

FELDSPAR AND NEPHELINE SYENITE

By Michael J. Potter

Feldspar

Feldspars are aluminosilicates with varying amounts of sodium, potassium, or calcium. In glassmaking, the largest end use, feldspar provides alumina for improving hardness, durability, and resistance to chemical corrosion; shipments of glass containers were projected to decrease by 2% in 1996 (Ceramic Industry, 1996a). In ceramics, feldspar is used as a flux, lowering the vitrifying temperature of a ceramic body during firing and forming a glassy phase. Housing starts, where feldspar is used in plumbing fixtures, glass fiber for insulation, and tile, were 1.4 million, an increase of 3% from activity in 1995 (Ceramic Industry, 1996b).

Production.—U.S. production of marketable feldspar (including aplite) in 1996 was 890,000 metric tons with a value of \$39.4 million, according to the U.S. Geological Survey (USGS). Feldspar was mined in seven States, led by North Carolina and followed by, in descending order, California, Virginia, Georgia, Oklahoma, Idaho, and South Dakota. North Carolina accounted for about 54% of the total. Twelve U.S. companies had a total of 14 mine/plant operations—North Carolina had 5, California had 4, and the remaining 5 States listed above each had 1. South Carolina had a grinding (only) facility.

Domestic production data for feldspar were collected by the USGS by means of a voluntary survey. Of the 14 known mine/plant operations, 8, representing 57% of the total operations canvassed, reported production of about 578,000 tons, or 65% of the total shown in table 1. The estimated production of the nonrespondents, about 312,000 tons, was derived from past years' production levels and trends.

Consumption.—Of feldspar (including aplite) sold or used in the United States, 70% went into the manufacture of glass, including glass containers and glass fiber. Feldspar used in making pottery and other uses was 30% of the output.

World Review.—Capacity.—The data in table 8 are an approximation of rated capacity at yearend 1996. Because actual capacity data were not available, rated capacity was considered to approximate recent peak production during the past 5 years for the United States and foreign countries.

Brazil.—The Feldspar Corp., a U.S.-based company, is hoping to move into local production with a Brazilian partner within 2 years. Target output could reach 100,000 tons per year for domestic and export markets. However, the investment necessary to set up the project would be formally announced only after an evaluation of reserves. Brazil's current production is 150,000 tons per year (Industrial Minerals, 1996a).

Besides small operations, two other companies, Arqueana de Minérios and Prominex Mineração, both in Minas Gerais State, produced a combined total of about 50,000 tons per year of mainly potash feldspar (Kendall, 1996).

Canada.—Daren Resources Ltd.'s first-phase evaluation of its Similkameen feldspar property in British Columbia indicated high-quality potash feldspar, which could be used in glass and ceramics applications. The next phase of testing will be to determine what type of metallurgical processing might be applied (Industrial Minerals, 1996b).

Germany.—A journal article (Jakobs, 1996) described a kaolin/feldspar/quartz operation of Amberger Kaolinwerke Eduard Kick GmbH (AKW), which is said to be the leading producer of potash feldspar in Europe. Also discussed was a comparison of various grinding systems in the production of feldspar and quartz powder. The ore source is part of the most important sedimentary feldspar deposits in the Hirschau-Schaittenbacher Basin of eastern Bavaria. Average values for raw material in the western part range from 6% to 12% for feldspar, 76% to 78% for quartz, and 10% to 14% for kaolin. In the eastern part, they are about 20% for kaolin and 80% for quartz. AKW was producing about 35,000 tons per year of feldspar powder and 40,000 tons per year of quartz powder. The company's Hirschau ore-processing plant uses grading, electrostatic separation, flotation, and other steps.

Namibia.—A paper (Mitchell and Evans, 1996) discussed the feasibility of producing glass and ceramic-grade feldspar from granite fines and tailings from a former Namibian tin mine. In a typical feldspar operation, extraction and size reduction may account for 20% to 25% of operating costs. Production of feldspar from feldspathic quarry fines and/or mine tailings would reduce these costs because the material has already been extracted and crushed. Magnetic separation and froth flotation produced a high-purity feldspar. Based on the laboratory results, the potential for scaling up the processing to a commercial scale could be a viable prospect.

