

# FELDSPAR AND NEPHELINE SYENITE

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Feldspar was used in commerce in the form of aluminosilicates that contained calcium, potassium, and sodium. Nepheline syenite, which is a light-colored, silica-deficient feldspathic rock made up mostly of sodium and potassium feldspars and nepheline, was not mined in the United States but was imported from Canada for use in the glass and ceramic industries.

## Feldspar

In glassmaking, alumina from feldspar improves product 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.

In 2000, U.S. shipments (domestic sales) of glass containers, a major end use of feldspar, were about 3% less than in 1999 (U.S. Census Bureau, February 2001, Glass containers—Current industrial reports, accessed April 23, 2001, at URL <http://www.census.gov/cir/www/m32g.html>). In the housing and remodeling markets, feldspar was used in glass fiber insulation, sanitaryware, and tile. Housing starts were an estimated 1.59 million, which was about 4% less than in 1999 (U.S. Census Bureau, January 18, 2001, Housing starts and building permits in December 2000, accessed May 4, 2001, at URL [http://www.census.gov/const/C20/c20\\_0012.txt](http://www.census.gov/const/C20/c20_0012.txt)).

Ceramic tile consumption (including imports) in the United States increased each year during the 1990s to 206.9 million square meters (Mm<sup>2</sup>) in 1999 from 85.1 Mm<sup>2</sup> in 1991. Imports

accounted for approximately 67% of the tile consumed in the United States in 1999 (Daniels, 2000).

**Production.**—In 2000, U.S. production of marketable feldspar was an estimated 790,000 metric tons (t) with a value of \$44.5 million (table 1). 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 44% of the total. Mining was by 9 companies with a total of 12 plant operations—4 in North Carolina, 3 in California, and 1 in each of the remaining States listed above.

Domestic production data for feldspar were collected by the U.S. Geological Survey by means of a voluntary survey. Of the 12 known plant operations, 6 responded by the data closeout date. The six operations represented about 60% of the year 2000 production shown in tables 1 and 2. Data for the remaining six operations were estimated from prior year production levels.

Oglebay Norton Co. acquired the mica operations of Franklin Industrial Minerals, located in New Mexico and North Carolina. The North Carolina site also produced feldspathic sand, kaolin, quartz sand, and potassium feldspar. The operations were incorporated under a wholly owned subsidiary, Oglebay Norton Specialty Minerals, Inc. (North American Minerals News, 2000).

**Consumption.**—Of the U.S. feldspar sold or used, 66% went into the manufacture of glass, including glass containers and glass fiber. Pottery (including electrical insulators, sanitaryware, tableware, and tile) and other uses, such as fillers,

## Feldspar and Nepheline Syenite in the 20th Century

In 1900, U.S. feldspar production was about 22,500 metric tons with a value of about \$181,000. Quantitative end-use data were not available for that year, but uses were reported to be floor and wall tiles, glass, pottery, scouring soaps, and wood fillers. Feldspar was produced by selective mining and hand sorting of coarse-grained pegmatites from deposits located in Connecticut, Maine, New York, and Pennsylvania. Material was processed by dry crushing and grinding. Around 1910, uses for feldspar included enamelware, true porcelain, vitrified sanitaryware, and whiteware. Feldspar was used in both ceramic bodies and glazes. A major development in processing technology was the flotation process developed in 1939 in a cooperative effort between the U.S. Bureau of Mines and the feldspar industry. This process enabled treatment of a broader range of ores in which feldspar was more intermixed with quartz, mica, and other accessory

minerals. The first commercial flotation plant began operation in North Carolina in 1946.

Nepheline syenite, mined in Ontario, Canada, is a feldspathic rock that, when processed, competes with feldspar in glass, pottery, and filler use. Official recording of U.S. imports of nepheline syenite began in 1939, when about 26,500 tons were imported. U.S. imports of nepheline syenite reached a high of about 497,000 tons in 1978.

