



2016 Minerals Yearbook

FELDSPAR AND NEPHELINE SYENITE [ADVANCE RELEASE]

FELDSPAR AND NEPHELINE SYENITE

By Arnold O. Tanner

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant.

In 2016, feldspar production in the United States was estimated to be 470,000 metric tons (t) valued at \$33.1 million, an almost 10% decrease in quantity and a 11% decrease in value compared with 2015 (table 1). Exports of feldspar in 2016 decreased by 61% to 5,890 t, valued at \$1.5 million, and imports of feldspar decreased by 69% to 36,900 t, valued at \$3.4 million. Imports of nepheline syenite (predominantly from Canada) increased by 27% to about 572,000 t valued at \$73 million. World production of feldspar in 2016 was 23.4 million metric tons (Mt) (tables 1, 7).

Feldspars, which constitute about 60% of the earth's crust, are anhydrous aluminosilicate minerals of two main groupings: potassium- to sodium-alkali feldspars and sodium- to calcium-plagioclase feldspars. The alkali feldspars mostly are used in glassmaking and ceramics, and the plagioclase feldspars, especially the sodium-rich varieties, are mainly used in ceramics and various construction applications. Plagioclase of higher calcium content is used for its alumina content in various construction products, such as fiberglass or for strengthening of glass-reinforced plastic products. In a broader sense, by volume, much of the sand and gravel used as aggregate in concrete and asphalt is composed of plagioclase, and plagioclase is a significant constituent of some building stones. Nepheline syenite is an essentially quartz-free igneous rock composed of alkali feldspars and nepheline, which is a feldspathoid mineral that forms in place of alkali feldspars because the magma (melt) was deficient in silica. Nepheline syenite has uses similar to those of alkali feldspar.

United States apparent consumption of domestic and imported feldspar and imported nepheline syenite from Canada combined was more than 1 Mt, primarily in ceramics and glass production for use in the construction industry and in glass for use in the automotive industry; both also were used as filler in various products such as paints and coatings (tables 1, 4). Domestic feldspar production data include feldspar-quartz mixtures from silica producers and aplite (a rock with quartz and feldspar as the dominant minerals) from one producer. Domestic nepheline syenite production primarily was used in the production of roofing granules, but it was also used in the production of ceramic and porcelain tiles and in other construction applications. Discussion of nepheline syenite follows that of feldspar.

Feldspar

Production.—Data on domestic production, sales, and use of feldspar in this chapter were collected by the U.S. Geological Survey (USGS) by means of a voluntary survey. Production for nonreporting operations was estimated by using previous years' submissions and worker-hour reports from the U.S. Department of Labor's Mine Safety and Health Administration. Of the seven companies that produced feldspar, five responded to the canvass,

representing 46% of the 2016 production tonnages listed in tables 1 and 2.

Feldspar was mined in six States (table 3). North Carolina was by far the leading producer State; the remaining five were, in descending order of estimated output, Virginia, California, Idaho, Oklahoma, and South Dakota. Production was from 10 mines and beneficiating facilities—4 in North Carolina, 2 in California, and 1 in each of the 4 remaining States (table 3).

I-Minerals Inc. continued the mine permitting process for its Helmer-Bovill project in north-central Idaho; the mine would produce potassium feldspar, halloysite, kaolin, and quartz. Early in the year, pilot plant work by an independent laboratory resulted in a potassium feldspar product with 13% to 14% potassium oxide (K_2O) and low iron [0.03% ferric oxide (Fe_2O_3)] content (I-Minerals Inc., 2017). The company produced small quantities of feldspathic (feldspar-quartz) sands from its WBL Tailings resource area, which was adjacent to the Helmer-Bovill property, for use in the production of ceramic tiles. The WBL Tailings are feldspar- and quartz-rich materials that were left on the property from 1960 to 1974 by the former mine operator, who then focused on kaolin production from the ores. I-Minerals' reclamation mining permit allows it to mine about 45,000 metric tons per year (t/yr) of feldspathic sand from the WBL Tailings between June and October of each year through 2022. Feldspar-quartz sand from the WBL Tailings was sold to Quarry Tile Co.'s tile plant in Spokane, WA. In addition to providing a revenue stream, the sale of sands from WBL reduced the tailings storage requirements for the company (I-Minerals Inc., 2014). WBL Tailings was one of three mineral resource areas on the Helmer-Bovill property, a multiminerall project from which the company expected an annual production of 47,000 t of potassium feldspar during a projected 25-year mine lifespan (I-Minerals Inc., 2016).