Turkey.—A study was made to investigate the possibility of beneficiating low-grade pegmatite from the Sogut area. This ore comprises quartz, muscovite, kaolinite, albite, and sanidine. Pegmatite was ground in a ball mill, followed by three stages of flotation to remove mica, Fe_2O_3 , and quartz. The best test result yielded a concentrate with 0.51% Fe_2O_3 , which was used in sanitaryware, dinnerware, electrical porcelain, and tile body. For example, 20% to 30% pegmatite instead of 10% to 17% feldspar was used in sanitaryware, and 20% to 30% pegmatite instead of 12% to 17% feldspar was used in dinnerware. Results were said to be good (Sumer, 1996).

Current Research and Technology.—A journal article (Arvidson and Dillé, 1996) discussed advances in magnetic separation of industrial minerals in wet and dry applications. The first rare-earth magnetic separator (REMS) prototype model was developed in 1981, and a new generation of REMS was introduced between 1990 and 1991. Wet processing became available for medium-intensity applications. In one application, a feldspar producer upgraded its flotation product

by using magnetic roll separators after a drying circuit. The upgrading consisted of magnetically removing fine, weakly magnetic muscovite and moderately magnetic biotite. In another application, a feldspar producer upgrading its feldspar product stream by flotation to remove quartz and a large amount of muscovite mica also used magnetic roll separation. This resulted in an Fe₂O₃ level of 0.08%. By using a three-stage magnetic separator, Fe₂O₃ levels were reduced further to 0.06%.

Outlook.—Glass containers have faced competition from plastic and metal. Consequently, some glass container manufacturers have been looking overseas to expand their markets. For example, Owens-Illinois, Inc. of Toledo, OH, acquired the largest glass container manufacturers in Hungary, Estonia, and Finland to capitalize on the emerging markets in Eastern Europe. Owens-Illinois also will be increasing capacity by about 20% during over the next 2 years in several of its Latin American plants (Ceramic Industry, 1996c).

The United States has been importing about 58% of its tile consumption. Also, foreign ownership represents a significant part of the U.S. industry with many major foreign firms having U.S. facilities (Ceramic Industry, 1996d).

In Europe, most countries recycle glass containers to some degree. Some examples of countries and their national recycling rate, according to one source were Denmark, 63%; Germany, 75%; Italy 53%; and the United Kingdom, 27% (Glass, 1996).

In Spain, data from glass container manufacturers showed a continued reactivation of the industry. The increasing popularity of glass containers is due to their quality and environmental credentials, such as recycling (Cano, 1996).

In the United Kingdom, with the market doing well, the outlook for glass packaging looks bright (Green, 1996).

Asia is the largest consumer of tile, accounting for about 36% of worldwide consumption. Most Asian countries produce mainly for their own consumption, with little trade, because of rapid growth of individual economies. Also, high customs duties on imported tiles are imposed by respective governments. Overall, Asia is projected to become dominant in the global tile industry (Tsai, 1996).

Nepheline Syenite

Nepheline syenite is a light-colored feldspathic rock comprising mostly soda and potash feldspars and nepheline. In glassmaking, nepheline syenite provides alumina and alkali and, as a flux, lowers the melting temperature, prompting faster melting and fuel savings. Nepheline syenite is used as a flux in sanitaryware, dinnerware, floor and wall tiles, and other whiteware.

In Canada, Unimin Canada, Ltd., has two deposits, at Nephon and Blue Mountain, and two processing plants 175 kilometers northeast of Toronto. An estimated 60% of the output went to U.S. markets; 20%, to the Canadian market; and 20%, to markets in Europe and other countries.

At yearend 1996, prices for Canadian nepheline syenite ranged from about \$22 to \$24 per ton (depending on iron content) for glass-grade, 30-mesh material, bulk, in car lots/truck lots and \$69 per ton for ceramic-grade, 200-mesh, bagged, 1-ton lots (Industrial Minerals, 1996c, p. 73). The

other producer was North Cape Minerals A/S at Stjernoya, Norway. An estimated 75% of the production was glass grade; the remainder was ceramic, amber, and filler grades. Sales were mostly to Europe.

