathic materials is to act as a flux and as a chemical moderator in the melting of raw materials in a batch that will produce glass or ceramics. A flux lowers the melting temperature of a batch of raw materials. Some minor uses are listed below but are not of significance compared to the major use.

GLASS

Worldwide, about 60% of feldspar and nepheline syenite usage is accounted for by the glass industry, principally container glass and fiberglass. The two commodities contribute alumina, which reduces the tendency to devitrify and improves the chemical durability of the glass. Contained alkalis partially reduce soda ash and act as a flux which reduces the high viscosity of molten silica end brings the glass manufacture into the temperature range that is industrially accessible, that is, below the melting point of refractory linings for furnaces.

CERAMICS

A further 35% of feldspar and nepheline syenite use is in ceramics where they act as a flux in ceramic mixtures, for example, when making vitreous china and porcelain. The two end uses for feldspar and nepheline syenite are essentially the same for both end products.

OTHER USES

Filler: Acts as an inert filler in paint, foam rubber and plastics. It adds properties such as strength, chipping resistance, thermal shock resistance and thermal expansion resistance.

Abrasives: Inclusion in abrasives, scouring powders and soaps.

Coating: Some welding rods and electrodes are coated with a mixture containing feldspar or nepheline syenite.

Aggregate: A light colored road aggregate.

Chemical: As a flame damper in the match industry. A source of alumina and other chemicals (chiefly in the USSR).

CANADIAN USAGE

Over the past five years Canada has produced an average of about 509,000 tons per year of nepheline syenite, but, no feldspar. Domestic usage has accounted for 17% of production or about 87,000 tons per year. The remaining 83% of production is exported. Categories of domestic usage are:

Glass & Fiberglass	66,990 tons	77 %
Ceramics	13,050 "	15 %
Paints	5,220 "	6 %
Other	1,740 "	2 %
Total	87,000 tons	

UNITED STATES USAGE

An approximation of comparative usage is provided by 1987 statistics from the U. S. Bureau of Mines covering feldspar:

Glass (container & fiber)	393,000 tons	54 %
Ceramics	335,000 "	46 %
Other (outlined above)	2,000 "	<1 %
Total	730,000 tons	

It should be noted that about 45% of domestic consumption in glass is accounted for by silica-feldspar mixtures, called feldspathic sands. This usage is confined to the western United States where good quality silica sands are difficult to find and produce and where feldspars have, likewise, not been developed. Thus, flotation feldspar of the type that is traditionally produced in the Spruce Pine District of North Carolina, and elsewhere, accounts for only about 220,000 tons destined for the glass industry. On the other hand, the ceramics industry uses about 90% of the flotation products and accounts for a higher consumption of feldspar than the glass industry. As noted just above under "Uses - Canada", a large portion of Canadian nepheline syenite is exported and a the major portion is destined for the glass industry in the U. S.

WESTERN NORTH AMERICA - MARKETS

MARKET FACTORS

Because feldspar and nepheline syenite are freight sensitive, the markets most likely to be penetrated from British Columbia are those where the British Columbia materials have some economic advantage due to geographical location in relation to the marketplace. Therefore, two regional market segments are evaluated:

- Western Canadian Provinces, Pacific Northwest States of the United States and Northern California.
- Southern California, Western States (other than the Pacific Northwest States and California) plus Oklahoma and Texas.

Regional market number one is, of course, the most logical market because it is the closest to British Columbia. This region also lacks any feldspar or nepheline syenite production, which makes production in British Columbia particularly appropriate and attractive. Therefore, the most likely North American marketplace for British Columbia feldspars or nepheline syenite is Western Canada, the Pacific Northwest states of the United States and Northern California.

As the market region is expanded from the areas just mentioned, transportation costs become higher and competition becomes more pronounced. There is feldspar production in South Dakota which servicea Colorado and some of California. Mexican production of feldspar has captured a significant portion of the

markat for potash feldspar in southern California. Local production in southern California by Steelhead Resources is an important competitor. With these producers in mind, regional market number two is considered as those markets in Southern California, other western United States plus Oklahoma and Texas. Market penetration in the more distant markets of region number two will be difficult unless the British Columbian feldspathic materials have some unique technical characteristics or if unusually favorable fresight rates and other economics could be arranged.

Consumers in both market regions are listed in "Appendix B- Consumers".

All sales in the container glass, fiberglass and specialty glass markets are made directly by the feldspathic material producing company to the glass producer. Almost all large tonnages moving to large consumers in the ceramics industry, such as whiteware manufacturers of bathroom and kitchen fixtures, are also made directly. Distributors or manufacturers' representatives often sell feldspars for those ceramics used by potters, schools, hobbyists, etc., but, tonnages moved through distributors is relatively minor in comparison to the large direct-sales shipments for the major uses in glass and whitewares.

FELDSPATHIC MATERIALS

The feldspathic materials that compete in Western North America are: feldspar, nepheline syenite, aplite and feldspathic

sand. The first three commodities have been discussed in detail earlier in the report. Feldspathic sand merits special attention due to its importance in western North America in the manufacturing of container glass and fiberglass.

Container glass, such as beverage bottles, pickle or catsup bottles, etc., chemically consist of the following approximate chemical constituents: Silica - 60%; soda ash - 19%, limestone 14-18% and alumina 4-5%.

Fiberglass consists of: Silica - 55%; limestone 25-30%; alumina 14%.

In the more easterly provinces and states of North America the silica is provided by high grade silica sands with low iron and low alumina. The alumina needed for fluxing is made up by the purchase of feldspar, nepheline syenite or aplite. There are only two major producers of high quality silica sand in the western states, one is in central California and one is in southern Nevada. There is also one smaller sized silica sand operation in British Columbia. Due to this dearth of high quality silica sand in the west, and particularly in the two western provinces and the west coast states the manufacturers have improvised to utilize a material called "feldspathic sand", which as the name implies, contains both feldspathic material (feldspar) and silica sand. The amount of alumina in the feldspathic sand averages about 6%.

Because feldspathic sands are available all along the west coast they are used in large quantities as will be shown below.

However, there is a major drawback to their use and that is that the chemical analyses of these sands vary widely within a deposit and in use. Glass manufacturers place a high premium upon consistency of chemical composition of their various raw materials and feldspathic sands do not provide the consistency needed. Nevertheless, feldspathic sands have traditionally been used because there were no other sensible economic alternatives.

Within the last year to two years there has appeared an alternative to feldspathic sands on the west coast. A large international company mines very high grade silica sand on the east coast of Australia. It appears as though this sand can possibly be landed at various west coast ports and provide the silica needed for glass manufacture. Should these shipments commence, then a western source of alumina would be required to supplement the silica sand and this would logically be feldspar, nepheline syenite or, possibly, aplite. Further, British Columbian materials would be a logical choice, especially for the more northerly market region mentioned above. The market implications of having an offshore source of silica sand and British Columbian feldspar or nepheline syenite are discussed further below.

Note:

Conversions of tonnages of various feldspathic materials to contained alumina are necessary in this section of the report. The approximate assumed percentages of alumina in each material

are used for conversion as follows: (All tonnages in this section of the report are in short tons.)

Feldspar	18%	Al_2O_3
Nepheline Syenite	23%	"
Aplite (U.S.A.)	22%	"
Feldspathic Sands	5-6%	"

WESTERN PROVINCES, PACIFIC NORTHWEST & NORTHERN CALIFORNIA

	Material	Tonnages Consumed	Alumina Contained
Container Glass:			
	Feldspathic Sand	632,000	35,040
	Nepheline Syenite	12,100	2,780
Fiberglass:			
	Feldspathic Sand	100,000	6,000
	Nepheline Syenite	10,800	2,490
Ceramics:			
	Nepheline Syenite	2,000	460
	Feldspar	1,500	350
Total Alumina:			47,120

POTENTIAL MARKETS

As can be seen from the above, there are 24,900 short tons per year of nepheline syenite consumed in the region. All of this is used in western Canadian provinces or Pacific Northwest states and none in Northern California. Therefore, production of this tonnage in British Columbia should compete favorably against Ontario nepheline syenite. British Columbian feldspar could also compete in portions of this market.

Feldspar usage is confined to ceramics. Competition is with high quality South Dakota potassium feldspar. To penetrate this market would require a similar material.

Alumina equivalent in feldspathic sand utilized in this region is about 47,000 tons per year. Not all of this tonnage is potentially convertible to high grade silica sand and an alumina source, such as feldspar or nepheline syenite. For example, about one-half of the tonnage is consumed by one large container glass manufacturer in northern California. This company can use a sand with relatively loose specifications and would not convert to other imported raw materials.

However, it is estimated that about 6,000 tons per year of equivalent alumina could potentially be converted to feldspar or nepheline syenite. The tonnage of each, if the total of 6,000 tons were converted to either would be: feldspar (17% Al_2O_3)- 33,000 tons and nepheline syenite (23% Al_2O_3) - 26,000.

Without knowing all of the technical characteristics of the deposits that might be developed in British Columbia it is not possible to estimate the market share attainable in this region. However, due to the remoteness of other, present suppliers, the feldspathic materials of British Columbia should enjoy a significant market penetration in competition to existing uses of nepheline syenite and feldspars in the region. Displacement of feldspathic sands will take more market development but is also believed to be attainable at some time in the future.

SOUTHERN CALIFORNIA, WESTERN STATES, OKLAHOMA & TEXAS

	Material	Tonnages Consumed	Alumina Contained
Container Glass:			
	Feldspathic Sand	270,000	16,700
	Nepheline Syenite	5,000	1,150
	Feldspar	13,500	2,430
	Aplite	10,000	2,090
Ceramics:			
	Feldspar	28,840	5,200
Total Alumina:			27,570

POTENTIAL MARKETS

Local sources of feldspar and feldspathic sands will continue to dominate this market area. In theory the 27,570 tons of alumina contained represents a market for feldspar, at 18% Al_2O_3, of about 150,000 tons per year and of nepheline syenite, at 23%, of 100,000 tons. However, it is highly unlikely that feldspathic sands would be totally displaced in this particular market region. This more remote market region will be accessed from British Columbia only if the materials in that province exhibit some unique technical characteristics or if freight rates and international currency exchanges happen to represent an unusual opportunity.

INTERNATIONAL TRADE

REGIONAL PRODUCTION/CONSUMPTION

There is international trade of feldspar and nepheline syenite but not on a global basis, rather, trade is regionalized. For example, essentially all of the feldspar produced in Europe is consumed within Europe. Norway produces nepheline syenite which is consumed in Europe. In the same way, Canada is the world's largest producer of nepheline syenite but the vast majority of this production is exported to the United States. There is also a modest movement of feldspar amongst the Pacific Basin countries.

