

# FELDSPAR AND NEPHELINE SYENITE

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## Feldspar

Feldspars are aluminosilicates containing varying amounts of calcium, potassium, or sodium. In glassmaking, feldspar provides alumina for improving hardness, durability, and resistance to chemical corrosion. In ceramics, feldspar is used as a flux, lowering the vitrifying temperature of a ceramic body during firing and forming a glassy phase.

Glass and ceramics continued to be the major end uses of feldspar. Glass usage in soft drink containers has decreased in recent years because of competition from lighter weight and shatter-resistant packaging materials, such as aluminum and polyethylene terephthalate. One sector having positive growth for glass containers in the United States has been the growing beer industry, which has diversified its products, such as ales, lagers, and stouts (Kendall, 1998). The demand for beer in many developing countries has been increasing, and in these markets, glass holds a strong position (Ceramic Industry, 1998a).

The glass container recycling rate in the United States was 35% in 1997. The quality of recycled glass (as cullet) has been diminished by contamination from included metal caps and ceramics. The recycling rates for amber and green glass have been considerably higher than for flint (clear) glass, even though the latter accounts for around 60% of total U.S. container production (Kendall, 1998).

**Production.**—U.S. production of marketable feldspar in 1998 was an estimated 820,000 metric tons (t) with a value of \$40.8 million (table 1). Although this was a decrease compared with 900,000 t in 1997, the amount of marketed feldspar sold or used in 1998 (table 4), 915,000 t, was similar to that of 1997. Feldspar was mined in seven States, which were, in descending order of output, North Carolina, Virginia, California, Georgia, Oklahoma, Idaho, and South Dakota. North Carolina accounted for about 46% of the total. Mining was by 10 companies with 13 mine/plant operations—North Carolina had 5 operations, California, 3; and the remaining 5 States listed above, 1 each. South Carolina had a feldspar-grinding facility.

In early 1998, FMC Corp., Lithium Division closed its mining and processing operation at Cherryville (Bessemer City), NC, (North American Mineral News, 1998). Spartan Minerals Corp. in Pacolet, SC, operated a grinding mill using stockpiled material from FMC. With the depletion of stockpiled material, Spartan shut down its mill at yearend.

Domestic production data for feldspar were collected by the U.S. Geological Survey by means of a voluntary survey. Of the 13 known mine/plant operations, 6, or 46% of the total operations canvassed, responded by the data closeout date. The

six operations represented 60% of the production shown in table 1.

**Consumption.**—Of U.S. feldspar sold or used, 69% went into the manufacture of glass, including glass containers and glass fiber. Pottery and other uses, such as fillers, accounted for the remainder.

The home construction and renovation industries used glass fiber insulation, plumbing fixtures, and tile. According to preliminary data, housing starts were about 1.6 million units in 1998 (Simons, 1999) compared with 1.48 million units in 1997.

**World Review.**—On the basis of preliminary data for 1998, Italy was the largest feldspar producer with 2.3 million tons (Mt) (table 9). Turkey was second with about 1 Mt, and the United States was third with 820,000 t. Thailand produced more than 600,000 t, and France, Germany, and Spain each had outputs in the 400,000- to 550,000-metric-ton-per-year (t/yr) range.

**Australia.**—Manna Hill Mining Co. Pty. Ltd. began mining from its two soda feldspar operations near Manna Hill in South Australia, about 400 kilometers (km) northeast of Adelaide. Measured reserves of one deposit were said to be more than 1 Mt of pure albite, with an additional inferred resource. Quartz and mica were not found in the ore body, and no mineral separation facilities were said to be required. Test results indicated that the albite was suitable for use in glass and ceramics manufacture. A large additional resource was found adjacent to the deposit. The company was negotiating with potential buyers for its products inside and outside the country (Industrial Minerals, 1998c).

Minerals Corp. Ltd., based in Ingleburn, New South Wales, was seeking investors to assist in developing a deposit of alaskite rock near Oberon, New South Wales, 180 km west of Sydney. Typical composition of this alaskite is 32% albite, 28% quartz, 26% sodic microcline, 12% muscovite, and 1.5% other minerals. Reserves were reported to be very large. Processing would include multiple-stage froth flotation yielding feldspar, mica, and silica (Industrial Minerals, 1998b).