References Cited

- Arvidson, B.R., and Dillé, Brian, 1996, Improved high-intensity magnetic separation for industrial minerals: *Industrial Minerals Processing Supplement*, no. 348, p. 29-35.
- Cano, J.M., 1996, Spanish results show continued strong improvement for glass packaging: *Glass*, v. 73, no. 8, p. 316.
- Ceramic Industry, 1996a, Business outlook: *Ceramic Industry*, v. 146, no. 5, p. 17.
- 1996b, Business outlook: *Ceramic Industry*, v. 146, no. 9, p.12.
- 1996c, Glassware—Slowing growth: *Ceramic Industry*, v. 146, no. 9, p. 54.
- 1996d, Whitewares—Challenges continue: *Ceramic Industry*, v. 146, no. 9, p. 27.
- Glass, 1996, EU glass container trends: *Glass*, v. 73, no. 8, p. 309.
- Green, Theresa, 1996, Strong UK performance: *Glass*, v. 73, no. 8, p. 313.
- Industrial Minerals [London], 1996a, Feldspar Corp. investing in local production: *Industrial Minerals*, no. 345, June, p. 13.
- 1996b, Kaolin and feldspar from Daren Resources: *Industrial Minerals*, no. 350, November, p. 9.
- 1996c, Prices: *Industrial Minerals*, no. 350, December, p. 73.
- Jakobs, Udo, 1996, Processing of quartz and feldspar for the ceramics industry: *Industrial Minerals Processing Supplement*, no. 348, p. 13-17.
- Kendall, Tom, 1996, Brazil—Dancing to a new tune: *Industrial Minerals*, [London] no. 350, p. 51.
- Mitchell, Clive, and Evans, E.J., 1996, Glass and ceramic grade feldspar from waste [abs.]: *Industrial Minerals* [London], no. 350, November, p. 55-56.
- Sumer, Guner, 1996, Beneficiation of Turkish pegmatites and their usage in ceramic bodies: *Industrial Minerals Processing Supplement*, no. 348, p. 18-19.
- Tsia, Terry, 1996, Asian tiles: *Industrial Minerals*, [London] no. 349, p. 61, 65, 67.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Feldspar. Ch. in *Mineral Commodity Summaries*, annual¹.
- Feldspar. Ch. in *United States minerals resources*, U.S. Geological Survey Professional Paper 820.

Other

- Bolger, R., 1995, Feldspar and nepheline syenite: *Industrial Minerals* [London], no. 332, May, p. 25-45.
- Feldspar. Ch. in *Mineral Facts and Problems*, U.S. Bureau of Mines Bulletin 675.
- Guillet, G.R., 1994, Nepheline syenite, in Carr, D.D., and others, eds., *Industrial minerals and rocks* (6th ed.): Littleton, CO, Society for Mining, Metallurgy and Exploration, Inc., p. 711-730.
- Kauffman, R.A., and Van Dyk, Dean, 1994, Feldspar, in Carr, D.D., and others, eds., *Industrial minerals and rocks* (6th ed.): Littleton, CO, Society for Mining, Metallurgy, and Exploration, Inc., p. 473-481.
- Roskill Information Services Ltd., 1996, *The economics of feldspar 1996* (8th ed.): London, Roskill Information Services Ltd., 180 p.

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

TABLE 1
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS 1/

		1992	1993	1994	1995	1996
United States:						
Feldspar:						
Produced 2/	metric tons	725,000	770,000	765,000	880,000	890,000
Value	thousands	\$28,500	\$31,400	\$31,200	\$37,400	\$39,400
Exports	metric tons	17,700	17,700	17,300	14,700	10,200
Value	thousands	\$2,210	\$1,840	\$1,940	\$1,970	\$1,390
Imports for consumption	metric tons	13,000	7,050	7,360	8,980	7,150
Value	thousands	\$923	\$514	\$513	\$813	\$594
Nepheline syenite:						
Imports for consumption	metric tons	335,000	289,000	333,000	316,000	247,000
Value	thousands	\$14,700	\$15,400	\$18,700	\$19,700	\$20,900
Consumption, apparent 3/						
(feldspar plus nepheline syenite)	thousand metric tons	1,060	1,050	1,090	1,190	1,130
World: Production (feldspar)	do.	5,990 r/	6,130 r/	6,420 r/	6,780 r/	6,750 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% 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
1995	397	17,400	485	20,000	880	37,400
1996	379	17,700	510	21,700	890	39,400