In 2000, U.S. feldspar production was 790,000 tons. End uses were glass (66%) and pottery and other uses (34%). Feldspar use in glass containers faced competition from recycled glass, metal, paper, and plastic containers. Imports of nepheline syenite were 356,000 tons. Total world production of feldspar in 2000 was about 9 million tons. Italy produced 2.6 million tons; Turkey, 1.1 million tons; and France, 600,000 tons. Output came from at least 46 other countries.

accounted for the remaining 34% (table 4). Tableware included plates, mugs, cups, and saucers and was categorized in the trade based on the contained proportions of clay, kaolin, quartz, and feldspar and on the firing process. Earthenware, the most common form of tableware and originally considered to be the cheapest form, has been offered in highly decorated versions with a more upscale image. Stoneware is earthenware given more strength by being fired at high temperature. It is nonporous and commands a higher price. Porcelain is semitransparent earthenware made by combining white china clay with either powdered glass or other hard materials. Bone china is a combination of porcelain and bone ash; fine bone china is an even thinner version (Selzer, 2000).

**Prices.**—The prices for ceramic grade sodium feldspar, 170–250 mesh, ex-works United States, increased at yearend 2000 by about \$3 per ton at both lower and upper ends of the price range to about \$67 to \$80 per ton. This increase is not reflected in table 5. Ceramic grade feldspar, 200 mesh, bagged, ex-works Eastern United States, increased by about \$7 per ton compared with the price earlier in the year to about \$139 per ton; this was also a \$34 increase per ton compared with the price in December 1999. Glass grade feldspar, 30 mesh, bulk, ex-works Eastern United States, increased by about \$8 per ton at the upper end of its range to \$57 per ton (not listed in table 5) (Mineral Price Watch, 2001).

**World Review.—Europe.**—After 1989–90, inexpensive natural gas was no longer available to ceramic factories in Eastern Europe from the former Soviet Union. With credit from Western European kiln manufacturers, a number of shuttle and tunnel kilns were put into service in Eastern and Central Europe during the mid-1990s. Private housing development in Eastern and Central Europe required large quantities of building materials, including sanitaryware, ceramic tiles, and roofing tiles. Western sanitaryware manufacturers began investing in some of the ceramic plants and brought marketing expertise. The quality of the sanitaryware and tile improved significantly, and most local producers were exporting at least 50% of their output (MacQuaid, 2000).

**Mexico.**—Housing construction was reported to consist of 370,000 to 380,000 units per year. The sanitaryware, or vitreous china, market in Mexico amounted to about 5.5 million units per year, including wash basins and other bathroom fixtures and accessories. Remodeling was another significant outlet for these items. Mexico exported about 70% of its sanitaryware production to the United States. A typical liquid slurry feed material (slip) for sanitaryware consisted of 22% to 27% ball clay, 26% to 35% kaolin, 22% to 32% silica, and 18% to 27% feldspar. The kaolin and ball clay were imported primarily from the United States; in Mexico, exploration for industrial minerals was still in the early stages (Harris, 2000).

**Spain.**—Feldspar output in 2000 was an estimated 425,000 t (table 8). End usage was 64% in ceramics, such as glazes, porcelain, sanitaryware, and tiles; 32% in glass; and 2% in other applications, such as paints, plastics, and rubber. Feldspar imports were about 350,000 metric tons per year (t/yr), of which 250,000 t/yr was sodium feldspar from Turkey (Regueiro y Gonzalez-Barros and Marchan Sanz, 2000).