Consumption.—In 2016, approximately 64% of domestic feldspar sold or used was consumed in the manufacture of glass, including glass containers, flat glass, specialty glass, and fiberglass for home insulation (table 4). In glassmaking, feldspar promotes the mixing of the melt components by fluxing (reducing the melt viscosity and the melting temperature) the system. The alkalis in feldspar (especially potassium and sodium ions) lower the melting temperature within the mix and promote the melting of and chemical bonding of the other glass batch minerals such as quartz to produce a glass. Alumina and calcium ions in feldspar impart increased resistance to physical and chemical breakdown of the glass product.

Much of the remaining feldspar consumption was in the manufacture of ceramics, including ceramic and porcelain tile, electrical insulators, sanitaryware, and tableware. In ceramics, as in glassmaking, the alkalis (calcium, potassium, and sodium) in feldspar act as flux, working with soda ash to lower the melting temperature of the mixture while increasing the fusibility of the

batch materials. Feldspar also controls the degree of vitrification of the ceramic body during firing. Smaller quantities of feldspar are used as fillers and extenders in paint, plastics, and rubber.

In 2016, a number of factors may have contributed to the decrease in the production and consumption of domestic feldspar—increased production and transportation costs; some remaining stocks from imports in 2015 and continued high levels of feldspar imports, especially of potassium feldspar (domestically in increasingly shorter supply); substitution of nepheline syenite for feldspar in ceramic (especially porcelain) tile; and competition from imported ceramic tile (up by 6% in 2016 from imports in 2015) (Whitmire, 2017a).

Continued competition from materials other than glass for food and drink containers and a recent trend to import less expensive containers from China contributed to the general decline in United States feldspar production. The use of cullet (recycled broken or waste glass) in the manufacture of glass containers, which is dependent on local and regional recycling and manufacturing infrastructure, competed with primary raw materials such as feldspar (Glass Packaging Institute, 2017).

The construction industry is a major consumer of glass and ceramic products, particularly for windows, flooring, and sanitaryware. In the United States, construction starts for new private housing increased by 5% to 1.7 million units in 2016. This continued the upward trend that began in 2010. The 2016 housing starts, however, remained lower than those reported for virtually all years from 1959 through 2007 (U.S. Census Bureau, 2017b). The value of total construction put in place, which uses significant quantities of flat glass and ceramic tile products, increased for the fifth consecutive year, up by more than 6% to about \$1.19 trillion in 2016, surpassing the previous peak of \$1.16 trillion in 2006 (U.S. Census Bureau, 2017a).

In 2016, U.S. production of ceramic and porcelain tiles increased by 14% to nearly 88 million square meters (Biraldi, 2017a, p. 70). Domestic feldspar producers reported a 20% decline in consumption for ceramics overall, perhaps in part as the result of continued high levels of feldspar imports and increased substitution of domestic nepheline syenite for feldspar in darker colored ceramic tiles. Shipments of tile increased for the seventh consecutive year. Sales were up by 5% to 87.8 million square meters in 2016 from 83.4 million square meters in 2015 (Biraldi, 2017a, p. 70). In 2016, imports of tile maintained the same market share, accounting for nearly 69% of United States tile consumption; major sources were China (29%), Mexico (23%), Italy (19%), Spain (9%), and Turkey (5%). Exports of tile in 2016 increased by 10%, with the majority going to Canada (63%) and Mexico (8%) (Whitmire, 2017b).