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 1996

Company	Plant location	Product
APAC Arkansas Inc.	Muskogee, OK	Feldspar-silica mixture.
Corona Industrial Sand Co.	Corona, CA	Do.
The Feldspar Corp.	Monticello, GA	Potash feldspar.
Do.	Spruce Pine, NC	Soda-potash feldspar.
FMC Lithium Div.	Bessemer City, NC	Feldspar-silica mixture.
Franklin Industrial Minerals	Kings Mountain, NC	Potash feldspar.
PW Gillibrand Co.	Simi Valley, CA	Feldspar-silica mixture.
KT Feldspar Corp.	Spruce Pine, NC	Soda-potash feldspar.
Pacer Corp.	Custer, SD	Potash feldspar.
Santa Cruz Aggregates Co.	Felton, CA	Feldspar-silica mixture.
Spartan Minerals Corp.	Pacolet, SC	Do.
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	1995		1996	
	Quantity	Value	Quantity	Value
Flotation concentrate:				
Glass	132	7,000	151	7,970
Pottery	230	14,700	231	14,900
Total	362	21,700	382	22,900
Other: 3/				
Glass	440	20,000	459	22,200
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Total	473	24,200	493	25,200
Total:				
Glass 4/	572	27,000	610	30,200
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Total	835	45,900	875	48,000

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

1/ Includes potash feldspar (8% K₂O 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 FELDSPAR, YEAREND 1996

(Dollars per metric ton, bulk, ex-works, USA)

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

Source: Industrial Minerals (London), No. 351, Dec. 1996, p. 72.

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

Country	1995		1996	
	Quantity (metric tons)	Value	Quantity (metric tons)	Value
Canada	1,780	\$240,000	1,250	\$190,000
Ecuador	--	--	1,990	135,000
France	--	--	736	78,000
Italy	3,780	564,000	1,310	487,000
Mexico	7,980	870,000	1,600	227,000
Panama	--	--	2,510	133,000
Taiwan	217	63,800	--	--
Thailand	343	63,200	320	59,500
Venezuela	--	--	271	32,900
Other	546	161,000	174	50,500
Total	14,700	1,970,000	10,200	1,390,000

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	1995		1996	
	Quantity (metric tons)	Value 2/	Quantity (metric tons)	Value 2/
Mexico	8,490	\$642,000	6,920	\$516,000
Other	488	171,000	233	78,000
Total	8,980	813,000	7,150	594,000

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

2/ Customs value.

Source: Bureau of the Census.

TABLE 8
WORLD FELDSPAR ANNUAL PRODUCTION
CAPACITY, DECEMBER 31, 1996 1/ 2/

(Thousand metric tons)

	Rated capacity
North America:	
Mexico	160
United States	890
Total	1,050
South America:	
Argentina	56
Brazil	205
Colombia	78
Venezuela	220
Other	35
Total	594
Europe:	
Finland	51
France e/	632
Germany	385
Italy	1,810
Norway e/	100
Poland	46
Portugal	100
Russia e/	100
Spain	247
Uzbekistan e/	80
Other	134
Total	3,680
Africa:	
South Africa	49
Other	53
Total	102
Asia and Oceania:	
India	99
Iran	77
Japan	72
Korea, Republic of	322
Thailand	670
Turkey	503
Other	88
Total	1,830
World total	7,260

e/ Estimated.

1/ Includes capacities of operating plants as well as plants on standby basis.