The following tables are enclosed at the end of this report and are discussed below:

Table I	World Production Of Feldspar
Table II	Canada - Nepheline Syenite Production
Table III	U.S.A. - Nepheline Syenite Imports
Table IV	Canada - Feldspar Imports
Table V	Japan - Imports
Table VI	Korea - Imports

As can be seen by Table I, Western Europe is the largest producing region followed by Asia and North America. Because production and consumption are regional, as mentioned above, the area of most interest to this study is North America.

Canada and United States

Table II shows that Canada has produced an average of 509,000 tonnes per year of nepheline syenite from 1982 to 1986. Production, consumption and exports have decreased somewhat lately and capacity utilization is in the range of 60% to 65%.

The reason is that s large portion of consumption is in the container glass industry, which has been adversely affected by increased usage of plastic and aluminum, thinner glass walls to containers that do use glass and recycling laws that encourage the utilization of cullet (recycled glass).

Of the average of 509,000 tonnes per year of nepheline syenite produced in Canada, 75% is exported. The remaining 25% is consumed in traditional industries - glass, fiberglass and insulation account for 77%, ceramics for 15%, paints for 6% and miscellaneous for 2%. Of the average of 378,000 tonnes exported, 88%, or 333,000 tonnes, is destined for the United States, where it is consumed in glass and ceramics.

There is the possibility of some small production of nepheline syenite commencing in the southeast corner of the United States, but, for all practical purposes, significant shipments of nepheline syenite from Canada to the United States will continue. Table III designates the main ports through which nepheline syenite is imported into the United States from Canada. As would be expected with production in Ontario, most of the imports arrive in the United States through Detroit, Michigan or Buffalo, New York, however, consumption is widespread throughout the states. It is noted that the total U.S.A. imported tonnage in Table III is slightly less than that shown for 1986 in Table II and is assumed that Table II is more accurate for tonnage. But, Table III does indicate the main ports. Figure 1, taken from "Industrial Minerals Magazine" is enclosed and shows the

eastern producers and relative market areas for each type of product in the east.

Table IV shows that Canada is a modest importer of feldspar, having dropped from over 4,000 tonnes per year in 1980 and 1981 to just over 2,000 tonnes in the last few years. For reference, the United States neither exports nor imports significant quantities of feldspar. Exports in 1987 were 7,000 short tons out of a total production of 730,000 tons and imports were 5,000 tons, mainly from Mexico.

Japan And South Korea

The Pacific Basin countries of particular importance to this study are Japan and South Korea. This interest is due to their geographical location in relation to British Columbia combined with their advanced level of industrialization. Other Asian countries are also producers, consumers or importers of feldspar and nepheline syenite.

Table V and VI show that Japan and South Korea each imports something less than 10,000 tonnes per year. Table I shows that Japan is a major producer of feldspathic materials with production between 470,000 and 500,000 tonnes per year. However, Japanese production consists of only about 30,000 tonnes per year of true feldspar and the remainder is aplite, a granitic rock that is much less attractive commercially for the production of glass and ceramics than are feldspars and nepheline syenite.

Due to the eastern province location of nepheline syenite production in Canada and the predominantly eastern seaboard

locations of feldspar production in the United States, these materials have not been competitive in the Pacific Basin. With production of feldspar and nepheline syenite in British Columbia and more economical ocean freights to the Pacific ports, it is possible to significantly increase exports from British Columbia to Japan, South Korea and other countries in that sector of the world.

Pacific Basin Production

There is no nepheline syenite production in the region, feldspar production is as follows: (metric tonnes)

Country	1984	1985	1986
Australia	3,390	3,600	8,100
Burma	6,218	6,350	2,700
Hong Kong (*)	23,101	26,777	99,000
India	42,859	40,000	45,000
Japan (**)	35,100	30,600	32,400
South Korea	127,057	145,414	138,600
Pakistan	5,486	5,400	11,700
Philippines	11,486	11,900	6,300
Sri Lanka	3,155	2,878	9,900
Taiwan	15,452	11,055	9,800
Thailand	74,404	104,586	99,000
Total	347,708	388,560	462,500

(*) Transshipments - Mainly Chinese origin.
(**) Japan aplite not included.

Japan:

Japanese domestic feldspathic sources are varied. They include: 1. Pegmatitic feldspar, 2. Replacement-type sodic feldspar, 3. Aplitic rocks and 4. Altered granite. In addition to the feldspar shown in the above table, Japan produces over 450,000 tonnes per year of aplite.

Most of the pegmatitic deposits are too small to be exploited economically, nevertheless, around 30,000 to 35,000 tonnes per year of feldspar is produced in Japan. This domestic production is generally supplemented by 6,000 to 10,000 tonnes of imports, largely from China with 3,000 to 6,000 tonnes per year and less than 1,000 tonnes per year each from Korea and India. Imports also include 1,000 to 1,500 tonnes of nepheline syenite from Canada and Norway.

Total requirement of feldspar in glass in Japan is in the range of 65,000 to 70,000 tonnes per year. Some of this is supplied by aplite. Ceramic consumption consists of the raw materials mentioned above and a product they call "toseki" or china stone, which is a combination of quartz, sericite and kaolin.

Japan exports between 30,000 and 35,000 tonnes per year of feldspathic materials. About 90% of exports go to Taiwan with the remainder to Indonesia. Exports include aplite.

South Korea:

Feldspar production in South Korea runs around 130,000 to 150,000 tonnes per year. The government reports that 14 companies produce feldspar. The two largest companies each produce between 20,000 and 25,000 tonnes per year. Korea imports about 7,000 tons per year of feldspar.

Thailand:

Feldspar production has been spurred by the large Thai ceramic industry and its need to develop indigenous raw

materials. Output is officially around 100,000 tonnes per year. Both potash and soda feldspars are mined. Potash spar is produced in the northern province of Tak and is used in a glass factory near Bangkok. Soda spar is produced in the central province of Ratchaburi. Soda spar is also produced in the southern province of Hakhon Si Thammarat, largely for the export market.

Taiwan:

Production of feldspar in Taiwan is modest and, in fact, has declined in recent years from 25,000 tonnes to less than 10,000 tonnes per year. Imports for 1986 were as follows: (tonnes)

	Feldspar	Nepheline Syenite
Japan (inc. aplite)	29,111	
South Korea	15,158	
Thailand	9,183	
Hong Kong (China)	8,635	
Australia	6,800	
Canada		1,032
United States	703	
Netherlands	480	
Zimbabwe	180	
Sweden	40	
Total	70,290	1,032

Philippines:

Production of feldspar in the Philippines has decreased from 16,000 tonnes in 1980 to about 6,000 tonnes in 1986. All domestic production is used for glass production. Imports are in the range of 2,500 tonnes per year from Japan, Thailand and the United States.

Indonesia:

There is no domestic production of feldspar. Import statistics for 1984, the latest year available, indicate about 13,500 tonnes from China, Japan and Thailand.

Malaysia:

There is no apparent feldspar production in Malaysia. The latest import statistics for 1984 show about 12,000 tonnes imported from India, China and Thailand.

Australia:

Domestic feldspar production has gradually increased to over 10,000 tonnes per year at present. Feldspar has replaced calcined alumina and imported Canadian nepheline syenite as an alumina source for glass. In addition to present production in the Broken Hill District and in Western Australia, other firms are examining both feldspar and nepheline syenite production potential.

Summary Of Pacific Basin

Imports by the countries discussed above are of specific interest to this study. At present, practically all trade is intra-Pacific Basin with minor quantities of materials, mainly nepheline syenite from Canada, being imported into the region. The lack of imports into the Pacific Basin from Canada or the United States has been caused by the lack of production on the west coast of either Canada or the United States.

A supply of feldspar and or nepheline syenite in the province of British Columbia could radically change the supply

situation in the Pacific Basin. Due to its geographical location, British Columbia is in an excellent location to service the Pacific Basin as the ports in the province have done with other commodities such as coal and sulfur. With a good and consistent quality material located in British Columbia, a politically stable area, it is estimated that there would be an appreciable increase of imports to the Pacific Basin countries from British Columbia. Present imports and potential exports from British Columbia are as follows:

	Present Tonnes	Market Share	Potential Tonnes
Japan	10,000	50 %	5,000
Taiwan	70,000	25 %	17,500
Indonesia	13,500	10 %	1,350
Malaysia	12,000	10 %	1,200
South Korea	7,000	10 %	700
Philippines	2,500	10 %	250
Total	115,000		26,000

As noted earlier, Japan produces over 450,000 tonnes per year of aplite, which is low in alumina (Al_2O_3) one of the major desired ingredients of a feldspathic material. Japanese aplite analyses about 13% tn 14% Al_2O_3 compared to over 23% for a typical nepheline syenite and about 17% for a feldspar. It is believed that a combination of geographical location and technical factors combined with Japan's generally increasing demand for high grade raw materials and trend toward easing of import restrictions could displace a significant portion of aplite with material from British Columbia. It is well-known that a correctly structured sales and marketing program,

conducted through a Japanese trading company, is required in order to penetrate this market. If, say, 10% of Japanese aplite could be penetrated by British Columbia material this would result in additional exports of 45,000 tonnes per year.

Penetration of existing imports to the various countries listed, combined with replacement of aplite in Japan, results in a potential export market from British Columbia to the Pacific Basin of:

Existing markets	26,000 tonnes per year
Aplite Replacement	45,000 " " "
Total Export Potential	71,000 tonnes per year

PRICES AND SPECIFICATIONS

Prices for the various materials discussed in this study are listed below. Prices are contingent upon the quality and specifications reqnired by the marketplace. "Appendix - A- Specifications" shows the specifications for the materials that are the subject of this study. These can be compared to the prices shown below. A list of analytical laboratories that can test feldspathic materials to determine their chemical and physical characteristics and conformation to specifications is enclosed as "Appendix - C - Laboratories".

FELDSPAR

United States

The following prices are applicable to the specifications shown in Appendix A under "The Feldspar Corporation:.

Grade	Source	Price US$/s.t.	Add For Bags 50 lb.	100 lb.
Ceramics:				
NC - 4	N. Carolina	$48.25	$13.50	$11.25
C - 6	Connecticut	$63.00	$12.50	N. A.
G - 200	Georgia	$80.00	$12.50	$10.25
K - 200	N. Carolina	$77.50	N. A.	$10.25
Glass:				
Aplite	Virginia	$27.75	N. A.	
F - 20	N. Carolina	$32.00		$16.00
C - 20	Connecticut	$44.00	N. A.	
G - 40	Georgia	$62.50		$10.25
K - 40	N. Carolina	$57.25		$10.25
Fillers:				
G - Fill	N. Carolina	$35.00	$13.50	N. A.