**Indonesia.**—Much of the high-grade feldspar for the country's tableware and porcelain industries was being imported. Test work, however, was carried out to beneficiate and upgrade feldspar from a large deposit at Banjarnegara in central Java. Two stages of froth flotation yielded material with almost 10% total alkali content and an iron content of 0.11%; this material could be applied in the manufacture of medium-grade porcelain tableware. Further optimization of the flotation process might result in a feldspar product suitable for high-grade porcelain or bone china tableware bodies (Asian

Ceramics, 1998b).

**Italy.**—The country's ceramics industry was one of the largest in Europe, and its tile industry was probably the world's largest. A major trend in the Italian tile industry, and worldwide, was the growth of the *grès porcellenato* (unglazed porcelain stoneware) tile market. Feldspar was a major constituent in this type of material, making up 60% of the mix compared with 40% in a typical single-fired tile (Pearson, 1998).

Maffei SpA was the largest producer of feldspar in Italy. Its products included aplite, rhyolite, and pegmatite grits for white and red single-firing ceramics and ground feldspar and grits for single-firing ceramics, *grès porcellenato*, sanitaryware, tableware, and container glass (Pearson, 1998). In northern Sardinia, Maffei Sarda Srl has been mining sodium feldspar since 1989. From 1995 to 1997 (latest available data), output was about 300,000 t/yr. The company's products were used in white single-firing and *grès porcellenato* tiles. A new product, containing soda-potash feldspar, had a high level of whiteness, which allowed it to be used in sanitaryware and even in bone china (Benedusi, 1998).

Gruppo Minerali Industriali Spa, with its subsidiaries, was the second largest feldspar producer. Besides traditional products for the tile industry, the company started to move into more specialized markets requiring additional processing, such as sanitaryware, enamels, and frits. In the area of process development, the company pioneered a technique to extract feldspathic material from granite. Material was extracted from the manufacturing residues of granite dimension stone from a mining dump in the Lago Maggiore region. The product was said to be suitable for ceramic tiles and sanitaryware (Pearson, 1998).

**Malaysia.**—Although the country has suitable clay and quartz deposits for its ceramic and glass industries, it lacks workable feldspar deposits. To decrease the amount of imported feldspar, research was undertaken to obtain a feldspar-quartz product (silspar) from pegmatite material. Two locations proved to be suitable. The Bukit Mor deposit contains 65% to 70% feldspar, 25% to 30% quartz, and 5% to 7% muscovite. The other pegmatite deposit is Simpang Pulai. Upgraded material from the deposits was tested by firing at various temperatures to evaluate the quality of the fused product for whiteness, number of dark specks, etc. The production cost for silspar was about one third the cost of imported feldspar. Any decision for commercial-scale production has yet to be made, but the potential of the process has been shown (Habib, Hussin, and Low, 1998).

**Turkey.**—Pending local approval, feldspar producers were planning to expand capacity of the main port, Güllük, in the country's feldspar producing region, the Menderes Massif. Capacity at Güllük, located on the west coast of Turkey, would be increased from 1 million tons per year (Mt/yr) to 3 Mt/yr (Industrial Minerals, 1998a).

Turkey has had a long history in the production of ceramics. In recent years, the tile and sanitaryware industries have become well established, and the country was working to reach a similar status with its tableware industry. A substantial period of technology transfer from Germany and Italy enabled

plant modernizations and advanced factories. Quality products have been achieved, and the remaining goal will be for the country's tableware to become sufficiently well known in the world market (Asian Ceramics, 1998c).

**Outlook.**—With a very active U.S. construction market, tile consumption increased about 17% in 1997 (latest data). With global competition from Italy, Mexico, Spain, and other countries, however, 62% of the U.S. tile supply was from imports. Worldwide, China was reported to be the largest tile producer in 1996 (latest data) with 1,400 million square meters (Mm<sup>2</sup>). Italy was second with about 550 Mm<sup>2</sup>, and Spain was third with approximately 410 Mm<sup>2</sup>. The United States had an output of about 50 Mm<sup>2</sup> (Ceramic Industry, 1998b).