Porcelain tile, which is less porous than ceramic tile, increasingly was becoming the tile of choice in the United States; the majority of 2016 U.S. imports for flooring were of porcelain tile rather than ceramic tile. In March, Dallas-based Dal-Tile Corp. (Daltile) (a subsidiary of Mohawk Industries Inc.) began operation of its first tile kiln at its \$180 million, 167,000-square-meter glazed porcelain and colorbody tile manufacturing plant in Dickson, TN. Additional production lines were being added at the facility because the company anticipated employing as many 200 workers at the plant by the beginning of 2017 and 320 by the end of 2018 (Gadd, 2016). Also taking advantage of the

proximity of important raw materials for the tile industry, such as clays and feldspar, Landmark Ceramics, the North American subsidiary of Italy-based Gruppo Concorde, completed construction of a \$90 million, 70,600-square-meter porcelain ceramic tile plant at Mt. Pleasant, TN, in November. The plant began production in mid-summer 2016 (Powell, 2016). In April, China-based Wonderful Group began construction of a \$150 million, 46,500-square-meter ceramic tile plant in Lebanon, TN, with operations expected to begin in the first half of 2017 (American Wonder Porcelain, 2016).

The automobile industry was also a major consumer of glass products. In 2016, for the seventh consecutive year, the production and sales of automobiles and light trucks in North America increased. Production was up slightly in 2016 from that in 2015, following a 3% increase in 2015 from that in 2014 (Ward's Automotive Group, 2017a). Sales increased slightly in 2016 from those in 2015, following a nearly 6% increase in 2015 from those in 2014 (Ward's Automotive Group, 2017b).

Foreign Trade.—In 2016, about 45% of United States exports of feldspar went to Venezuela, 34% to Canada, 11% to Colombia, and most of the remainder to countries in Central America (table 5). In 2016, most imports of feldspar continued to be from Turkey, with substantially less coming from Spain, Mexico, India, Germany, and Brazil, in descending order by tonnage (table 6). Most of the shipments of feldspar from Turkey were imported by two companies: one a manufacturer of ceramic and porcelain floor and wall tiles and the other a producer and supplier of raw materials used in the production of ceramic tiles and sanitaryware.

World Review.—More than 70 countries had significant resources of feldspar and more than 40 produced feldspar in 2016; world production was 23.4 Mt. The leading feldspar-producing countries in 2016 were Turkey and Italy, followed by China, India, and Thailand, in descending order of production (table 7).

As in the United States, feldspar consumption worldwide is largely for glassware and ceramics. Worldwide ceramic tile production, about 50% of which was for floor tile, increased by more than 5.5% to nearly 13.1 billion square meters, with the largest significant increases in China and India (Biraldi, 2017a, p. 56, 60). China, the world's leading tile producer, accounted for nearly 50% of world production, and India and Brazil exchanged rankings to become second and third, respectively, the former with a 12% increase in production and the latter with a 12% decrease. Ceramic tile production increased most notably in Iran (by 13%), Spain (by 12%), and Vietnam (by 10%). Global consumption of ceramic tile increased by 5% to 12.8 billion square meters. China, the world's leading ceramic tile consumer, accounted for 43% of world consumption, and India and Brazil ranked second and third, respectively (Biraldi, 2017a, p. 62).

Although China continued to be the leading exporter of tile with 37% of world exports, exports from China decreased for the third consecutive year. Spain ranked second, accounting for 14% of global tile exports, and Italy was third with 12% of exports. Exports from Spain and Italy increased by 5% each, and exports from India, Iran, Brazil, and Turkey, in descending order of increase, also increased significantly (Biraldi, 2017a, p. 64).

China.—Feldspar was mined in the eastern and southeastern Provinces of China. Ranked third globally, China produced an estimated 3.8 Mt of feldspar in 2016, which was used in the production of ceramic tile, sanitaryware, and tableware. Porcelain tile was the main type of ceramic tile produced, followed by polished and antique-style tile. The country's ceramic tile output increased by 9% to 6.5 billion square meters, of which nearly 1.03 billion square meters was exported (Biral di, 2017a, p. 60, 64). China produced about one-third of the world's sanitaryware, accounting for 43% of world exports in 2016 (Biral di, 2017b, p. 63).