The following prices are applicable to the specifications shown in Appendix A under "Feldspar Division - Pacer Corporation:

South Dakota Feldspar Prices: (US$ per ton, f.o.b. plant)

200 mesh	Bulk	$ 80.00
200 mesh	100 lb. bags	$ 91.25
200 mesh	50 lb. bags	$ 93.50
325 mesh	Bulk	$ 82.00
325 mesh	100 lb. bags	$ 93.25
325 mesh	50 lb. bags	$ 95.50

Mexico

The following prices are applicable to the specifications shown in Appendix A under "Materias Primas - Minerales de San Jose S. A.". The chemical specifications shown in Appendix A for Materias Primas are essentially the same for all products, the difference in price is contingent upon fineness of particle sizes.

M- 20 (20 mesh)	US$ 63.00 per tonne
M- 40 (40 mesh)	US$ 67.00 per tonne
M-200 (200 mesh)	US$125.00 per tonne

NEPHELINE SYENITE

Canada

Prices shown below correspond to specifications shown in Appendix A under "Indusmin Ltd." as they are the only producers of nepheline syenite in Canada.

Indusmin Ltd.:

Glass Grades -

Prices (in US$ per short ton, bulk, f.o.b. Ontario)

Glass Grade 30 mesh, low iron $28.00 - $30.50

Glass Grade 30 mesh, high iron $21.50 - $24.75

Ceramic Grades -

Prices (in US$ per short ton, bulk & bagged, f.o.b. Ontario)

	Bulk	Bagged (50#)
A 200 (Crest)	$45.00	$64.00
A 270 (Peak)	$46.75	$65.75
A 400	$66.50	$85.50

Filler & Extender Grades-

Prices (US$ per short ton, bulk and bagged, f.o.b. Ontario)

Product	Bulk	Bagged
Minex 2	$ 45.00	$ 64.00
Minex 3	$ 46.75	$ 65.75
Minex 4	$ 66.50	$ 85.50
Minex 7	$ 80.00	$ 99.00
Minex 10	$160.00	$179.00

Norway

Prices shown below correspond to specifications shown in Appendix A under "Norsk Nefelin" as they are the only producers of nepheline syenite in Norway.

Prices (Pound Sterling & US$ per tonne, CIF UK port, bulk)

Glass Grade L55-75 or $ 83.50 - $112.50

Ceramic Grade L65-85 or $ 97.50 - $127.50

Purchasing Specifications

Appendix A contains two sets of purchasing specifications for Brockway, Inc., a United States container glass producing company and Owens-Corning Fiberglas Co. These are for reference to purchasing procedures. Also enclosed in Appendix A for reference only are the feldspar specifications formerly produced by the Crystal Silica Co. in southern California.

TRANSPORTATION

A detailed evaluation of freight rates is not within the scope of the present study. However, indicative rates are as follows:

North Carolina	- West Coast U. S.	US$75.00 per ton
South Dakota	- West Coast U. S.	US$60.00 per ton
South Dakota	- Alberta	US$56.00 per ton
Ontario	- West Coast U. S.	US$70.00 per ton
Ontario	- British Columbia	C$94.00 per ton
Ontario	- Alberta	C$90.00 per ton

FELDSPAR/NEPHELINE SYENITE - POTENTIAL PRODUCTION SITES

In 1987, the Industrial Minerals subsection of the Geological Survey Branch, British Columbia Ministry of Energy, Mines and Petroleum Resources undertook a review of potential sources of nepheline syenite and feldspathic minerals. In total, 10 sites were selected for mapping and/or sampling to assess their development potential. The evaluation and laboratory work is, at the time of writing, in progress and only preliminary data are available.

As a part of this resources assessment study, representative samples from each site were submitted to the Mineral Processing Laboratories of CANMET in Ottawa, Ontario, to study the beneficiation potential for individual locations. The following are brief description of potential production sites for feldspathic minerals in British Columbia. The numbers refer to locations shown on an attached map.

1. Sumar Mountain (Mineral Inventory Number 92G-37)

This site was reported to the Geological Survey Branch in 1986. The rock, classified as a fine-grained aplite, outcrops over a large area northeast of Abbotsford near Sumas Mountain. The mineralogical assessment of typical samples identified albite and quartz as the main components with only trace amounts of chlorite. Iron is present mainly as limonite as joint filling, probably deposited by circulated meteoric waters. Incomplete

analytical data indicate Al_2O_3 between 15-18 per cent, Na_2O approximately 8 percent and Fe_2O_3 between 0.15-0.40 percent.

2. Scuzzy Creek (Mineral Inventory Number 92H-52)

Deltaic fans of fine to very coarse feldspathic sands, ranging in colour from white to light grey to dark brown, are located along Scuzzy Creek and one of its tributaries. The sand consists of quartz and plagioclase feldspar with minor mica and amphibole. The analysed sand samples had the following composition:

Al_2O_3	14.41 - 15.40 per cent
Na_2O	4.44 - 4.84 " "
K_2O	0.44 - 0.49 " "
CaO	2.77 - 3.05 " "
Fe_2O_3	0.53 - 0.76 " "

Preliminary process data indicates iron content can be reduced to between 0.10 - 0.15 per cent.

3. Copper Mountain (Mineral Inventory Number 92H - 90)

A coarse-grained feldspathic rock described as pegmatite is present as an oval shaped intrusive body 1,200 by 2,000 metres in diameter in the core of the Copper Mountain stock which ranges from gabbro to monzonite. The pegmatite core was sampled and analysed with the following results:

Al_2O_3	19.25 - 20.38 per cent
Na_2O	4.25 - 8.49 " "
K_2O	2.80 - 9.94 " "
CaO	0.18 - 1.93 " "
Fe_2O_3	0.21 - 0.43 " "

No processing data are available as yet.

4. Yellow Lake (Mineral Inventory Number 82E/SW-191)

Phonolite lava flows, described as the Yellow Lake Member of the Penticton Group of Eocene volcanics, occur between Keremeos and Penticton and consist of plagioclase and aegirine-augite phenocrysts in fine-grained matrix. The analysed samples have the following composition:

Al_2O_3	13.63 - 19.49 per cent
Na_2O	3.37 - 5.86 " "
K_2O	4.46 - 6.97 " "
CaO	1.46 - 8.47 " "
Fe_2O_3	3.30 - 6.93 " "

Because of the fine-grained nature of the rock, no commercial grade suitable for other than dark-colored glass manufacturing can be produced.

5. Kruger Mountain (Mineral Inventory Number 82E/SW-106)

An intrusion of nepheline syenite, several square kilometers in size, outcrops between Keremeos and Osoyoos. Most of the rocks are mafic phases with high iron content which is present mainly as disseminated, very fine-grained (below 200 mesh) magnetite. One leucocratic phase analysed:

Al_2O_3	14.27 per cent
Na_2O	3.71 " "
K_2O	5.91 " "
CaO	0.87 " "
Fe_2O_3	0.65 " "

While the results of processing tests are not yet available, it is expected that the iron content will be significantly reduced.

6. Greenwood (Mineral Inventory Number 82E/SE-224)

Leucocratic intrusions of a medium- to fine-grained granite occur north of Greenwood. The rock consists of quartz, orthoclase and oligoclase with minor biotite and traces of chlorite. The chemical composition of the rock is:

Al_2O_3	15.44 - 16.87 per cent
Na_2O	4.01 - 4.35 " "
K_2O	3.07 - 4.45 " "
CaO	1.80 - 1.89 " "
Fe_2O_3	1.12 - 2.00 " "

No processing data are available as yet.

7. Lumby (Mineral Inventory Number 82L/SE-15)

Pegmatite outcrops over an area 2.65 by 1.25 kilometres along the slopes and the crest of wooded hills 13 kilometres east of Lumby. The rock is coarse-grained, consisting of 70-75 per cent feldspar, 20-25 per cent quartz with minor muscovite, biotite and garnet. Preliminary analysis indicates the following composition of collected samples:

Al_2O_3	19.0 - 21.0 per cent
Na_2O	3.7 - 7.0 " "
K_2O	5.0 - 12.0 " "
CaO	0.4 - 2.5 " "
$Fe2O_3$	0.06- 0.07 " "

While final results from processing tests are not yet available, results indicate full liberation at 20 mesh and a final product with Fe_2O_3 content of 0.05 per cent. During 1987/88 the deposit was under study by Brenda Mines Limited of Peachland.

8. Mount Copeland (Mineral Inventory Number 82M-255)

A band of nepheline syenite gneiss is exposed over approximately 6 kilometres on the southern flank of Mount Copeland, 15 kilometres northwest of Revelstoke. The rock is composed of orthoclase with subordinate nepheline and albite and a small quantity of amphibole, pyroxene and magnetite. The rock has a banded texture and contains both fine- and coarse-grained zones. The chemical composition of over 30 samples is as follows:

Al_2O_3	19.66 - 24.88 per cent
Na_2O	2.94 - 8.76 " "
K_2O	7.49 - 10.14 " "
CaO	0.04 - 3.53 " "
Fe_2O_3	0.84 - 5.42 " "

No processing data are available as yet.

9. Trident Mountain (Mineral Inventory Number 82M-173)

Nepheline syenite occurs as a lenticular mass on the crest and slopes of Trident Mountain. The rock is medium-grained, white to grey in colour and consists of microcline, albite and nepheline with minor biotite and ilmenite. The composition of a typical sample is:

Al_2O_3	20.73 per cent
Na_2O	8.35 " "
K_2O	3.12 " "
CaO	1.20 " "
Fe_2O_3	0.52 " "

Preliminary processing data indicates a product of 85 per cent brightness can be obtained. Analytical results are not yet available.

10. Hellroaring Creek (Mineral Inventory Number 82F/NE-110)

The deposit is located 20 kilometres southwest of Kimberley. Pegmatite outcrops are exposed over an area 4.0 by 1.5 kilometres. Medium- to coarse-grained rock consists of microcline, albite and quartz with minor muscovite and black tourmaline. Some of the quartz is present as massive lenticular zones. Chemical composition of collected sample is as follows:

Al_2O_3	12.02 - 16.79 per cent
Na_2O	1.95 - 6.44 " "
K_2O	0.79 - 11.35 " "
CaO	0.07 - 0.64 " "
Fe_2O_3	0.05 - 1.56 " "

No final results of processing tests are as yet available, but, preliminary results indicate full liberation at 50 mesh with mica, feldspar and silica concentrates that meet industry standards. Preliminary results indicate Fe_2O_3 in feldspar concentrate can be reduced to the 0.02 - 0.07 per cent range. The deposit has been evaluated by Lumberton Mines Ltd. of Calgary.

More detailed information, data and analyses are available from:

Mr. Z. D. Hora
Industrial Minerals Specialist
Geological Survey Branch
Ministry of Energy, Mines and Petroleum Resources
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SUMMARY

- Feldspar, nepheline syenite and aplite production in North America is principally located in Ontario and the eastern-most states of the United States. Some feldspar production occurs in South Dakota, southern California and Mexico.
- Production of feldspar or nepheline syenite in British Columbia is well situated to take advantage of western regional markets that are presently supplied from more remote locations.
- In addition to western regional markets in North America, feldspar or nepheline syenite from British Columbia is in an excellent location to penetrate Pacific Basin import markets.