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

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

(Metric tons)

Country 3/	1992	1993	1994	1995	1996 e/
Algeria	4,647	6,500	6,000 e/	6,000 e/	6,000
Argentina	48,509	55,764	39,825 r/	36,901 r/	37,000
Australia e/	15,000	15,000	16,000	16,000	17,000
Austria	11,059	8,492	4,883	5,000 e/	4,500
Brazil (crude)	202,632 r/	205,000 r/	205,000 r/ e/	205,000 r/ e/	205,000
Burma 4/	1,618	6,289	6,976	7,000 e/	6,500
Chile	5,744	4,149	9,967	10,000 e/	9,000
Colombia	78,446	60,458	76,188 r/	58,100 r/	60,000
Ecuador	3,251	2,015 r/	2,200 r/	2,000 r/ e/	2,000
Egypt	32,326	38,900 e/	39,745	39,800 e/	6,000
Finland	47,500	51,477	43,483 r/	45,000 r/ e/	45,000
France e/	282,000	274,000	390,000 r/	632,000 r/ 5/	600,000
Germany	384,747	360,154	379,427 r/	350,000 e/	375,000
Greece e/	26,600	15,000	35,000	30,000	30,000
Guatemala e/	8,048 5/	7,500	7,600	7,700	7,700
India	67,743	66,792	64,693 r/	98,683 r/	90,000
Iran	52,120	76,873	75,000 e/	75,000 e/	6,000
Italy	1,387,968 r/	1,534,210 r/	1,806,935 r/	1,800,000 r/ e/	1,800,000
Japan 6/	72,285	71,568	56,007	65,086 r/	58,542 5/
Kenya e/	1,200	1,200	1,200	1,200	1,500
Korea, Republic of	281,083	321,964	319,658	320,000 e/	320,000
Macedonia e/	20,000	15,000	15,000	15,000	15,000
Mexico	159,718	123,512	133,441 r/	121,779 r/	130,000
Morocco e/	1,000	1,000	1,000	1,000	1,000
Nigeria e/	700	700	700	700	700
Norway e/ 7/	100,000	75,000 r/	62,905 r/ 5/	65,000 r/	65,000
Pakistan	19,166	17,034	15,335 r/	21,163 r/	21,000
Peru	10,021	11,400 r/	11,400 r/ e/	11,400 r/ e/	11,400
Philippines	48,400 r/	44,600 r/	30,000 e/	30,000 e/	40,000
Poland	34,000	43,000	46,000 r/	46,000 r/ e/	45,000
Portugal	99,645	90,547	92,440 r/	74,000 r/ e/	75,000
Romania	27,715	87,701	10,400	10,000 e/	10,000
Russia e/	100,000	70,000	55,000	55,000	45,000
Serbia and Montenegro	5,111	2,679	3,238	3,200 e/	3,200
South Africa	49,425	43,400	37,156	47,874 r/	45,000
Spain 8/	247,415	239,000	225,000 e/	225,000 e/	225,000
Sri Lanka	7,524	8,000 e/	12,280	12,000 e/	13,000
Sweden	34,598	35,492 r/	44,520 r/	30,000 e/	30,000
Taiwan	2,216	1,716	778	-- r/	--
Thailand	559,806	600,835	554,227 r/	670,178 r/	650,000
Turkey	464,736	366,000	502,608 r/	400,000 e/	500,000
United Kingdom (china stone)	8,243	6,960	7,000 e/	7,000 r/ e/	8,000
United States	725,000	770,000	765,000	880,000	890,000 5/
Uruguay e/	3,000	3,000	3,000	3,000	2,500
Uzbekistan e/	80,000	70,000	70,000	70,000	70,000
Venezuela	168,689	220,000	136,507	170,404	170,000
Zambia e/	113 5/	100	100	100	100
Zimbabwe	2,696	1,553	1,617	1,600 r/ e/	1,650
Total	5,990,000 r/	6,130,000 r/	6,420,000 r/	6,780,000 r/	6,750,000

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 Apr. 24, 1997.

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

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

5/ Reported figure.

6/ In addition, the following quantities of aplite ore were produced in metric tons: 1992--416,304; 1993--403,724; 1994--381,160; 1995--388,000 (revised); and 1996--365,580.

7/ Excludes nepheline syenite.

8/ Includes pegmatite.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF NEPHELINE SYENITE 1/ 2/

Year	Quantity (metric tons)	Value 3/ (thousands)
1995	316,000	19,700
1996	247,000	20,900

1/ Crude and ground combined.

2/ Data are rounded to three significant digits.

3/ Customs value.

Source: Bureau of the Census.