Greenland.—Hudson Resources Inc. continued work on its Naajat (White Mountain) anorthosite (calcium-rich plagioclase feldspar) project in western Greenland; the project had an inferred resource of 27 Mt. In 2016, Hudson made significant progress on construction of project infrastructure. The company planned to produce 200,000 t/yr of anorthosite, with a major portion of that to be sold to Owens Corning Inc. for use as feed material at its fiberglass plants. Hudson had a 10-year supply contract with Owens Corning with an option to extend for successive 10-year periods. Owing in part to a late revision in the process plant design and other delays, Hudson expected to begin shipments by mid-2018 instead of late 2017 (Patel, 2015; Hudson Resources Inc., 2017a, b). Owens Corning planned to use the Naajat anorthosite for making electrical-grade glass (E-glass), which is the most common glass fiber used in composites, fabrics, and glass-reinforced plastics for products where strength and high electrical resistivity are required. Other potential applications for the anorthosite were as an alumina source in making refractories and ceramics; as filler and coating material for paints, paper, and plastics; and potentially as a feed for aluminum smelters (Hudson Resources Inc., 2014). The project's environmental impacts are expected to be low because it is essentially a rock quarry and dock facility with nearby access to shipping on the tidewater and because of the purity of the ore; thereby not requiring chemicals or water for onsite processing (Hudson Resources Inc., 2013).

India.—Of the estimated 1.5 Mt of feldspar that was produced in India during 2016, about 440,000 t (nearly 30%) was exported, down from more than 40% of output in 2015 but similar to the fraction that was exported in 2014 (United Nations Statistics Division, undated a). In 2016, total domestic consumption of feldspar was about 600,000 t in the organized sector (generally large-scale operations that are incorporated with the Government of India and therefore are required to follow Government regulations regarding employees), 78% of which was in the ceramics industry, 13% in the glass industry, 9% in the cement industry, and a negligible amount in other industries (Indian Bureau of Mines, 2016, 2017; Surbhi, 2016).

Italy.—Most of Italy's feldspar output was consumed in the domestic ceramics industry. In 2016, the country exported 262,000 t of feldspar, 94% of which went to Spain. Italy imported about 2.4 Mt of feldspar, of which nearly 92% was from Turkey and 7% was from France (United Nations Statistics Division, undated a). Production of ceramic tile, the leading sector of the country's ceramics industry, increased by 5.3% to 416 million square meters in 2016 from 395 million square meters in 2015 (Biral di, 2017a, p. 60). Total exports for the

ceramic tile industry increased by 5% to 332 million square meters in 2016, with 50% of exports going to Western Europe (Biral di, 2017a, p. 64).

Philippines.—AIM Exploration Inc. (Henderson, NV) withdrew its 40% share from a joint venture with Paladino Management & Development Corp. (Makati City, Philippines) after the expansion of the joint feldspar mine in the Philippines was completed in late 2015. Significant changes in the country's mining laws were cited as the reason for the withdrawal (OTC Markets Group, 2016).

Turkey.—Turkey was the world's leading feldspar producer with an estimated 5.5 Mt in 2016 (table 7). Most of the country's production was exported, the majority of which went to Italy (44%), Spain (28%), Russia (5%), and Bulgaria and Poland (about 3% each) (United Nations Statistics Division, undated a). Feldspar was mined in the southwestern part of Anatolia, mainly from the Menderes Massif.