Hal McVey

Enclosures

TABLE I

World Production of feldspar (tonnes)

	1980#	1984#	1985#	1986e	1987e
France	210,000	208,900	171,500	198,000	207,000
W. Germany	380,880	286,200	261,400	317,700	324,000
Italy	344,301	985,603	1,116,375	1,228,000	1,233,000
Austria	10,946	2,554	13,570	2,700	
Finland	68,000	64,733	52,940	54,900	
Norway*	67,559	67,820	65,000	64,800	
Portugal	48,561	29,003	29,011	31,500	
Spain**	103,365	136,943	136,190	134,100	144,000
Sweden***	57,999	49,833	50,000	49,500	
Turkey	5,708	10,000	20,000	19,800	
Total, W. Europe	1,297,319	1,791,756	1,915,986	2,101,000	
Poland	85,955	46,300	60,100	79,200	
Romania	60,000	85,000	86,000	85,500	
USSR	310,000	330,000	340,000	333,000	333,000
Yugoslavia	57,710	34,000	49,900	45,000	
Total, E. Europe	513,665	495,300	536,000	542,700	
Egypt	3,309	12,413	27,400	14,400	
Kenya	387	682	640	900	
Morocco	--	1,000	1,000	900	
Mozambique	--	125	67	--	
Nigeria	5,000	5,000	5,000	3,600	
South Africa	52,247	39,018	33,012	53,100	
Zambia	475	184	185	--	
Zimbabwe	1,263	1,399	2,300	2,700	
Total, Africa	62,681	59,821	69,604	75,600	
Mexico	117,214	84,791	100,000	99,000	108,000
USA***	644,000	644,000	635,000	661,500	657,000
Total, N. America	761,214	728,791	735,000	760,500	765,000
Argentina	32,529	20,000	20,000	19,800	
Brazil	123,263	84,033	82,930	118,800	126,000
Chile	2,150	3,026	2,565	2,700	
Colombia	27,150	32,766	32,000	33,300	
Guatemala	--	4,986	5,582	6,300	
Peru	15,600	25,000	25,000	--	
Uruguay	2,820	500	1,000	900	
Venezuela	28,000	28,800	28,000	35,100	
Total S/C America	231,512	224,111	197,077	216,900	

TABLE I

World Production of feldspar (tonnes), continued

	1980#	1984#	1985#	1986e	1987e
Burma	2,026	6,218	6,350	2,700	
Hong Kong	2,974	23,101	26,777	99,000	
India	60,190	42,859	40,000	45,000	
Iran	--	2,500	2,500	2,700	
Japan[a]	470,394	476,189	498,000	497,700	
S. Korea	71,972	127,057	145,414	138,600	
Pakistan	10,898	5,486	5,400	11,700	
Philippines	15,925	11,486	11,900	6,300	
Sri Lanka	3,955	3,155	2,878	9,900	
Taiwan	25,149	15,452	11,055	9,900	
Thailand	24,158	74,404	104,586	99,000	
Total, Asia	247,247	346,818	387,460	327,600	
Australia	3,648	3,390	3,600	8,100	
Total, World	3,600,000	4,100,000	4,300,000	4,167,900	4,230,000

* Unground, production of ground withheld
** Including pegmatite
*** Sold or used by producers
+ Includes beneficiated and direct shipping ore
a Most is aplite -- feldspar production was:
30,000 tonnes (1980); 35,100 tonnes (1984);
30,600 tonnes (1985); 32,400 tonnes (1986).
Source: # British Geological Survey
e US Bureau of Mines estimate converted
from short to metric tonnes

TABLE II

Canada -- Nepheline syenite production, exports, and consumption

	1982		1983		1984		1985		1986	
	tonnes	'000$	tonnes	'000$	tonnes	'000$	tonnes	'000$	tonnes	'000$
PRODUCTION	550,480	17,324	523,249	18,131	520,640	17,866	467,186	17,898	485,259	20,413
CONSUMPTION										
Glass & glass fiber	57,368		54,127		55,218		43,820			
Insulation	12,143		16,331		15,812		17,013			
Ceramic products	10,465		16,571		12,916		12,900			
Paints	3,669		6,062		5,843		5,924			
Others*	1,725		1,543		1,766		1,873			
Total	85,373		94,634		91,555		81,530			
EXPORTS										
USA	373,932	13,557	345,245	13,469	334,349	13,689	314,092	14,031	297,990	na
Netherlands	24,490	1,014	20,995	1,019	21,830	960	17,230	745	19,037	14,750
Italy	6,834	495	8,614	658	10,482	823	6,041	468	5,672	1,130
United Kingdom	4,751	256	8,926	472	5,426	322	6,132	320	4,856	510
Australia	1,537	121	8,943	294	9,933	358	1,129	90	5,315	<1
Spain	269	18	1,927	105	897	63	2,294	117	1,190	130
Other	2,975	304	3,649	293	4,149	414	4,108	530	4,197	500
Total	414,788	15,765	398,299	16,310	387,066	16,629	351,026	16,300	338,257	17,740

* includes frits, enamel, plastics, rubber products, heavy clay products, paper and paper products, and other minor uses.

Source: Energy, Mines and Resources Canada

TABLE III

USA -- Imports of nepheline syenite by main ports

	Volume Long tons	Value FAS	Value CIF	$/long ton
1986				
Nepheline sysnite, crude				
Canada				
Ogdensburg, NY	1,363	117,160	117,160	$ 85.96
Buffalo, NY	109	9,557	9,557	$ 87.68
Seattle, WA	1,180	77,793	77,793	$ 65.93
Total	2,652	204,510	204,510	$ 77.12
Nepheline syenite, crushed, ground, pulverized				
Canada				
Ogdensburg, NY	2,980	277,391	277,391	$ 93.08
Buffalo, NY	71,708	3,648,662	3,648,662	$ 50.88
Seattle, WA	1,363	196,609	196,609	$144.25
Detroit, MI	188,088	6,952,619	6,952,619	$ 36.96
Total	264,139	11,075,281	11,075,281	$ 41.93

Source: US Commerce Department

TABLE IV

Canada -- Consumption and imports (value) of feldspar (crude or ground)

	Imports $	Consumption tonnes
1980	385,000	4,051
1981	642,000	4,606
1982	251,000	2,790
1983	309,000	2,213
1984	310,000	2,106
1985	308,000	2,014
1986	357,000	2,248

Source: Energy, Mines and Resources Canada
Statistics Canada

TABLE V

Japan -- Imports of feldspar and nepheline syenite

	1984		1985		1986	
	Quantity Tonnes	Value '000¥	Quantity Tonnes	Value '000¥	Quantity Tonnes	Value '000¥
N. Korea	957	8,560	50	1,399	880	7,191
China	5,470	76,046	5,173	89,962	3,626	42,519
India	1,145	22,141	1,186	22,516	784	10,170
Norway	35	3,074	18	2,438	18	2,040
Finland	--	--	8	371	--	--
Canada	904	40,517	1,268	57,157	1,438	47,695
USA	1	466	45	2,270	--	--
Australia	54	2,762	20	448	--	--
Total	9,612	164,363	7,802	178,875	6,766	110,463

Source: Mitsubishi Corp. & JETRO

TABLE VI

Republic of Korea -- Imports (tonnes)

	1985	1986
Feldspar		
Japan	734	402
Hong Kong	50	100
India	--	4
Others	20	265
Total	804	771
Nepheline syenite		
Canada	17	18
Norway	6	6
Total	23	24
Powder and other feldspar		
Thailand	4,722	4,364
Hong Kong	68	636
Japan	111	13
USA	17	2,084
Total	4,918	7,097