Among Spain's largest feldspar producers were Industrias del Cuarzo SA, with output of 125,000 t/yr of potassium feldspar

and 60,000 t/yr of feldspathic sands from its eolian (wind deposited) sands operation at Carrascal del Rio, Segovia; Compania Minera de Rio Piron, with around 100,000 t/yr of potassium feldspar from eolian sand deposits at its operation in Navas del Oro, Segovia; Llansa SA, producing about 80,000 t/yr of potassium/sodium and sodium feldspar from a pegmatite deposit in Llansa, Girona; and Basazuri SL, with 80,000 t/yr of albite in Lugo Province. Spain's reserves of feldspathic sands were said to be the largest in Europe (Regueiro y Gonzalez-Barros and Marchan Sanz, 2000).

**Outlook.**—According to Market Studies, Inc., Raleigh, NC, the dollar volume of the U.S. dinnerware market in 1998 was \$1.4 billion. Demand for semivitreous china dinnerware increased by 7% in 1998, while that of vitreous china increased by 5.2%. Sales of semivitreous china were about 54% of the market, or \$729 million. Continued growth in sales for the semivitreous category was projected to increase at a rate of 4.5% per year through 2003, reaching \$910 million by 2003. Market Studies also projected that overseas demand for vitreous china dinnerware would remain unchanged through 2003. However, demand for U.S. semivitreous china dinnerware exports could increase at a rate of 5.7% per year, reaching \$30 million by 2003 (Ceramic Industry, 1999).

The Cleveland, OH, market research company The Freedonia Group, Inc., projected U.S. demand for glass containers would grow more slowly than for plastic containers in the near term. The Freedonia study also projected that the market for glass bottles should improve somewhat because their replacement in the soft drink and milk markets largely has been completed, that there would be a decline in loss of market share to plastics in bottled water and distilled spirits, and that metal cans would continue to account for about one-half of the beverage container market in unit terms (Ceramic Industry, 2000).

Consumption of container glass was showing growth in the beer and soft drink markets in such areas as China and Southeast Asia. On a worldwide basis, however, the ceramic industry was projected to show stronger growth than glass containers (Roskill Information Services Ltd., 1999, p. 4).

## Nepheline Syenite

In glass and ceramics, nepheline syenite, like feldspar, provides alkalis that act as a flux to 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., operated two plants at its Blue Mountain deposit, about 175 kilometers northeast of Toronto. Output was about 617,000 t in 1998. An estimated 70% of the output went into glass, especially container glass and glass fiber. About 15% was used in ceramic applications and 15% in pigments and fillers (Guillet, 1994, p. 724). An estimated 60% of the output was shipped to the United States, 20% to the Canadian market, and 20% to European countries (Bolger, 1995, p. 31).

In Norway, North Cape Minerals AS produced about

320,000 t of nepheline syenite in 1998 from an underground mine on the Arctic island of Stjernoya. An estimated 70% of the output went to glass manufacturing, 28% to ceramics, and 2% to filler (Bolger, 1995, p. 38).

In the European Union, the glass container recycling rate was more than 50% of glass container consumption. The growing trend to use recycled glass in glass manufacture was reducing the demand for nepheline syenite and feldspar. The increasing use of alternative packaging containers made of such materials as aluminum, coated paper, and plastic also was having an adverse effect on glass container consumption (Saller, 1999).

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TABLE 1  
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS 1/

		1996	1997	1998	1999	2000
United States:						
Feldspar:						
Produced e/ 2/	metric tons	890,000 3/	900,000	820,000	875,000	790,000
Value e/	thousands	\$39,400	\$42,500	\$40,800	\$42,700	\$44,500
Exports 4/	metric tons	10,200	7,220	13,200	9,880	11,400
Value 4/	thousands	\$1,390	\$993	\$1,430	\$1,160	\$1,490
Imports for consumption 4/	metric tons	7,150	8,580	6,560	6,840	7,220
Value 4/	thousands	\$594	\$753	\$601	\$757	\$726
Nepheline syenite:						
Imports for consumption 4/	metric tons	247,000	346,000	320,000	311,000	356,000
Value 4/	thousands	\$20,900	\$23,900	\$24,100	\$23,200	\$24,800
Consumption, apparent (feldspar plus nepheline syenite) e/ 5/	thousand metric tons	1,130	1,250	1,130	1,180	1,140
World, production (feldspar)	do.	8,290 r/	8,550	8,950 r/	8,910 r/	9,280 e/

e/ Estimated. r/ Revised.