During the 1990's, use of sanitaryware has been affected by flat or decreased activity in the Western European construction industry. Production of sanitaryware was very labor intensive, with around 40% of the production cost being made up of labor costs. Traditional casting techniques were very time consuming. A technique known as pressure casting has shortened the manufacturing process considerably but was also more expensive than traditional casting. Pressure casting was mainly confined to wash basins. Eastern Europe, including Bulgaria, Czech Republic, Hungary, Poland, and Romania, offered cheaper labor than Western Europe for the production of labor-intensive, heavier sanitaryware pieces made by traditional casting methods. The area also offered market growth areas for finished products. Outside Europe, many producers invested in the growing sanitaryware markets of Asia and Latin America (Keegan, 1998).

In Japan, gradual recovery in the domestic housing market was projected in 1998, with corresponding growth in the tile and sanitaryware sectors. In Taiwan, the ceramics industry has been affected by suppressed construction activity and the threat of cheaper imports from such countries as Indonesia, the Republic of Korea, and Malaysia. Thailand has had one of the most technically advanced ceramics industries in the region but was projected to have flat construction activity in 1998 (Asian Ceramics, 1998a).

## Nepheline Syenite

Nepheline syenite is a light-colored, quartz-deficient feldspathic rock made up of mostly soda and potash feldspars and nepheline. In glass and ceramics, nepheline syenite, like feldspar, provides alkalis, which, as a flux, lower the melting temperature of a glass or ceramic mixture, prompting faster melting and fuel savings. In glass, nepheline syenite also supplies alumina, which gives increased resistance to scratching and breaking, improved thermal endurance, and increased chemical durability.

Canada and Norway produced nepheline syenite for glass and ceramic use. In Ontario, Canada, Unimin Canada, Ltd., had two deposits, at Nephton and Blue Mountain, and two processing plants 175 km northeast of Toronto. An estimated 60% of the output was shipped to U.S. markets; 20%, to the Canadian market; and 20%, to other countries.

In Norway, North Cape Minerals AS produced about 310,000 t of nepheline syenite in 1997 (latest data) from an

underground mine on the Arctic island of Stjernoya (Karlsen, 1998). An estimated 70% of the output went to glass manufacturing; 28%, to ceramics; and 2%, to filler.

Growth in consumption of nepheline syenite in glass containers, as with feldspar, has been affected by competition from metal and plastic containers. Use of nepheline syenite in bathroom fixtures, tile, and glass fiber insulation depended on the housing construction and remodeling markets.

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<sup>1</sup>Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1  
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS 1/

		1994	1995	1996	1997	1998
United States:						
Feldspar:						
Produced 2/	metric tons	765,000	880,000	890,000	900,000	820,000 e/
Value	thousands	\$31,200	\$37,400	\$39,400	\$42,500 e/	\$40,800 e/
Exports	metric tons	17,300	14,700	10,200	7,220	13,200
Value	thousands	\$1,940	\$1,970	\$1,390	\$993	\$1,430
Imports for consumption	metric tons	7,360	8,980	7,150	8,580	6,560
Value	thousands	\$513	\$813	\$594	\$753	\$601
Nepheline syenite:						
Imports for consumption	metric tons	333,000	316,000	247,000	346,000	320,000
Value	thousands	\$18,700	\$19,700	\$20,900	\$23,900	\$24,100
Consumption, apparent, feldspar plus nepheline syenite 3/						
	thousand metric tons	1,090	1,190	1,130	1,250 e/	1,130 e/
World: Production, feldspar	do.	6,490	7,880 r/	8,170 r/	8,250 r/	8,080 e/

e/ Estimated. r/ Revised.

1/ Data are rounded to three significant digits.

2/ Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-silica mixtures and aplite; includes potash feldspar (8% K<sub>2</sub>O or higher).

3/ Production plus imports minus exports.

TABLE 2  
FELDSPAR PRODUCED IN THE UNITED STATES 1/

(Thousand metric tons and thousand dollars)

Year	Flotation concentrate		Other 2/		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1997 e/	377	17,800	522	24,700	900	42,500
1998 e/	348	17,800	472	23,000	820	40,800

e/ Estimated.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes hand-cobbed, feldspar-silica mixtures (feldspar content), and aplite.