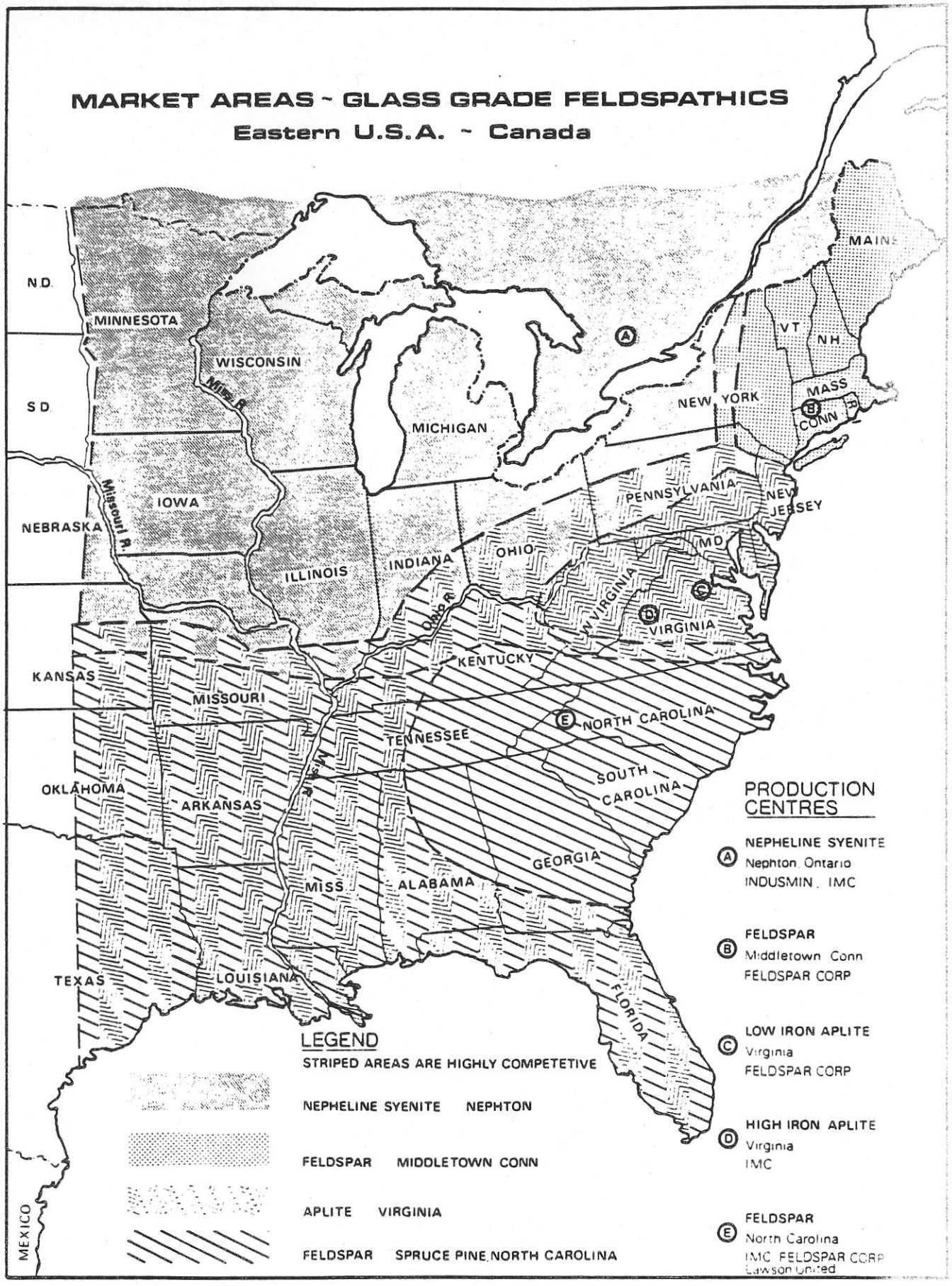

MARKET AREAS - GLASS GRADE FELDSPATHICS
Eastern U.S.A. - Canada
N.D.
MINNESOTA
WISCONSIN
Miss. R.
S.D.
MICHIGAN
NEBRASKA
Missouri R.
IOWA
ILLINOIS
INDIANA
OHIO
Ohio R.
KENTUCKY
W. VIRGINIA
VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VT
NH
MASS
CONN R.
NEW JERSEY
MD
KANSAS
MISSOURI
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
OKLAHOMA
ARKANSAS
Miss. R.
GEORGIA
MISS
ALABAMA
TEXAS
LOUISIANA
FLORIDA
MEXICO
A
B
C
D
E
LEGEND
STRIPED AREAS ARE HIGHLY COMPETETIVE
NEPHELINE SYENITE NEPHTON
FELDSPAR MIDDLETOWN CONN
APLITE VIRGINIA
FELDSPAR SPRUCE PINE NORTH CAROLINA
PRODUCTION CENTRES
A NEPHELINE SYENITE
Nephton, Ontario
INDUSMIN, IMC
B FELDSPAR
Middletown Conn
FELDSPAR CORP
C LOW IRON APLITE
Virginia
FELDSPAR CORP
D HIGH IRON APLITE
Virginia
IMC
E FELDSPAR
North Carolina
IMC FELDSPAR CORP
Lawson United

Figure 1

APPENDIX - A

SPECIFICATIONS

The Feldspar Corporation	- Feldspar and Aplite
Pacer Corporation	- Feldspar
Materias Primas	- Feldspar
Indusmin Ltd.	- Nepheline Syenite
Norsk Nefelin	- Nepheline Syenite
Crystal Silica Company	- Byproduct Feldspar
Brockway Inc.	- Purchasing Specifications
Owens-Corning Fiberglas	- Purchasing Specifications

THE Feldspar CORPORATION

P.O. Box 99
Spruce Pine, N.C. 28777
Telephone (704) 765-9051

		GLASS SPARS			
Grade	Aplite	F-20	C-20	G-40	K-40
Chemical Analysis					
SiO_2	63.60	68.00	68.70	67.30	67.10
Al_2O_3	22.00	19.00	18.50	18.00	18.30
Fe_2O_3	.10	.075	.10 Max.	.10	.07
CaO	5.50	1.85	.90	1.02	.36
MgO	Trace	Trace	Trace	Trace	Trace
K_2O	2.60	3.75	4.10	10.50	10.10
Na_2O	6.00	7.15	7.20	2.85	3.80
Ignition Loss	.20	.13	.25	.20	.26
Screen Analysis % retained on:					
16 Mesh	.0	.0	.0		
20 Mesh	.0	.0	.4		
30 Mesh	1.5	.5	8.0		
40 Mesh	25.0	12.0		.75	1.35
50 Mesh	55.0		49.0		
100 Mesh	97.0	78.0	81.0	61.0	56.15
200 Mesh	100.0	97.8	96.1	92.0	90.05
Price Per Ton in bulk f.o.b. plant	$26.75	$30.75	$41.35	$57.25	$57.25
Bagging Per Ton 100 lb. bags	unavailable	16.00	unavailable	10.25	10.25
Palletizing Per Wood Pallet Single-faced Rail					**7.75
Truck		7.75		7.75	**7.75
Corrugated Paper Pallets		1.50		1.50	
Shipping Point	Beaver Dam, Va.	Spruce Pine, N.C.	Middletown, Conn.	Monticello, Ga.	Kings Mtn., N.C.
Freight Rate To:					

LTL prices on all spars: Less than 24,000 lbs. - $110.00 ton, including bags
**Truck pallets (40" x 40") - Rail pallets (40" x 52")

July 15, 1985

THE Feldspar CORPORATION

P.O. Box 99
Spruce Pine, N.C. 28777
Telephone (704) 765-9051

POTTERY SPARS

Grade	NC-4	C-6	G-200	K-200
Chemical Analysis SiO_2	68.15	68.70	67.00	67.10
Al_2O_3	19.00	18.50	18.30	18.30
Fe_2O_3	.067	.07	.08	.07
CaO	1.60	.90	1.02	.36
MgO	Trace	Trace	Trace	Trace
K_2O	4.0	4.10	10.50	10.10
Na_2O	7.0	7.20	2.85	3.80
Ignition Loss	.10	.25	.20	.26
Screen Analysis Ground to: 170 Mesh	1.5% + 200 10.0% + 325			
200 Mesh	.4% + 200 4.5% + 325	.5% + 200 5.5% + 350	.5% + 200 5.0% + 325	.5% + 200 5.0% + 325
250 Mesh	.10% + 200 2.0% + 325			
Price per ton in bulk f.o.b. plant	$46.25	$56.50	$76.50	$77.50
Bagging per ton				
50 lb. bags	13.50	12.50	12.50	unavailable
100 lb. bags	11.25	unavailable	10.25	10.25
Palletizing Per Wood Pallet				
Single-faced Rail				**7.75
Truck	7.75	7.75	7.75	**7.75
Corrugated Paper Pallets	1.50	1.50	1.50	1.50
Shipping Point	Spruce Pine, N.C.	Middletown, Conn.	Monticello, Ga.	Kings Mtn., N.C.
Freight Rate to:				

LTL prices on all spars: Less than 24,000 lbs. - $110.00/ton, including bags

**Truck pallets (40" x 40") - Rail pallets (40" x 52")

July 15, 1985

Feldspar Division

PACER CORPORATION
Box 311 - Custer, South Dakota - 57730

FELDSPAR DATA SHEET - CUSTER AND KEYSTONE

PHYSICAL SPECIFICATIONS

140 MESH

On U.S.	140	-	2.0% Max
	200	-	3.5 Max
	325	-	15.0 Max
	Pan	-	79.5

200 MESH

On U.S.	140	-	.5% Max
	200	-	1.5 Max
	325	-	10.0 Max
	Pan	-	88.0

325 MESH

On U.S.	140	-	trace %
	200	-	.3 Max
	325	-	5.0 Max
	Pan	-	94.7

TYPICAL CHEMICAL ANALYSIS

Ignition Loss	.3 %
Silica (SiO_2)	68.3
Alumina (Al_2O_3)	17.5
Iron Oxide (Fe_2O_3)	.10 Max
Lime (CaO)	.3
Magnesia (MgO)	trace
Soda (Na_2O)	3.0
Potash (K_2O)	10.5

THE Feldspar CORPORATION

P.O. Box 99
Spruce Pine, N.C. 28777
Telephone (704) 765-9051

"SIL-O-SPAR"

"SIL-O-SPAR" is a white feldspathic material designed specifically for use in sanitary ware bodies.

"SIL-O-SPAR" is produced by THE FELDSPAR CORPORATION (largest producer of feldspar in the world) in a plant at Spruce Pine, North Carolina, designed specifically to iniformly and consistently incorporate all the desirable characteristics possible. These characteristics are:

TYPICAL CHEMICAL ANALYSIS:

SiO_2	76.50
Al_2O_3	13.78
Fe_2O_3	.054
CaO	1.36
MgO	Trace
K_2O	3.07
Na_2O	5.03
Loss on Ignition	.12

SCREEN SIZE: 140 to 170 Mesh

pH (ASTM D-1208-58T)	9.0
FREE SILICA	33%
SURFACE AREA CM^2 / CM^3):	8-10,000
DENSITY (Lbs./Cu. Ft.): Bulk Density (Scott Volumeter)	37

PRICE, BULK $35.00/ton Bagged (50-lb. bags) - $48.50/ton LTL - $110.00/

RAIL FREIGHT _____

DELIVERED COST _____

THE Feldspar CORPORATION

P.O. Box 99
Spruce Pine, N.C. 28777
Telephone (704) 765-9051

G-FILL

G-Fill is a white, non-combustible, feldspathic inert extender and reinforcing agent.

G-Fill is produced by THE FELDSPAR CORPORATION (largest producer of feldspar in the world) at Spruce Pine, North Carolina, in a plant designed specifically to uniformly and consistently incorporate all the desirable characteristics possible. These characteristics are:

TYPICAL CHEMICAL ANALYSIS:

SiO_2	76.50
Al_2O_3	13.78
Fe_2O_3	.054
CaO	1.36
MgO	Trace
K_2O	3.07
Na_2O	5.03
Loss on Ignition	.12

pH (ASTM D-1208-58T):	9.0
OIL ABSORPTION (ASTM D-281-31):	22.0%
SURFACE AREA CM^2/CM^2:	8-10,000
GE BRIGHTNESS:	90.0
DENSITY (Lbs./Cu. Ft.):	
Bulk Density (Scott Volumeter)	37
Packed	87

G-Fill is non-soluble, contains no free ions, and is uniformly treated to prevent agglomeration.

Samples available.

PRICE: F.O.B. Spruce Pine, N.C. (per ton):

In Bulk	$35.00/ton
In Bags - 50 lb. each*	$48.50/ton

*LTL -$110.00 per ton including bags

THE Feldspar CORPORATION

P.O. Box 99
Spruce Pine, N.C. 28777
Telephone (704) 765-9051

FELEX 100

"FELEX 100" is an inert, white mineral filler and extender specifically prepared for use in coatings, plastics, caulks, sealants, adhesives and elastomers. FELEX 100 offers outstanding resistance to abrasion, chemicals, and weathering. FELEX 100 requires less pigment than other extenders to achieve the same degree of color in coating systems because of its white color and unique physical and chemical properties. FELEX 100 is non-soluble, contains no free ions, and is easily dispersed in aqueous or non-aqueous solutions.