Nepheline Syenite

Production.—The only deposit of nepheline syenite mined in the United States was in Arkansas, where three operations produced the material primarily for use as roofing granules by the asphalt shingle industry and in lesser quantities as a flux in the manufacture of ceramic and porcelain floor tile in the southern and southeastern United States. It also was used in the manufacture of ceramic bricks and for asphalt and concrete aggregates and related products. In the production of bricks and darker body ceramic tiles, use of nepheline syenite from the Arkansas deposit, which typically contained 3% or more iron oxide, lowered the temperature of the melt more than a nepheline syenite (or feldspar) of lower iron content and resulted in a darker colored product. Nepheline syenite was produced by two companies: 3M Co. (Industrial Mineral Products Division) and Granite Mountain Quarries Co. (a subsidiary of McGeorge Contracting Co. Inc.). 3M mined nepheline syenite from the Arch Street Mine, which was also a crushed-stone-producing facility that had been active since the 1930s. Although 3M primarily produced roofing granules from its nepheline syenite, it was the leading U.S. producer of nepheline syenite for the tile industry and supplied nepheline syenite to the brick industry. Granite Mountain Quarries Co. produced nepheline syenite from Granite Mountain Quarry #1 and Granite Mountain Quarry #2 mostly for use as construction aggregates supplied to its sister construction companies and for use as railroad ballast. All three properties are to the south and southeast of Little Rock, AR (Jay Lukkarila, Mining Engineer, 3M Co. Industrial Products Division, written commun., June 15, 2017; U.S. Department of Labor, Mine Safety and Health Administration, 2017).

Consumption.—In glass and ceramics manufacture, nepheline syenite, like feldspar, provides alkalis that act as flux. In glass, nepheline syenite also supplies alumina, imparting the same benefits as feldspar. Nepheline syenite also typically is used as a filler in adhesives, paint, plastics, and sealants, and it can be used in the production of aluminum and fertilizers and also as a construction aggregate. During the past several years, the consumption of Arkansas nepheline syenite for the manufacture of porcelain floor tile in the United States has increased.

Foreign Trade.—Exports decreased by about 39% in 2016 from those of 2015. In 2016, about 3,440 t of the material was exported to a number of countries, most notably to Mexico (56%), Canada (28%), and Australia (7%) and also to nine other countries (about 1% each) (U.S. Census Bureau, 2017c). Since 2012, imports of nepheline syenite from Canada have been on average 40% higher than those during the preceding decade.

World Review.—Nepheline syenite was produced in Brazil, Canada, China, Norway, Russia, and Turkey for feldspathic uses. The leading producing company was Belgium-based SCR-Sibelco NV, through its subsidiaries Sibelco Europe in Norway and Unimin Corp. in Canada. Others included Fineton Industrial Minerals Ltd. in China and OJSC Apatit AG and United Company RUSAL Plc in Russia.

Canada.—Canada's sole nepheline syenite producer, Unimin, operated two mines about 175 kilometers northeast of Toronto, Ontario—one at Blue Mountain and the other at Nephton. Production of marketable nepheline syenite was estimated to be 571,000 t in 2016, down from 614,000 t in 2015 (Natural Resources Canada, 2017). The material was consumed in the glass, ceramics, filler, and abrasives markets. Canada's nepheline syenite exports were 585,000 t in 2016, up by 26% from 467,000 t in 2015 (United Nations Statistics Division, undated b); 572,000 t was exported to the United States, up by 27% from 449,000 t in 2015 (table 1).

Norway.—Sibelco Europe produced nepheline syenite in the summer and autumn from an open pit on the Arctic Island of Stjernoy. Onsite processing of the ore (crushing, drying, milling, sieving, magnetic separation, and air classification) resulted in various products for the glass, ceramics, and paint industries and for desulfurization of steel. In 2016, exports of nepheline syenite from Norway were 336,000 t. About 24% of the exports were to the Netherlands, 20% to Poland, 14% to Germany, 12% to the United Kingdom, 11% to Italy, 10% to Spain, and 5% to France (United Nations Statistics Division, undated b).

Russia.—The Kiya-Shaltyr Mine on the Goryachegorsk Massif in east-central Siberia, operated by RUSAL, produced 4.4 Mt of nepheline ore, an 8% increase from 4.1 Mt produced in 2015, for use in the production of alumina. RUSAL accounted for approximately 7% of the global production of alumina and aluminum. The increase in nepheline syenite production in 2016 corresponded with the company's plan to return alumina production at the Achinsk alumina refinery to the level achieved in 2014; in 2015, seasonal factors and weather conditions in the fourth quarter had slowed production (United Company RUSAL Plc, 2017).