TABLE 3  
PRODUCERS OF FELDSPAR AND FELDSPATHIC MATERIALS IN 1998

Company	Plant location	Product
APAC Arkansas Inc.	Muskogee, OK	Feldspar-silica mixture.
The Feldspar Corp.	Monticello, GA	Potash feldspar.
Do.	Spruce Pine, NC	Soda-potash feldspar; feldspar-silica mixture.
FMC Corp. Lithium Division	Bessemer City, NC	Feldspar-silica mixture.
Franklin Industrial Minerals	Kings Mountain, NC	Potash feldspar.
PW Gillibrand Co.	Simi Valley, CA	Feldspar-silica mixture.
Granite Rock Co.	Felton, CA	Do.
KT Feldspar Corp.	Spruce Pine, NC	Soda-potash feldspar.
Pacer Corp.	Custer, SD	Potash feldspar.
Spartan Minerals Corp.	Pacolet, SC	Feldspar-silica mixture.
Unimin Corp.	Byron, CA	Do.
Do.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Soda-potash feldspar.
U.S. Silica Co.	Montpelier, VA	Aplite.

TABLE 4  
 FELDSPAR SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/ 2/

(Thousand metric tons and thousand dollars)

Use	1997 e/		1998 e/	
	Quantity	Value	Quantity	Value
Flotation concentrate:				
Glass	148	7,950	155	8,620
Pottery	233	15,100	W	W
Miscellaneous	--	--	W	W
Total	382	23,000	355	21,000
Other: 3/				
Glass	478	24,500	477	22,700
Pottery	W	W	84	5,640
Miscellaneous	W	W	--	--
Total	513	27,600	560	28,300
Total:				
Glass 4/	626	32,400	632	31,300
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Total	895	50,600	915	49,300

e/ Estimated. W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Includes potash feldspar (8% K<sub>2</sub>O or higher).

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Includes hand-cobbed, feldspar-silica mixtures (feldspar content), and aplite.

4/ Includes container glass, glass fiber, and other glass.

TABLE 5  
 PRICES FOR U.S. FELDSPAR, YEAREND 1998

(Dollars per metric ton)

	Price 1/
Glass grade:	
30 mesh, soda	44-55
80 mesh, potash	88
Ceramic grade:	
170 to 250 mesh, soda	66-77
200 mesh, potash	105

1/ Bulk, exworks, United States.

Source: Industrial Minerals, no. 375, December 1998, p. 78.

TABLE 6  
 U.S. EXPORTS OF FELDSPAR, BY COUNTRY 1/

Country	1997		1998	
	Quantity (metric tons)	Value	Quantity (metric tons)	Value
Canada	1,490	\$223,000	2,190	\$300,000
Dominican Republic	271	35,900	264	43,100
Ecuador	2,630	255,000	4,340	356,000
Italy	1,140	181,000	4,880	392,000
Mexico	857	151,000	325	54,200
Thailand	319	59,500	200	39,300
Venezuela	254	31,000	441	50,700
Other	266	56,400	515	191,000
Total	7,220	993,000	13,200	1,430,000

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7  
U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY 1/

Country	1997		1998	
	Quantity (metric tons)	Value 2/	Quantity (metric tons)	Value 2/
Mexico	8,210	\$630,000	6,250	\$535,000
China	--	--	200	24,000
Other	369	122,000	108	41,500
Total	8,580	753,000	6,560	601,000

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Customs value.

Source: Bureau of the Census.

TABLE 8  
U.S. IMPORTS FOR CONSUMPTION OF NEPHELINE SYENITE 1/ 2/

Year	Quantity (metric tons)	Value 3/ (thousands)
1997	346,000	23,900
1998	320,000	24,100

1/ Crude and ground combined.

2/ Data are rounded to three significant digits.

3/ Customs value.

Source: Bureau of the Census.

