

FELDSPAR AND NEPHELINE SYENITE

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Feldspar

Feldspars are aluminosilicates that contain different proportions of calcium, potassium, or sodium. In glassmaking, alumina from feldspar improves 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.

Reflecting a strong economy, U.S. housing starts in 1999 were an estimated 1.66 million, or 3% higher than in 1998, with about 1.62 million (Census Bureau, January 19, 2000, Housing starts and building permits in December 1999, press release, accessed May 5, 2000, at URL http://www.census.gov/const/C20/c20_9912.txt). Housing construction and remodeling industries used feldspar in glass fiber insulation, plumbing fixtures, and tile. Demand for ceramic tile has been growing. Although the U.S. tile industry was said to be strong, U.S. imports continued to be substantial, providing about 68% of consumption in 1998 (latest data) (Ceramic Industry, 1999b, p. 40).

Italy remained the largest source of U.S. tile imports, with about 41 million square meters (Mm²) in 1998 (latest data), or about 36%. Spain supplied about 24 Mm² and Mexico, 23 Mm². These three countries accounted for about 78% of imports. California, Florida, and Texas were estimated to account for 56% of all U.S. tile usage (Ceramic Industry, 1999b, p. 42-43).

Total U.S. tile shipments were estimated to be about 60 Mm² in 1999. Domestic shipments plus U.S. imports of ceramic tile were an estimated 200 Mm² in 1999, an increase of about 9% from that of 1998. U.S. tile exports in 1999 were an estimated 4 Mm² (Ceramic Industry, 1999b, p. 41-42).

Production.—U.S. production of marketable feldspar in 1999 was an estimated 875,000 metric tons (t) with a value of \$42.7 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 12 mine/plant operations—4 operations in North Carolina, 3 in California, and 1 in each of the remaining 5 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 mine/plant operations, 5, or 42% of the total operations canvassed, responded by the data closeout date. The five operations represented 59% of the production shown in table 1.

Consumption.—Of U.S. feldspar sold or used, 68% went into

the manufacture of glass, including glass containers and glass fiber. Pottery and other uses, such as fillers, accounted for the remainder (table 4).

Typical feldspathic content in glass is 8% for container glass and up to 18% for insulation glass fiber. After clay, feldspathic material is the largest ingredient in the raw material batch for ceramic bodies. Typical feldspathic contents are less than 25% in earthenware, 25% to 35% in sanitaryware, 10% to 55% in floor and wall tiles, and 30% to 55% in electrical porcelain (Saller, 1999a).

World Review.—In Europe, glass accounts for 5% to 10% of total sales in the packaging market. Europe consumes over 17 million tons per year of glass containers, subdivided into beverage, 70% to 75% and food, 20% to 25%. The European Union (EU) recycles over 50% of its container glass consumption per year, which accounted for 8.05 million metric tons (Mt) in 1998. According to the European container glass federation, glass recycling grew 7.5% per year over the past 10 years, compared to a growth rate of 2.5% per year for container glass production over the same period (Saller, 1999c, p. 25-26).

Glass recycling rates vary from country to country in Europe. In 1998, six countries had rates varying from 81% to 91%, five countries had rates from 41% to 69%, and five countries ranged from 24% to 37%. For one country, the recycling rate was not available. Throughout Europe, a much greater proportion of colored glass is recycled, compared with flint (clear) glass; the permissive amount of iron contamination in colored glass is 0.96% and in flint glass, 0.05% (Saller, 1999c, p. 26).

Europe's commitment to environmental protection and higher recycling rates was projected to continue. Higher tonnages of recovered and recycled waste glass could lead to a decrease in raw material consumption, including feldspar. However, glass manufacturers are still confronted with incompatibility, inconsistency, and contamination in cullet, leaving raw material producers with a share in glass container manufacture (Saller, 1999c, p. 33).

China is the world's largest tile producing and consuming country. Annual output was estimated to be 1.5 billion square meters, with 90% being consumed domestically. The quality of ceramic tile continued to improve; however, a slowdown in real estate development had brought about an oversupply and low profit margin in the domestic tile industry (Saller, 1999b, p. 49-50).

Italy and Spain have been the largest tile producers in Europe. Floor and wall tile are made largely from clay, silica, and feldspar. The EU, from the most recent data (1997), was producing about a third of world tile output. Italy was the leading producer within the EU with over 31,000 employees

and an output of 572 Mm². Tile production in Italy was concentrated in the Sassuolo district between the provinces of Modena and Reggio Emilia. Italy accounted for 20% of world production, 50% of EU production, and 50% of all exported ceramic tile. The main export markets are France, Germany, and the United States (Saller, 1999b, p. 43).