In 2016, phosphate producer PJSC PhosAgro AG, through its subsidiary OJSC Apatit, was Russia's only producer of nepheline concentrate. At the Apatit mining and beneficiation complex, the company mined and processed apatite-nepheline ore from the Khibiny deposit on the Kola Peninsula in the Murmansk region of northwest Russia. The Apatit operation produced phosphate rock, nepheline concentrates, and other mineral concentrates. In 2016, nepheline concentrate production increased slightly to 958,000 t and sales also increased slightly, with all sales going to Basel Cement Pikalevo (PJSC PhosAgro AG, 2017, p. 44–45).

Outlook

Production and transportation costs for U.S. producers of feldspar and nepheline syenite are expected to increase, and feldspar reserves at some operations are decreasing. Domestic feldspar producers may find increasing competition from imports of feldspar, which have increased significantly in the past several years, especially with the recent decrease in quantities of economically minable domestic potassium feldspar. Feldspar producers also may continue to find competition from domestic nepheline syenite used in the production of some ceramic tiles and imported nepheline syenite in the production of glass and ceramic products. Higher transportation charges for delivered raw materials could increase the cost of producing glass and tile.

Sales of glass food containers in the United States are expected to continue to increase slightly during the next several years as a result of consumer demand and Federal and State government initiatives for environmentally friendly and recyclable food and beverage packaging; this increase would likely increase feldspar consumption by glass container manufacturers. However, significant increases in glass container recycling and use of cullet could reduce the quantities of raw materials needed to manufacture these containers.

In the United States, new residential construction and commercial and residential remodeling are expected to increase, creating higher demand for ceramics, fiberglass, and glass, and thus for feldspar and nepheline syenite. Following the trend of the past several years, the ceramics industry is expected to continue to recover for the next several years, which is likely to increase the use of feldspar and nepheline syenite. Consumption of domestic ceramic tile is expected to continue to increase in 2017 (Whitmire, 2017b).

Worldwide, demand for ceramic tile is expected to rise as a result of increases in construction and in the residential replacement (remodeling) market, especially in the growing economies of China, Japan, and India. Although consuming much of its own output, China is likely to continue to be the leading exporter of ceramic tile. Residential replacement, which typically accounts for more than one-half of the total market globally, was projected to be the fastest growing market for ceramic tile at an estimated compound annual rate of growth of more than 9.8% from 2015 through 2024 (GlobeNewswire, Inc., 2016a). An increasing trend toward replacing marble floors, metal slabs, and paints with ceramic tile and the increasing use of ceramic tiles for wall coverings (especially in kitchens) because they are easy to clean are anticipated to drive regional growth in the residential replacement market. Increased use of ceramic and porcelain floor tiles as replacement for hardwood and other flooring items is expected because of high durability and frost and thermal shock resistance (GlobeNewswire, Inc., 2016a, b). A trend in recent years of innovative ideas and products in ceramics, such as thinner, stronger ceramic sheets that can be laid without removing existing floor tiles, and an increasing percentage of porcelain tile production (especially in China and India) that offers superior physical and chemical characteristics, in part owing to increased feldspar content, are

likely to help expand their use in the ceramics industry and thus the demand for feldspar. The recent use of inkjet technology to design relatively affordable ceramic tiles with the realistic appearance of hardwood and other flooring materials may be another factor for growth in the industry (Occams Business Research & Consulting Pvt. Ltd., 2017).