TABLE 9  
FELDSPAR: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1994	1995	1996	1997	1998 e/
Algeria	6,900	7,000	7,000 e/	7,000 e/	7,000
Argentina	42,516	37,095	72,539	40,000 e/	35,000
Australia e/	16,000	16,000	17,000	20,000	20,000
Austria	4,883	--	--	--	--
Brazil (crude)	205,000 r/	198,854 r/	200,000 r/	200,000 r/ e/	200,000
Burma 4/	5,605	8,749	9,000 e/	10,000 e/	8,000
Chile	9,967	7,293	3,702	3,808 r/	3,800
Colombia	76,188	58,100	78,093 r/	66,845 r/	55,000
Ecuador	5,692	10,297 r/	10,321 r/	60,328 r/	50,000
Egypt e/	39,745 5/	39,800	40,000	40,000 5/	40,000
Finland	43,483	41,808	40,265 r/	40,000 r/ e/	40,000
France	390,000 e/	632,000	546,000	550,000 e/	500,000
Germany	379,427	329,624	359,666	455,969 r/	450,000
Greece e/	35,000	30,000	30,000	30,000	30,000
Guatemala e/	7,500	7,600	7,500	7,500	7,500
India	64,693	99,618	85,213	90,000 e/	88,000
Iran e/	79,000 5/	80,000	80,000	80,000	80,000
Italy	1,806,935	2,199,000	2,310,000	2,300,000 e/	2,300,000
Japan 6/	56,007	65,086	55,122 r/	55,000 e/	52,000
Kenya e/	1,200	500	100	100	100
Korea, Republic of	319,658	367,578	319,112	320,000 e/	320,000
Macedonia e/	15,000	15,000	15,000	10,000	10,000
Mexico	133,441	121,779	139,972 r/	155,760 r/	160,000
Morocco	1,000 e/	17,233	12,659 r/	15,110 r/	15,000
Nigeria	1,000 e/	3,722 r/	800 r/	1,000 e/	500
Norway 7/	62,905	75,397	75,000 e/	75,000 e/	75,000
Pakistan	15,335	21,163	32,572	30,000 e/	31,000
Peru e/	11,400	11,400	11,400	11,400	11,400
Philippines	43,805 r/	29,950 r/	40,000 e/	30,000 r/ e/	30,000
Poland	46,000	46,000	64,000 r/	50,000 r/ e/	50,000
Portugal	92,440	106,559	98,596 r/	100,000 e/	100,000
Romania	31,123	30,920	34,975 r/	25,962 r/	30,000
Russia e/	55,000	55,000	45,000	45,000	40,000
Serbia and Montenegro	3,238	5,441 r/	4,801 r/	4,880 r/	5,000
South Africa	37,156	47,874	53,600 r/	59,700 r/ e/	60,000
Spain 8/	250,000 e/	379,284	415,000 r/	425,000 r/	425,000
Sri Lanka	12,280	7,500	11,200	14,950 r/	15,000
Sweden e/	44,520 5/	45,000	45,000	50,000	50,000
Taiwan	854	--	20	--	--
Thailand	554,227	670,178	684,983 r/	611,789 r/	600,000
Turkey	502,608	760,250	910,814 r/	900,000 r/ e/	1,000,000
United Kingdom (china stone) e/	7,000	7,000	8,000	8,000	8,000
United States	765,000	880,000	890,000	900,000	820,000
Uruguay	3,000 e/	3,000 e/	23,306 r/	12,579 r/	12,000
Uzbekistan e/	70,000	70,000	70,000	70,000	70,000
Venezuela	136,507	227,000	205,000 r/	160,000 r/	170,000
Zimbabwe	1,617	3,920	3,248	3,500 r/ e/	3,500
Total	6,490,000	7,880,000 r/	8,170,000 r/	8,250,000 r/	8,080,000

e/ Estimated. r/ Revised.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through April 24, 1999.

3/ In addition to the countries listed, former Czechoslovakia, Madagascar, and Namibia produce feldspar, but output is not officially reported; available general information is inadequate for the formulation of reliable estimates of output levels.

4/ Data are for fiscal years beginning April 1 of that stated.

5/ Reported figure.

6/ In addition, the following quantities of aplite ore were produced in metric tons: 1994--381,000; 1995--388,000; 1996--365,000; 1997--310,000 (revised), and 1998--300,000 (estimated).

7/ Excludes nepheline syenite.

8/ Includes pegmatite.