The European tile industry included four main categories: stoneware, porcelain, earthenware, and terracotta. Intensive research yielded new products, including porcelain tiles, also known as *porcellanato* or *granito* tiles, which have very low water absorption. They were launched by the Italians in 1984. Their initial main application was in outdoor floorings, but considerable progress in porcelain tile durability and resistance to wear and tear and chemicals led to a greater acceptance of products in a wider range of applications (Saller, 1999b, p. 45-46).

Spain was the second largest tile producer in Europe with around 230 ceramic floor tile producers employing about 19,000 people. Output in 1997 was 480 Mm². Most of the producers were located in the region of La Plana in the province of Castellón. Exports in 1997 were 241 Mm², or 53% of total sales. Major markets were France, Germany, Portugal, the United Kingdom, and the United States (Saller, 1999b, p. 46, 49).

Canada.—Toronto-based Avalon Ventures Ltd. announced prefeasibility study results for its Big Whopper petalite (lithium-containing mineral) deposit near Kenora, Ontario. The study provided for initial ore production of 200,000 t; the yield would include 21,200 t of high-grade petalite; 25,400 t of petalite/feldspar mix; 42,600 t of soda feldspar; and 9,400 t of potash feldspar. The potash feldspar, containing about 1% rubidium, was said to be especially suitable for electrical porcelain. A full feasibility study was to be carried out subsequently (North American Minerals News, 1999).

France.—Denain-Anzin Mineraux operated 10 quarries and 3 principal feldspar production sites in France. The company's total feldspar output was over 600,000 metric tons per year, some of which was used in sanitaryware. The Western Europe sanitaryware market was described as mature, directly linked to housing improvements. The region represented a market of 50 million units per year of sanitaryware, which was one-third of the world market (Mottet, 1999).

Turkey.—Albite (soda feldspar) deposits occur in the southwestern part of the country in the southern part of the metamorphic Menderes Massive. In 1998, Turkey exported about 1.36 Mt of feldspar; most of the material was shipped through the port of Güllük. Italy was the largest recipient, with about 945,000 t, or 74%; Spain received about 225,000 t, or 18%; and Egypt about 51,400 t, or 4% (Bozdogan, 1999).

Current Research and Technology.—Owens-Illinois, Inc. developed a new process that substantially reduced the amount of glass needed to manufacture a typical glass bottle. Benefits included increased strength, reduced raw materials and energy consumption, and lower transportation costs. For example, a reduction of 10% to 20% in raw materials was possible in the production of a typical 0.35 liter (12 oz.) capacity beer bottle

(Glass, 1999).

Outlook.— In the U.S. dinnerware market, imports have increased at a rate of 5% per year during the past 7 years. U.S. producers had annual gains of 2.1% during this period. As a result of this influx of imports, domestic manufacturers' share of the U.S. market has fallen from 32% in 1991 to 27% in 1998 (latest data) (Ceramic Industry, 1999a).

The dollar volume of the U.S. dinnerware market in 1998 was \$1.4 billion. Demand for semivitreous china dinnerware increased 7% in 1998, while vitreous china increased 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, according to a nongovernment source, to increase at an annual rate of 4.5% over the next 5 years, reaching \$910 million by 2003 (Ceramic Industry, 1999a).

U.S. imports from China were \$385 million in 1998, or 39% of total imported dinnerware. The United Kingdom was the second largest supplier, with 13% of import share. U.S. exports of dinnerware, which have been unchanged in recent years, had a value of about \$63 million in 1998. Canada was the largest recipient with 41%; the United Kingdom was next with 8% (Ceramic Industry, 1999a).

According to the nongovernment source mentioned above, overseas demand for vitreous china dinnerware was projected to remain unchanged over the next 5 years. However, demand for U.S. semivitreous china dinnerware could increase at an annual rate of 5.7%, reaching \$30 million by 2003 (Ceramic Industry, 1999a).

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., operated two plants, 8 kilometers (km) apart, at its Blue Mountain deposit, about 175 km northeast of Toronto. Output was about 617,000 t in 1998 (latest data) (Saller, 1999a). 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 (Saller, 1999a). 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.