References Cited

- American Wonder Porcelain, 2016, New plant in Lebanon, Tennessee: Lebanon, TN, American Wonder Porcelain news release, April 13. (Accessed January 24, 2018, at <https://www.wonderporcelain.com/new-plant-in-lebanon/>.)
- Biraldi, Luca, 2017a, World production and consumption of ceramic tiles: Modena, Italy, Ceramic World Review, no. 123, August/October, p. 56–70. (Accessed January 9, 2018, at <http://www.ceramicworldweb.it/cww-en/statistics-and-markets/world-production-and-consumption-of-ceramic-tiles-4/>.)
- Biraldi, Luca, 2017b, World sanitaryware exports and imports: Modena, Italy, Ceramic World Review, no. 124, November/December, p. 62–72. (Accessed January 30, 2018, at http://www.ceramicworldweb.it/file/Home/cww/pdf/cwr/2017/cwr-124/062_073%20FOCUS%20Sanitary%20Fondo.pdf.)
- Gadd, Chris, 2016, Dickson Dal-Tile plant begins operations, shipping: The Tennessean [Nashville, TN], April 21. (Accessed January 24, 2018, at <http://www.tennessean.com/story/news/local/dickson/2016/04/21/dickson-dal-tile-plant-begins-operations-shipping/83330828/>.)
- Glass Packaging Institute, 2017, Recycling: Arlington, VA, Glass Packaging Institute. (Accessed March 23, 2017, at <http://www.gpi.org/recycling/why-recycle-glass/>.)
- GlobeNewswire, Inc., 2016a, Ceramic tiles market size to reach \$178.16bn by 2024—Global Market Insights Inc.: El Segundo, CA, GlobeNewswire, Inc., October 4. (Accessed January 31, 2017, at <https://globenewswire.com/news-release/2016/10/04/876799/0/en/Ceramic-Tiles-Market-size-to-reach-178-16bn-by-2024-Global-Market-Insights-Inc.html>.)
- GlobeNewswire, Inc., 2016b, Ceramic tiles market worth USD 125.32 billion by 2020—Radiant Insights, Inc.: El Segundo, CA, GlobeNewswire, Inc., February 24. (Accessed January 31, 2017, at <https://globenewswire.com/news-release/2016/02/24/813553/0/en/Ceramic-Tiles-Market-Worth-USD-125-32-Billion-By-2020-Radiant-Insights-Inc.html>.)
- Hudson Resources Inc., 2013, Hudson completes community meetings for the White Mountain project in Greenland and provides project update: Vancouver, British Columbia, Canada, Hudson Resources Inc. press release, November 27, 3 p. (Accessed December 10, 2014, at <http://www.hudsonresources.ca/files/NR2013-08.pdf>.)
- Hudson Resources Inc., 2014, Hudson produces specialty grade calcined alumina using White Mountain anorthosite: Vancouver, British Columbia, Canada, Hudson Resources Inc. press release, December 11, 3 p. (Accessed February 15, 2015, at <http://www.hudsonresources.ca/files/NR2014-05.pdf>.)
- Hudson Resources Inc., 2017a, Hudson announces agreement to establish distribution hub in Savannah, Georgia: Vancouver, British Columbia, Canada, Hudson Resources Inc. press release, May 18, 2 p. (Accessed September 15, 2017, at <http://www.hudsonresources.ca/files/NR2017-09.pdf>.)
- Hudson Resources Inc., 2017b, Hudson provides update on engineering and construction activities at the White Mountain anorthosite project in Greenland: Vancouver, British Columbia, Canada, Hudson Resources Inc. press release, June 29, 2 p. (Accessed September 15, 2017, at <http://www.hudsonresources.ca/files/NR2017-10.pdf>.)
- I-Minerals Inc., 2014, I-Minerals Inc. completes sale of quartz-feldspar sands to Quarry Tile: Vancouver, British Columbia, Canada, I-Minerals Inc. news release, October 29. (Accessed October 30, 2015, at <https://www.imineralsinc.com/news/i-minerals-inc-completes-sale-of-quartz-feldspar-sands-to-quarry-tile>.)