1/ Data are rounded to no more than three significant digits.

2/ Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.

3/ Reported figure.

4/ Source: U.S. Census Bureau

5/ Production plus imports minus exports.

TABLE 2  
ESTIMATED FELDSPAR PRODUCTION IN THE UNITED STATES 1/

(Thousand metric tons and thousand dollars)

Year	Flotation concentrate		Other 2/		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1999	408	19,200	467	23,500	875	42,700
2000	335	20,500	455	24,000	790	44,500

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

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

TABLE 3  
PRODUCERS OF FELDSPAR AND FELDSPATHIC MATERIALS IN 2000

Company	Plant location	Product
APAC Arkansas Inc.	Muskogee, OK	Feldspar-quartz mixture.
The Feldspar Corp.	Monticello, GA	Potassium feldspar.
Do.	Spruce Pine, NC	Sodium-potassium feldspar; feldspar-quartz mixture.
PW Gillibrand Co.	Simi Valley, CA	Feldspar-quartz mixture.
Granite Rock Co.	Felton, CA	Do.
KT Feldspar Corp.	Spruce Pine, NC	Sodium-potassium feldspar; feldspar-quartz mixture.
Oglebay Norton Specialty Minerals Inc.	Kings Mountain, NC	Feldspar-quartz mixture.
Pacer Corp.	Custer, SD	Potassium feldspar.
Unimin Corp.	Byron, CA	Feldspar-quartz mixture.
Do.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
U.S. Silica Co.	Montpelier, VA	Aplite.

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

(Thousand metric tons and thousand dollars)

Use	1999		2000	
	Quantity	Value	Quantity	Value
Glass 3/	598	31,400	519	26,700
Pottery and miscellaneous	277	19,200	271	19,200
Total	875	50,600	790	46,000

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.

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

TABLE 5  
PRICES FOR U.S. FELDSPAR, YEAREND 2000

(Dollars per metric ton)

	Price 1/
Glass grade:	
30 mesh, soda	44-50
80 mesh, potash	94-99
Ceramic grade:	
170 to 250 mesh, soda	64-77
200 mesh, potash	137

1/ Bulk, ex-works, United States.

Source: Industrial Minerals, no. 399, December 2000, p. 74.

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

Country	1999		2000	
	Quantity (metric tons)	Value	Quantity (metric tons)	Value
Canada	1,750	\$241,000	1,610	\$213,000
Costa Rica	907	125,000	1,500	210,000
Dominican Republic	227	27,100	312	60,000
India	--	--	378	40,000
Italy	5,140	457,000	5,720	598,000
Malaysia	120	31,000	82	27,000
Mexico	663	130,000	533	84,400
Nicaragua	396	46,300	817	113,000
Panama	152	15,000	--	--
Thailand	100	20,000	2	8,400
Venezuela	263	30,300	174	37,000
Other	164 r/	39,500 r/	261	99,000
Total	9,880	1,160,000	11,400	1,490,000

r/ Revised. -- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

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

Country	1999		2000	
	Quantity (metric tons)	Value 2/	Quantity (metric tons)	Value 2/
Mexico	6,190	\$549,000	7,080	\$636,000
Other	646 r/	208,000 r/	132	89,700
Total	6,840	757,000	7,220	726,000

r/ Revised.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Customs value.

Source: U.S. Census Bureau.