References Cited

- Bozdogan, Ihsan, 1999, Markets for Turkish feldspar: *Industrial Minerals*, no. 387, December, p. 35, 37, and 39.
- Ceramic Industry, 1999a, Imports gain ground in U.S. dinnerware market: *Ceramic Industry*, v. 149, no. 9, August, p. 38-39.
- 1999b, Tile imports at an all-time high: *Ceramic Industry*, v. 149, no. 9, August, p. 40-43.
- Glass, 1999, O-I develops new bottle production process: *Glass*, v. 76, no. 11, November, p. 346.
- Mottet, Bruno, 1999, Challenges in the sanitaryware industry—The feldspar case, *in* *Euromin 99, European Industrial Minerals and Markets*, Nice, France, June 6-8, 1999: London, *Industrial Minerals*, 15 p.
- North American Minerals News, 1999, Big Whopper petalite prefeasibility study encouraging: *North American Minerals News*, issue 52, September, p. 3.
- Saller, Marcus, 1999a, In a state of flux—Feldspar and nepheline syenite reviewed: *Industrial Minerals*, no. 385, October, p. 43-53.
- 1999b, It's all tiled up for Italy and Spain: *Industrial Minerals*, no. 377, February, p. 43-51.
- 1999c, Lifting the lid off glass recycling: *Industrial Minerals*, no. 387, December, p. 25-33.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Feldspar. Ch. in *Mineral Commodity Summaries*, annual.¹
- Feldspar. Ch. in *United States Mineral Resources*, Professional Paper 820, 1973.
- Silica. Ch. in *Minerals Yearbook*, v. I, Metals and Minerals, annual.¹ (For 1995 and previous years, included under Industrial sand and gravel chapter.)
- Soda ash. Ch. in *Minerals Yearbook*, v. I, Metals and Minerals, annual.¹

Other

- Feldspar. Ch. in *Industrial Minerals and Rocks*, 6th ed., Society for Mining, Metallurgy, and Exploration, 1994.
- Feldspar. Ch. in *Mineral Facts and Problems*, U.S. Bureau of Mines Bulletin 675, 1985.
- Nepheline syenite. Ch. in *Industrial Minerals and Rocks*, 6th ed., Society for Mining, Metallurgy, and Exploration, 1994.
- Roskill Information Services Ltd., London, 1999.

¹Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS 1/

		1995	1996	1997	1998	1999
United States:						
Feldspar:						
Produced 2/	metric tons	880,000	890,000	900,000 e/	820,000 e/	875,000 e/
Value	thousands	\$37,400	\$39,400	\$42,500 e/	\$40,800 e/	\$42,700 e/
Exports	metric tons	14,700	10,200	7,220	13,200	9,880
Value	thousands	\$1,970	\$1,390	\$993	\$1,430	\$1,160
Imports for consumption	metric tons	8,980	7,150	8,580	6,560	6,840
Value	thousands	\$813	\$594	\$753	\$601	\$757
Nepheline syenite:						
Imports for consumption	metric tons	316,000	247,000	346,000	320,000	311,000
Value	thousands	\$19,700	\$20,900	\$23,900	\$24,100	\$23,200
Consumption, apparent						
(feldspar plus nepheline syenite) 3/	thousand metric tons	1,190	1,130	1,250 e/	1,130 e/	1,180 e/
World: Production (feldspar)	do.	7,910 r/	8,320 r/	8,550 r/	8,990 r/	8,980 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-silica mixtures, aplite, and potash feldspar (8% K₂O 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
1998 e/	348	17,800	472	23,000	820	40,800
1999 e/	408	19,200	467	23,500	875	42,700

e/ Estimated.

1/ Data are rounded to no more than 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 1999

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.
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.
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	1998 e/		1999 e/	
	Quantity	Value	Quantity	Value
Flotation concentrate:				
Glass	155	8,620	W	8,950
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Total	355	21,000	356	23,000
Other: 3/				
Glass	477	22,700	W	22,400
Pottery	84	5,640	W	5,180
Total	560	28,300	518	27,600
Total:				
Glass 4/	632	31,300	598	31,400
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Grand total	915	49,300	875	50,600

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

1/ Includes potash feldspar (8% K₂O or higher).

2/ Data are rounded to no more than 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 1999

(Dollars per metric ton)

	Price 1/
Glass grade:	
30 mesh, soda	44-50
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. 387, December 1999, p. 70.

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

Country	1998		1999	
	Quantity (metric tons)	Value	Quantity (metric tons)	Value
Canada	2,190	\$300,000	1,750	\$241,000
Costa Rica	--	--	907	125,000
Dominican Republic	264	43,100	227	27,100
Ecuador	4,340	356,000	36	3,730
Italy	4,880	392,000	5,140	457,000
Mexico	325	54,200	663	130,000
Nicaragua	--	--	396	46,300
Thailand	200	39,300	100	20,000
Venezuela	441	50,700	263	30,300
Other	515	191,000	400	81,800
Total	13,200	1,430,000	9,880	1,160,000

-- Zero.