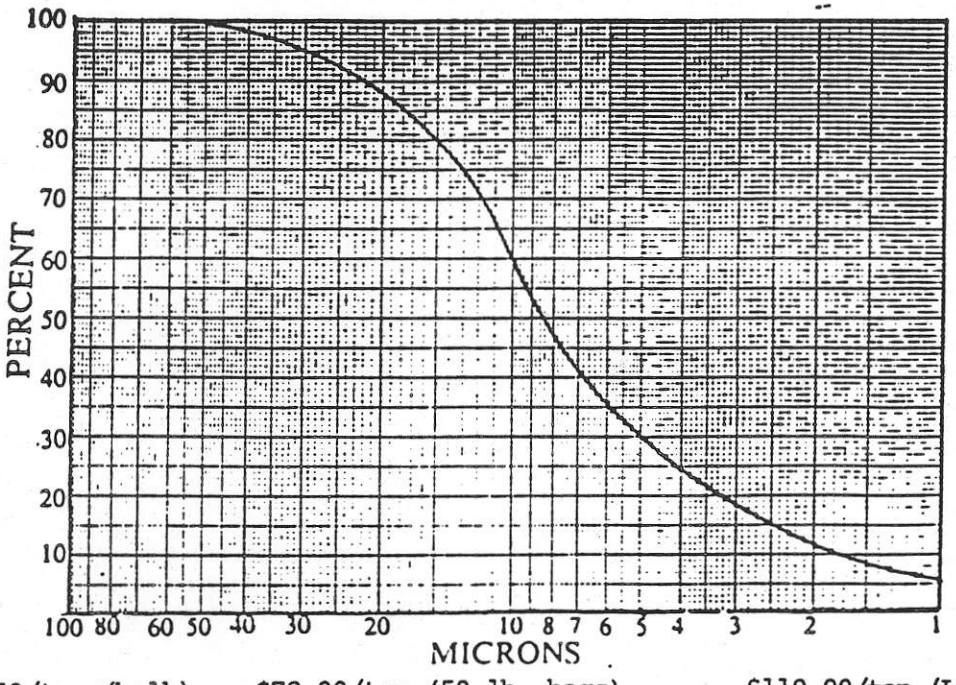
TYPICAL CHEMICAL ANALYSIS

	PERCENT
SiO_2	67.88
Al_2O_3	18.95
Fe_2O_3	.06
CaO	1.67
MgO	Trace
K_2O	4.36
Na_2O	6.95
Ign. Loss	.13

PROPERTIES

Residue on 325 Mesh	.05 Max.
Average particle size	8.4 microns
Surface area CM^2/CM^3	14,500
Oil absorption (ASTM D-281-31)	16-17 lb. per 100 lb.
pH (ASTM D-1208-58T)	9.5
Bulk Density (Loose)	40 lb. cu. ft.
(Bagged)	65 lb. cu. ft.
GE brightness	90
Refractive index	1.53
MOHS' hardness	6.0

PARTICLE SIZE DISTRIBUTION



Price: $65.50/ton (bulk) $78.00/ton (50-lb. bags) $110.00/ton (LTL)

MATERIAS PRIMAS
MINERALES DE SAN JOSE S.A.

LIC JOSE DENIZ PTE 2720 / COL OBISPADO
TEL 404060 / MONTERREY, N.L., 64010
A.P. 1016 / TELEX 382361 MIMME / MEXICO

M-20; M-40 & M-200 SAN JOSE FELDSPAR

TYPICAL ANALYSIS

SiO_2	66.0 – 68.0	K_2O	9.50 – 10.50
Al_2O_3	16.5 – 17.5	CaO	0.50 – 0.70
Fe_2O_3	0.09 – 0.120	MgO	0.08 – 0.10
Na_2O	3.20 – 3.50	LOI	0.40 – 0.50

TYPICAL GRADING

Aperture μ_m		140 US MESH	200 US MESH	325 US MESH
106.....On US	140	2.0 max	0.5 max	Traces
75.....	200	6.0 max	2.5 max	0.5 max
45.....	325	17.0 max	15.0 max	5.5 max
	PAN	75.0	82.0	94.0

USES

Insulators, chinaware, ceramic mosaic floor and tile, pottery, enamel, vitreous china plumbing fixtures and sanitary ware, ceramic spark plug, frits, etc.

MEANS OF DELIVERY

Rail and truckload.

bagging: 110 lbs paper bags

pallets: doubled–faced wooden pallets

INDUSMIN LTD. - SPECIFICATIONS

Glass Grades

Chemical Analyses (in %)	Low Iron	High Iron
SiO_2	59.9	60.0
Al_2O_3	23.5	23.4
Fe_2O_3	0.08	0.35
CaO	0.6	0.7
MgO	0.1	0.1
Na_2O	10.2	9.9
K_2O	5.0	4.8
BaO	-	-
SrO	-	-
P_2O_5	-	-
L.O.I. (Loss on Ignition)	0.6	0.7

Physical Analyses (US Sieve No.)

% Retained on	25 mesh	0.0	0.0
	30 "	0.1	0.1
	40 "	14.5	14.0
	50 "	48.0	46.0
	100 "	86.0	84.0
	200 "	98.0	97.2
	Pan	2.0	3.0

INDUSMIN LTD. - SPECIFICATIONS

Ceramic Grades

Chemical Analyses (%)	A-200	A-270	A-400
SiO_2	60.7	60.7	60.7
Al_2O_3	23.3	23.3	23.3
Fe_2O_3	0.07	0.07	0.07
CaO	0.7	0.7	0.7
MgO	0.1	0.1	0.1
Na_2O	9.8	9.8	9.8
K_2O	4.6	4.6	4.6
L. O. I.	0.7	0.7	0.7

Physical Analyses (US Sieve)			
% Retained on - 70 mesh	0.01	0.0	N. A.
100 "	0.05	0.01	
140 "	0.2	0.05	
200 "	0.7	0.15	
270 "	2.00	0.40	
325 "	5.25	1.75	
Pan	94.75	98.25	
% Finer than - 30 microns	70.0	78.0	98.0
20 "	55.0	65.0	90.0
10 "	33.5	42.0	65.0
5 "	19.0	23.0	33.5
2.5 "	10.0	12.5	16.0

INDUSMIN LTD. - SPECIFICATIONS

Filler & Extender Grades

The five filler and extender grades are a bright white powder with a density of 2.61 grams per cubic centimeter and a Mohs hardness of 5.5 to 6.0.

	Minex 2	Minex 3	Minex 4	Minex 7	Minex 10
Bright	94	95	96	98	98
Hegman		1.0	3.5-4.0	5.5-6.0	6.5-7.0
% Passing (US Sieve):					
200 mesh	99.3	99.9	100	100	
325 mesh	95.8	98.3	99.9	100	
400 mesh					100

NORSK NEFELIN - SPECIFICATIONS

Chemical Analyses (%)	Glass Grade	Ceramic Grade
SiO_2	55.9	56.0
Al_2O_3	24.2	24.2
Fe_2O_3	0.1	0.1
CaO	1.3	1.2
MgO	trace	trace
Na_2O	7.9	7.8
K_2O	9.0	9.1
L. O. I.	1.0	1.0

Physical Analyses (Tyler):

% Retained on - 20 mesh	0.0	-
32 "	0.1	-
35 "	4.9	-
48 "	30.0	-
65 "	52.2	-
200 "	89.0	0.1
325 "	-	0.5
Pan	11.0	99.4

CRYSTAL SILICA COMPANY

Subsidiary of Ottawa Silica Company, Ottawa, Illinois
P. O. Box 1280, Oceanside, California 92054
Area Code 619 / Telephone 757-2630

January 10, 1986

FELDSPAR BYPRODUCT OF FELDSPATHIC SAND PRODUCTION

Chemical Analysis

Fe_2O_3	.084%
Al_2O_3	6.50%
CaO	.50%
MgO	.036%
Na_2O	1.00%
K_2O	2.22%
TiO_2	.04%
Cr_2O_3	.006%
BaO	.11%
SiO_2	89.5%

Physical Analysis

U.S. Sieve #	Mean % On Sieve	Mean % Cumulative
30	Trace	Trace
40	13.0	13.0
50	37.5	50.5
70	21.5	72.0
100	18.5	90.5
140	7.0	97.5
PAN	2.5	2.5

01/01/83

PURCHASING SPECIFICATIONS - CONTAINER GLASS

BROCKWAY, INC. (NY)

Specifications for Feldspathic Sand

A. CHEMICAL SPECIFICATION

1. Flint Grade

SiO_2	± 0.25%	
Fe_2O_3	0.05%	Maximum
Al_2O_3	± 0.25%	
Total RO (CaO+MgO)	± 0.05%	
Total R_2O (Na_2O+K_2O)	± 0.15%	
TiO_2	0.03%	Maximum
ZrO_2	0.01%	Maximum
Cr_2O_3	0.001%	Maximum-must not impart visible color to glass
Moisture	0.10%	Maximum

2. Amber Grade

Same as flint grade except Fe_2O_3 variability must be limited to ±0.02 percent; top of range not to exceed 0.30 percent. Vendor is required to furnish Fe_2O_3 and Al_2O_3 analyses on at least a monthly basis.

Vendor is requested to furnish complete chemical analyses on at least a quarterly basis for both flint and amber grade feldspathic sand.

B. SCREEN SPECIFICATION

1. On U.S. 16 mesh, none. Any evidence of +16 mesh material will render the shipment unacceptable and subject to rejection. Sample size will be 10 to 20 pounds.

2.	On U.S. 20	0
	On U.S. 30	3% Maximum
	On U.S. 40	25% Maximum
	Through 140	5% Maximum
	Screening Time	10 Minutes

C. REFRACTORY PARTICLE SPECIFICATION

The raw material as received shall be free of any particles which will not dissolve in a container glass furnace being operated according to standard operating procedures and parameters.

The following listing illustrates examples of refractory particles which will place raw material shipments subject to rejection:

1. Quartz (SiO_2) grains larger than U.S. 16 mesh (1.19 mm).

2. Clay particles (e.g., kaolin, kaolinite, anauxite), and spinel larger than U.S. 20 mesh (.84 mm) or more than 50 particles larger than U.S. 30 mesh (.59 mm) per 10 lbs. of sample.

3. Alumina silicate refractory heavy minerals (e.g., kyanite, mullite, sillimanite, andalusite) larger than U.S. 30 mesh (.59 mm) or more than 10 grains larger than U.S. 40 mesh (.42 mm) per 10 lbs. of sample.

4. Alumina refractory heavy minerals (e.g., corundum) larger than U.S. 40 mesh (.42 mm).

5. The presence of zircon, cassiterite or chrome particles larger than U.S. 60 mesh (.25 mm).

The sample size used to analyze for these contaminants will be 15-20 pounds.