TABLE 8  
FELDSPAR: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1996	1997	1998	1999	2000 e/
Algeria e/	7,000	7,000	7,000	2,820 r/	3,000
Argentina	72,539	105,320	42,468 r/	62,926 r/	61,000
Australia e/	17,000	20,000	20,000	20,000	20,000
Brazil (crude)	276,621	225,000	200,000 r/	220,000 r/	240,000 4/
Burma 5/	13,295	11,960	12,000 e/	12,000 e/	12,000
Chile	3,702	3,808	1,460	1,500 e/	1,500
Colombia	78,093	66,845	55,000 e/	55,000 e/	55,000
Ecuador	10,321	60,328	60,000 e/	50,000 e/	55,000
Egypt	53,783	57,335 r/	325,654	330 r/ e/	330,000
Finland e/	40,265 4/	40,000	40,000	40,000	40,000
France	546,000	621,000	600,000 e/	600,000 e/	600,000
Germany	359,666	455,969	450,000 e/	460,000 e/	460,000
Greece e/	60,000	65,000	65,000	65,000	60,000
Guatemala e/	11,060 r/	11,000 r/	11,000 r/	11,000 r/	11,000
India	85,213	95,455	104,509	105,000 e/	110,000
Iran	106,000 e/	125,000	185,709 r/	239,779 r/	240,000
Italy	2,310,000	2,300,000 e/	2,748,000	2,600,000 e/	2,600,000
Japan e/ 6/	55,122 4/	55,000	50,000	52,000	52,000
Kenya e/	100	100	100	100	100
Korea, Republic of	319,112	341,018	248,493	250,000 e/	250,000
Macedonia e/	15,000	10,000	10,000	10,000	10,000
Mexico	139,972	155,760	197,866	262,241 r/	334,439 4/
Morocco	12,659	15,110	5,616	5,000 e/	5,000
Nigeria e/	800 4/	1,000	500	500	600
Norway e/ 7/	76,000 r/	75,000	75,000	75,000	75,000
Pakistan	32,572	25,169	31,191	32,000 e/	32,000
Peru	5,900 r/	2,500 r/	4,000 r/	1,600 r/	5,600 4/
Philippines e/	40,000	30,000	30,000	25,000	25,000
Poland	64,000	73,800 r/	26,500 r/	50,000 r/ e/	50,000
Portugal	98,596	121,380	120,000 e/	120,000 e/	120,000
Romania	34,975	25,962	37,010 r/	36,635 r/	35,000
Russia e/	45,000	45,000	40,000	45,000	45,000
Serbia and Montenegro	4,801	4,880	4,280 r/	3,453 r/	3,000
South Africa	53,644	59,688	56,761	58,986	66,774 4/
Spain 8/	415,189	398,000	430,000	425,000 e/	425,000
Sri Lanka	11,200	25,700 r/	25,274 r/	26,012 r/	26,500
Sweden e/	45,000	50,000	45,000 r/	45,000	45,000
Taiwan	20	--	--	-- e/	--
Thailand	684,983	611,789	440,288 r/	626,415 r/	542,991 4/
Turkey	910,814	1,011,542	1,089,483	1,100,000 e/	1,200,000
United Kingdom (china stone) e/	8,000	8,000	8,000	8,000	8,000
United States e/	890,000 4/	900,000	820,000	875,000	790,000
Uruguay	2,100 r/	3,229	2,940	1,556 r/	1,600
Uzbekistan e/	70,000	70,000	70,000	70,000	70,000
Venezuela	205,000	160,000	148,000 r/	156,000 r/	160,000
Zimbabwe	3,248	2,254	2,241	2,250 e/	2,250
Total	8,290,000 r/	8,550,000	8,950,000 r/	8,910,000 r/	9,280,000

e/ Estimated. r/ Revised. -- Zero.

1/ World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

2/ Table includes data available through April 24, 2001.

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

4/ Reported figure.

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

6/ In addition, the following quantities of aplite ore were produced in metric tons: 1996--365,580 (estimate); 1997--310,000 (estimate); 1998--310,000 (revised estimate); 1999--330,000 (revised); and 2000--330,000 (estimate).

7/ Excludes nepheline syenite.

8/ Includes pegmatite.