1/ Data are rounded to no more than 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/

(Metric tons and dollars)

Country	1998		1999	
	Quantity	Value 2/	Quantity	Value 2/
Mexico	6,250	535,000	6,190	549,000
China	200	24,000	4	4,000
Other	108	41,500	642	204,000
Total	6,560	601,000	6,840	757,000

1/ Data are rounded to no more than 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)
1998	320,000	24,100
1999	311,000	23,200

1/ Crude and ground combined.

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

3/ Customs value.

Source: Bureau of the Census.

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

(Metric tons)

Country 3/	1995	1996	1997	1998	1999 e/
Algeria e/	7,000 4/	7,000	7,000	7,000	7,000
Argentina	37,095	72,539	105,320 r/	80,000 r/ e/	80,000
Australia e/	16,000	17,000	20,000	20,000	20,000
Brazil (crude)	198,854	276,621 r/	225,000 r/	230,000 r/	230,000
Burma 5/	8,749	13,295 r/	11,960 r/	12,000 r/ e/	12,000
Chile	7,293	3,702	3,808	1,460 r/	1,500
Colombia	58,100	78,093	66,845	55,000 e/	55,000
Ecuador	10,297	10,321	60,328	60,000 r/ e/	50,000
Egypt	75,049 r/	53,783 r/	57,000 r/	325,654 r/	325,000
Finland	41,808	40,265	40,000 e/	40,000 e/	40,000
France	632,000	546,000	621,000 r/	600,000 r/ e/	600,000
Germany	329,624	359,666	455,969	450,000 e/	460,000
Greece e/	30,000	60,000 r/	65,000 r/	65,000 r/	65,000
Guatemala e/	7,600	7,500	7,500	7,500	7,500
India	99,618	85,213	95,455 r/	104,509 r/	105,000
Iran e/	80,000	106,000 r/	125,000 r/ 4/	125,000 r/	125,000
Italy	2,199,000	2,310,000	2,300,000 e/	2,748,000 r/	2,600,000
Japan 6/	65,086	55,122	55,000 e/	50,000 r/ e/	52,000
Kenya e/	500	100	100	100	100
Korea, Republic of	367,578	319,112	341,018 r/	248,493 r/	250,000
Macedonia e/	15,000	15,000	10,000	10,000	10,000
Mexico	121,779	139,972	155,760	197,866 r/	210,000
Morocco	17,233	12,659	15,110	5,616 r/	5,000
Nigeria	3,722	800	1,000 e/	500 e/	500
Norway e/ 7/	75,397 4/	75,000	75,000	75,000	75,000
Pakistan	21,163	32,572	25,169 r/	31,191 r/	32,000
Peru e/	11,400	11,400	11,400	11,400	11,400
Philippines e/	29,950 4/	40,000	30,000	30,000	25,000
Poland	46,000	64,000	74,000 r/ e/	70,000 r/ e/	70,000
Portugal	106,559	98,596	121,380 r/	120,000 r/ e/	120,000
Romania	30,920	34,975	25,962	30,000 e/	30,000
Russia e/	55,000	45,000	45,000	40,000	45,000
Serbia and Montenegro	5,441	4,801	4,880	5,000 e/	2,000
South Africa	47,874	53,644 r/	59,688 r/	56,761 r/	58,986 4/
Spain 8/	379,284	415,189 r/	398,000 r/	430,000 r/	425,000
Sri Lanka	7,500	11,200	14,950	15,000 e/	15,000
Sweden e/	45,000	45,000	50,000	50,000	45,000
Taiwan	--	20	--	--	--
Thailand	670,178	684,983	611,789	429,693 r/	500,000
Turkey	760,250	910,814	1,011,542 r/	1,089,483 r/	1,100,000
United Kingdom (china stone) e/	7,000	8,000	8,000	8,000	8,000
United States	880,000	890,000	900,000 e/	820,000 e/	875,000 4/
Uruguay	3,000 e/	23,306	3,229 r/	2,940 r/	3,000
Uzbekistan e/	70,000	70,000	70,000	70,000	70,000
Venezuela	227,000	205,000	160,000	158,000 r/	160,000
Zimbabwe	3,920	3,248	2,254 r/	2,241 r/	2,250
Total	7,910,000 r/	8,320,000 r/	8,550,000 r/	8,990,000 r/	8,980,000

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 27, 2000.

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: 1995--338,000; 1996--365,021; 1997--310,000; 1998--284,000 (revised estimate); and 1999--285,000 (estimated).

7/ Excludes nepheline syenite.

8/ Includes pegmatite.