BROCKWAY, INC. (NY)

Specifications for Nepheline Syenite

A. CHEMICAL SPECIFICATION

1. Low-Iron Syenite

Grade: Indusmin 340
IMC Summit (A) 40 mesh

SiO_2	± 0.50%	
Fe_2O_3	0.10%	Maximum
Al_2O_3	± 0.50%	
CaO	± 0.50%	
Total R_2O (Na_2O+K_2O)	± 0.50%	
Cr_2O_3	0.0010%	Maximum-must not impart visible color to glass
Moisture	0.10%	Maximum

2. High-Iron Syenite

Grade: Indusmin 343
IMC Ridge (B) 40 mesh

Same as low-iron syenite except Fe_2O_3 variability must be limited to ±.06%; top of range not to exceed 0.35%.

B. SCREEN SPECIFICATION

1. On U.S. 20 mesh, none. Any evidence of +20 mesh material will render the shipment unacceptable and subject to rejection. Sample size will be 10 to 20 pounds.

2.

On U.S. 30	0
On U.S. 40	1% Maximum
Through U.S. 200	5% Maximum
Screening Time	15 Minutes

C. REFRACTORY PARTICLE SPECIFICATION

The raw material as received shall be free of any particles which will not dissolve in a container glass furnace being operated according to standard operating procedures and parameters.

The following listing illustrates examples of refractory particles which will place raw material shipments subject to rejection:

1. Quartz (SiO_2) grains larger than U.S. 16 mesh (1.19 mm).

2. Clay particles (e.g., kaolin, kaolinite, anauxite), and spinel larger than U.S. 20 mesh (.84 mm) or more than 50 particles larger than U.S. 30 mesh (.59 mm) per 10 lbs. of sample.

3. Alumina silicate refractory heavy minerals (e.g., kyanite, mullite, sillimanite, andalusite) larger than U.S. 30 mesh (.59 mm) or more than 10 grains larger than U.S. 40 mesh (.42 mm) per 10 lbs. of sample.

4. Alumina refractory heavy minerals (e.g., corundum) larger than U.S. 40 mesh (.42 mm).

5. The presence of zircon, cassiterite or chrome particles larger than U.S. 60 mesh (.25 mm).

The sample size used to analyze for these contaminants will be 15-20 pounds.

BROCKWAY, INC. (NY)

Specifications for Aplite

A. CHEMICAL SPECIFICATION

SiO_2	± 0.5%	
Fe_2O_3	0.1%	Maximum
Al_2O_3	± 0.5%	
CaO	± 0.5%	
Total R_2O (Na_2O+K_2O)	± 0.5%	
Cr_2O_3	0.001%	Maximum-must not impart visible color to glass
Moisture	0.1%	Maximum

B. SCREEN SPECIFICATION

1. On U.S. 16 mesh, none. Any evidence of +16 mesh material will render the shipment unacceptable and subject to rejection. Sample size will be 10 to 20 pounds.

2.

On U.S. 20	0	
On U.S. 30	2%	Maximum
Through U.S. 200	5%	Maximum
Screening Time	15	Minutes

C. REFRACTORY PARTICLE SPECIFICATION

The raw material as received shall be free of any particles which will not dissolve in a container glass furnace being operated according to standard operating procedures and parameters.

The following listing illustrates examples of refractory particles which will place raw material shipments subject to rejection:

1. Quartz (SiO_2) grains larger than U.S. 16 mesh (1.19 mm).

2. Clay particles (e.g., kaolin, kaolinite, anauxite), and spinel larger than U.S. 20 mesh (.84 mm) or more than 50 particles larger than U.S. 30 mesh (.59 mm) per 10 lbs. of sample.

3. Alumina silicate refractory heavy minerals (e.g., kyanite, mullite, sillimanite, andalusite) larger than U.S. 30 mesh (.59 mm) or more than 10 grains larger than U.S. 40 mesh (.42 mm) per 10 lbs. of sample.

4. Alumina refractory heavy minerals (e.g., corundum) larger than U.S. 40 mesh (.42 mm).

5. The presence of zircon, cassiterite or chrome particles larger than U.S. 60 mesh (.25 mm).

The sample size used to analyze for these contaminants will be 15-20 pounds.

Owens Corning Fiberglas - Purchasing Specifications

no: CRM.59.03.319
date: 12/21/83
supersedes: PROPOSED

MATERIAL - Nepheline Syenite Grade 134

SCOPE

This specification outlines the necessary information for ordering and inspecting Nepheline Syenite, Grade 134.

No change shall be made in the quality of sucessive shipments of material furnished under this specification without first obtaining the written approval of Owens-Corning Fiberglas Corporation.

A. CHEMICAL ANALYSIS

Material	Percent by Weight Minimum	Maximum
SiO_2	59.0	61.0
Al_2O_3	22.5	23.3
Fe_2O_3		0.5
CaO		1.5
MgO		0.3
Na_2O	9.5	10.1
K_2O	4.7	5.3
LOI + Free Moisture		1.35
Free Moisture (H_2O)		0.25

NOTES:

1. The chemical and physical composition of the material must remain uniform from shipment to shipment.

2. The following impurities shall not exceed the limits specified below:

Phosphorous as P_2O_5	0.01% maximum
Arsenic as As_2O_3	0.01% maximum
Sulfide Sulfur	0.01% maximum
Metallic Iron	0.005% maximum

3. This material is completely free from foreign materials such as wood splinters, straw, etc., and tramp iron, or anything deleterious to our process.

4. The vendor must report significant process changes and may not supply a raw material from another mine or from another plant without prior notification to, and approval of, the Raw Material Section of Glass Technology, Owens-Corning Fiberglas, Granville, OH 43023.

Company Name
Authorized Signature
Title
Return to Toledo Purchasing Department

B. PHYSICAL ANALYSIS

Physical	Percent of Original Weight Retained Maximum
On 20 Screen	0.0
On 30 Screen	0.5
Thru 200 Screen	40.0

NOTE: U.S. Standard sieves are used.

C. TEST METHODS

Those employed by Owens-Corning Fiberglas Corporation as developed by the Analytical Division of the R & D Services Department and can be obtained from them.

D. SAFETY PRECAUTIONS

Nepheline syenite is classified as a nuisance dust. Exposure to high concentrations of dust may result in upper respiratory tract irritation. Avoid inhalation of dust. Wear nuisance dust respirator if work area is dusty.

This material has been reviewed by the Corporate Medical Services Department.

E. PACKAGING AND IDENTIFICATION

This material is shipped in cars or trucks as designated by the Purchasing Department. Cars or trucks must be thoroughly cleaned before loading. Material is identified on the Bill of Lading and invoice with product name and the following OCF Stores Code Number: 06M0124.

F. VENDOR

At the discretion of the Purchasing Department.

G. REJECTION

Owens-Corning Fiberglas Corporation reserves the right to reject upon receipt and hold for vendor's disposal, any portion or all the material which does not conform to all the requirements set forth herein.

H. SPECIFICATION INQUIRY

Any inquiry regarding the contents of this specification should be addressed to:

Raw Material Section
Glass Technology Department
Owens-Corning Fiberglas Corporation
P.O. Box 415
Granville, OH 43023

Aplite

A. SCOPE

This specification outlines the necessary information for ordering and inspecting aplite. sp

B. CHEMICAL ANALYSIS

Material	% By Weight Min.	Max.
SiO2		64.0
Al2O3	21.5	
Fe2O3		0.15
CaO		6.2
Na2O	5.0	
K2O	2.2	
H2O		0.4
LOI plus H2O		0.9

NOTE:

1. The chemical and physical composition of the material must remain uniform from shipment to shipment.

2. The following impurities shall not exceed the limits specified below:

Phosphorous as P2O5	0.01% max.
Arsenic as As2O3	0.01% max.
Sulfide sulfur	0.01% max.
Metallic iron	0.005% max.

3. This material shall be completely free from foreign materials such as wood splinters, straw, etc., and tramp iron, or anything deleterious to our process. Excess moisture shall not be present to cause freezing, inasmuch as storage rooms are not heated.

C. PHYSICAL ANALYSIS

	Max. % of Original Weight Retained (Accumulative)
+ 16 mesh	0.0
+ 20 mesh	0.5
+ 30 mesh	2.5
-200 mesh	5.0

NOTE:

1. U. S. Standard sieves are used.

D. TEST METHODS

Those employed by Owens-Corning Fiberglas Corporation as developed by the Analytical Division of the R&D Services Department and can be obtained from them.

E. SAFETY PRECAUTIONS

Avoid inhalation of dust and/or use approved respiratory equipment.

This material has been reviewed by the Corporate Medical Services Department.

F. PACKAGING AND IDENTIFICATION

This material to be shipped in cars or trucks as designated by the Purchasing Department. Cars or trucks shall be thoroughly cleaned before loading. 08M0123

G. VENDOR

At the discretion of the Purchasing Department.

H. REJECTIONS

The Owens-Corning Fiberglas Corporation reserves the right to reject any portion or all the material which does not conform to all the requirements set forth herein upon receipt at our stores.

I. SPECIFICATION INQUIRY

Any inquiry regarding the contents of this specification should be addressed to:

Raw Material Section
Glass Technology Department
Owens-Corning Fiberglas Corporation
P. O. Box 415
Granville, Ohio 43023

APPENDIX B

CONSUMERS

CONTAINER AND SPECIALTY GLASS

Anchor Glass Container (813) 870 - 6120
(Diamond Bathurst)
(Container General)
Tampa, Fla.
Tom Rogers

Plants: Antioch, Calif.
Hayward, Calif.
Vernon, Calif.
Henryetta, Okla.
Corsicana, Tex.
Houston, Tex.

Ball-Incon Glass (317) 747 - 6100
Muncie, Ind.
Ron Moore

Plants: Seattle, Wash.
El Monte, Calif.
Madera, Calif.
Okmulgee, Okla.

Brockway, Inc. (814) 268 - 3015
Brockway, Pa.
Dennis Golden

Plants: Oakland, Calif.
Pomona, Calif.
Ada, Okla.
Muskogee, Okla.

Consumers Glass (416) 232 - 3000
Lavington, British Columbia
Don Hoye

Plant: Lavington, B. C.

Coors Glass Co. (303) 425 - 7965
Wheat Ridge, Colo.
John Remigio

Plant: Wheat Ridge, Colo.

Domglas (403) 548 - 3901
Redcliff, Alberta
Vaughn Bullough

Plant: Redcliff, Alta.

Foster Forbes (317) 668 - 1200
Marion, Ind.
Randy Hosier

Plant: Maywood, Calif.

Gallo Glass Co. (209) 521 - 3411
Modesto, Calif.
Al Menshaw

Plant: Modesto, Calif.

Kerr Glass (213) 487 - 3250
Los Angeles, Calif.
Neil Ludwig

Plants: Santa Ana, Calif.
Sand Springs, Okla.

Latchford Glass (213) 587 - 7221
Los Angeles, Calif.
R. E. Todd

Plant: Huntington Park, Calif.
San Leandro, Calif.

Owens-Illinois (419) 247 - 5000
Toledo, Ohio
Al England

Plants: Vernon, Calif.
Oakland, Calif.
Tracy, Calif.
Portland, Ore.
Waco, Tex.

Spectrum Glass (206) 483 - 6699
Bothell, Wash.
Dave Grega

Plant: Bothell, Wash.

FIBERGLASS

CertainTeed, Inc. (215) 687 - 5000
(Reinforcing Div.)
Valley Forge, Pennsylvania
Robert Boyce

Plant: Wichita Falls, Tex.

CertainTeed, Inc. (209) 665 - 4831
(Insulation Div.)
Chowchilla, California
Tommy Ricci

Plant: Chowchilla, Calif.

Evanite Corp. (503) 753 - 1211
Corvallis, Oregon
Anup Sircar

Plant: Corvallis, Ore.

Fiberglas Canada (519) 336 - 5670
Sarnia, Ontario
John Priestley

Plants: Edmonton, Alta.
Mission, B. C.

GAF Industries (818) 334 - 7851
Irwindale, Calif.
Dave Pickard

Plant: Irwindale, Calif.

Manville, Inc. (303) 987 - 4900
Denver, Colo.
John Glascock.

Plants: Willows, Calif.
Cleburne, Tex.

Manville of Canada, Inc. (403) 227 - 5561
Innisfail, Alberta
Randy Brooks

Plant: Innisfail, Alga.

Northwest Fiberglass (206) 932 - 2091
Seattle, Wash.
Bob Lamb

Plant: Seattle, Wash.

Owens Corning Fiberglas (419) 248 - 8000
Toledo, Ohio
Jack Hostetler

Plant: Santa Clara, Calif.

Standard Industries
Permalife Glass Fiber Div. (512) 623 - 3131
San Antonio, Texas
Gerald Dubinski

Plant: San Antonio, Tex.

CERAMICS AND WHITEWARE

Armitage Shanks - Kilgore (214) 984 - 3525
Kilgore, Texas
Matthew Moore

Plant: Kilgore, Texas

Aztec Ceramics (512) 661 - 2323
San Antonio, Texas
Bill Denk

Plant: San Antonio, Tex.

Briggs Plumbing Fixtures (714) 825 - 3032
Colton, Calif.
Don Franco

Plant: Colton, Calif.

Burden China & Porcelain
El Monte, California
Judy Burden

Plant: El Monte, Calif.

Coors Ceramics (303) 278 - 4000
Golden, Colo.
Bart Hart, Devel. Engr.

Plant: Golden, Colo.

Crane Canada, Inc. (604) 931 - 2424
Port Coquitlam, British Columbia
Jerry Pritchard

Plant: Port Coquitlam, B. C.

Crane Plumbing Inc.
(Verson Allsteel Press) (409) 279 - 5314
Dallas, Texas
Ed Arnson

Plant: Hearne, Tex.

Dal-Tile (214) 398 - 1411
Dallas, Texas
Steve McIntyre

Plant: Dallas, Texas

Fairey and Co. (604) 584 - 3466
Surrey, British Columbia
Len Fairey

Plant: Surrey, B. C.

Frankoma Pottery (918) 224 - 5511
Sapulpa, Oklahoma
Ted Steeples

Plant: Sapulpa, Okla.

H. F. Coors China (213) 776 - 3350
Inglewood, California
John Million

Plant: Inglewood, Calif.

Hueckel Corp. (415) 754 - 0645
Antioch, California

Plant: Antioch, Calif.

Hycroft China Co. (403) 526 - 3575
Medicine Hat, Alberta
Nellie Mehrer

Plant: Medicine Hat, Alta.

Independent Porcelain (403) 527 - 3348
Medicine Hat, Alberta
Frank Weidel

Plant: Medicine Hat, Alta.

Industrial Minerals Co. (916) 383 - 2811
Sacramento, California
Ken Rekstad

Plant: Sacramento, Calif.

Kohler (915) 643 - 2661
Brownwood, Texas
Frank Williams

Plant: Brownwood, Texas

Appendix B

Norris Plumbing Fixtures (818) 965 - 3394
La Puente, California
David Shikuma

Plant: La Puente, Calif.

Plainsman Clays (403) 527 - 8535
Medicine Hat, Alberta
Joe Ziebart

Plant: Medicine Hat, Alta.

Universal Rundle (512) 426 - 3371
Hondo, Texas
Harry Miller

Plant: Hondo, Texas

Westwood Ceramics (213) 330 - 0631
Inglewood, California
Larry Sherrill

Plant: Inglewood, Calif.

APPENDIX - C

LABORATORIES

Alberta Research Council
11315 87 Avenue
Edmonton
Alberta T6G 2C2
(403) 439 - 5916

British Columbia Research Council

Cominco Engineering Services Ltd.
1200 West 73rd Avenue
Vancouver
British Columbia V6P 6G5
(604) 266 - 1471

Corning Engineering Laboratory Services
Corning Glass Works
Corning
New York 14831
(607) 974 - 6360

Emhart Corporation
Materials Testing Laboratory
P. O. Box 700
Windsor
Connecticut 06095
(203) 688 - 8551

Hunter Mining Laboratory, Inc.
994 Glendale Avenue
Sparks
Nevada 89431
(702) 358 - 6227

International Processing Research Corp.
(Formerly Colorado School of Mines Research)
5906 McIntyre Street
Golden
Colorado 80403
(303) 279 - 2581

Lakefield Research
P. O. Box 430
Lakefield
Ontario K0L 2H0
(705) 652 - 3341

Miles Industrial Minerals Research
12940 W. 16th Drive
Golden
Colorado 80401
(303) 233 - 4794

Ontario Research Foundation
Sheridan Park Research Community
Mississauga
Ontario L5K 1B3
(416) 822 - 4111

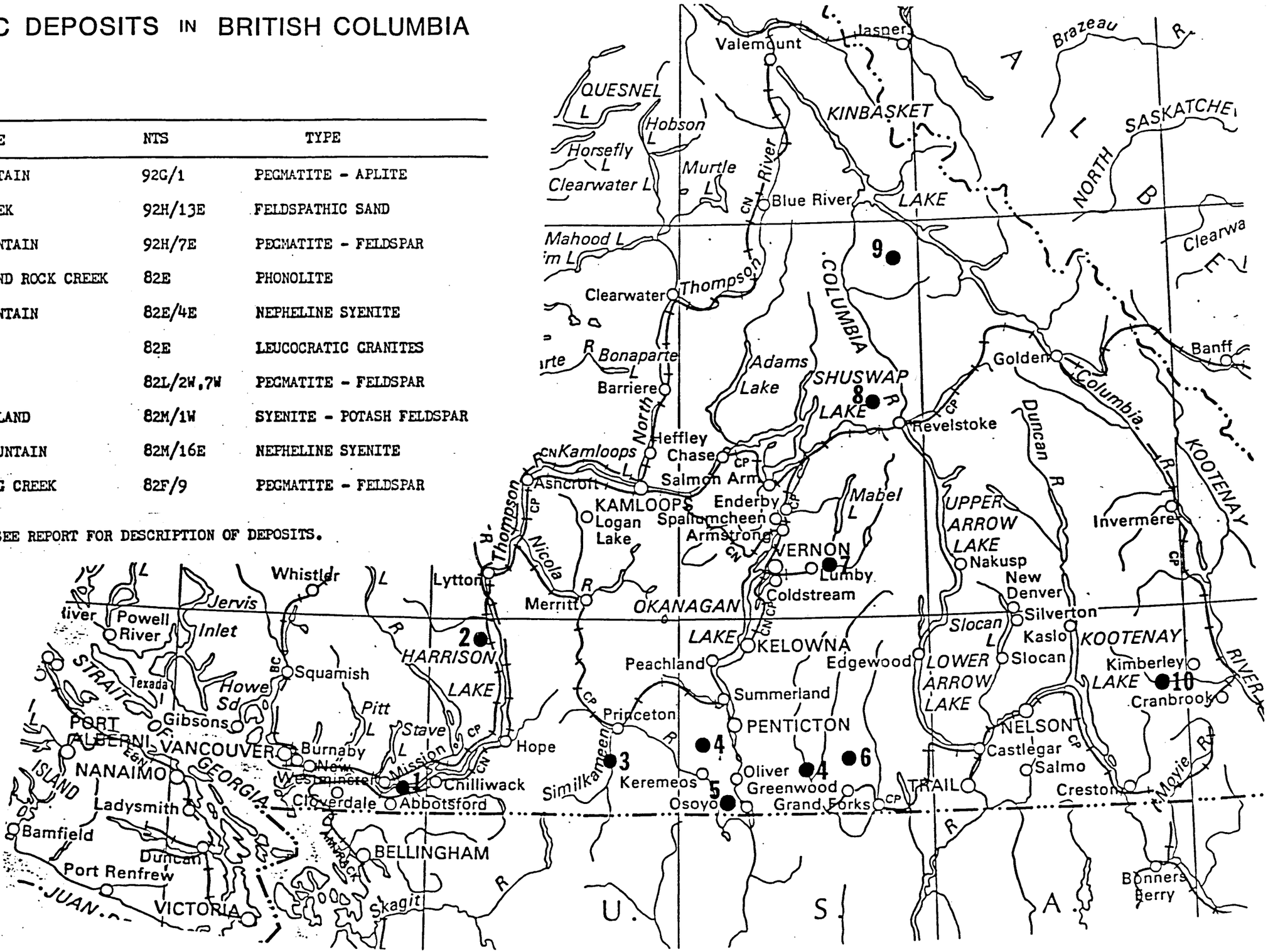
Ore Sorters (North America), Inc.
Irongate 1, Suite 203
777 South Wadsworth Blvd.
Lakewood
Colorado 80226
(303) 985 - 0238

Owens-Illinois Analytical Services
One Seagate
Toledo
Ohio 43666
(419) 247 - 8513

FELDSPATHIC DEPOSITS IN BRITISH COLUMBIA

NUMBER	NAME	NTS	TYPE
1	SUMAS MOUNTAIN	92G/1	PEGMATITE - APLITE
2	SCUZZY CREEK	92H/13E	FELDSPATHIC SAND
3	COPPER MOUNTAIN	92H/7E	PEGMATITE - FELDSPAR
4	KEREMEOS AND ROCK CREEK	82E	PHONOLITE
5	KRUGER MOUNTAIN	82E/4E	NEPHELINE SYENITE
6	GREENWOOD	82E	LEUCOCRATIC GRANITES
7	LUMBY	82L/2W,7W	PEGMATITE - FELDSPAR
8	MOUNT COPELAND	82M/1W	SYENITE - POTASH FELDSPAR
9	TRIDENT MOUNTAIN	82M/16E	NEPHELINE SYENITE
10	HELLROARING CREEK	82F/9	PEGMATITE - FELDSPAR

NOTE: SEE REPORT FOR DESCRIPTION OF DEPOSITS.



MAP 1