- I-Minerals Inc., 2016, I-Minerals receives Roskill mineral market report: Vancouver, British Columbia, Canada, I-Minerals Inc. news release, January 26. (Accessed January 30, 2017, at <https://www.imineralsinc.com/news/i-minerals-receives-roskill-mineral-market-report>.)
- I-Minerals Inc., 2017, I-Minerals' pilot plant work creates exceptional K-spar product: Vancouver, British Columbia, Canada, I-Minerals Inc. news release, January 31. (Accessed July 30, 2017, at <https://www.imineralsinc.com/news/i-minerals-pilot-plant-work-creates-exceptional-k-spar-product>.)
- Indian Bureau of Mines, 2016, Felspar [sic], in Part III—Mineral reviews (54th ed.) (advance release): Nagpur, India, Indian Minerals Yearbook 2015, v. III, December, p. 19–1 to 19–11. (Accessed January 10, 2017, at http://ibm.gov.in/writereaddata/files/12152016105036IMYB2015_Felspar_15122016_Adv.pdf.)
- Indian Bureau of Mines, 2017, Felspar [sic], in Part III—Mineral reviews (55th ed.) (advance release): Nagpur, India, Indian Minerals Yearbook 2016, v. III, December, p. 19–1 to 19–8. (Accessed January 10, 2017, at [http://www.ibm.nic.in/writereaddata/files/12262017134154Felspar%202016%20\(Advance%20Release\).pdf](http://www.ibm.nic.in/writereaddata/files/12262017134154Felspar%202016%20(Advance%20Release).pdf).)
- Natural Resources Canada, 2017, Annual statistics of mineral production: Ottawa, Ontario, Canada, Natural Resources Canada. (Accessed October 22, 2017, at <http://sead.nrcan.gc.ca/prod-prod/ann-ann-eng.aspx>.)
- Occams Business Research & Consulting Pvt. Ltd., 2017, Global ceramic tiles market insights, opportunity, analysis, market shares and forecast 2017–2024: Mumbai, India, Occams Business Research & Consulting Pvt. Ltd., March. (Accessed February 14, 2018, at <http://www.occamsresearch.com/ceramic-tiles-market>.)
- OTC Markets Group, 2016, AIM Exploration, Inc. background and update as of fall 2016: New York, NY, OTC Markets Group press release, November 9. (Accessed November 20, 2017, at <http://www.otcmarkets.com/stock/AEXE/news/AIM-Exploration-Inc--Background-and-update-as-of-Fall-2016?id=144319&b=y>.)
- Patel, Kasia, 2015, Hudson Resources seals major anorthosite deal with Owens Corning: Industrial Minerals, July 31. (Accessed June 29, 2016, via <http://www.indmin.com/>.)
- PJSC PhosAgro AG, 2017, Integrated report 2016—The phosphate journey—From mine to plate: Moscow, Russia, PJSC PhosAgro AG, 168 p. (Accessed January 31, 2018, via <https://www.phosagro.com/investors/reports/>.)
- Powell, Jay, 2016, Landmark Ceramics opens for business: The Daily Herald [Columbia, TN], November 12. (Accessed January 25, 2018, at <http://www.columbiadailyherald.com/news/20161112/landmark-ceramics-opens-for-business>.)
- Surbhi, S., 2016, Difference between organised and unorganised sector: New York, NY, Key Differences, February 3. (Accessed June 14, 2018, at <https://keydifferences.com/difference-between-organised-and-unorganised-sector.html>.)
- United Company RUSAL Plc, 2017, UC RUSAL announces fourth quarter and full year 2016 operating results: Moscow, Russia, United Company RUSAL Plc press release, February 16, 6 p. (Accessed January 31, 2018, at https://rusal.ru/upload/iblock/a6a/16.02.2017%20RUSAL_Trading%20update%204Q2016.pdf.)
- United Nations Statistics Division, [undated]a, Feldspar: United Nations Comtrade Database. (Accessed November 10, 2017, via <http://comtrade.un.org/db/>.)
- United Nations Statistics Division, [undated]b, Leucite, nepheline and nepheline syenite: United Nations Comtrade Database. (Accessed November 10, 2017, via <http://comtrade.un.org/db/>.)
- U.S. Census Bureau, 2017a, Construction spending—Historical value put in place: U.S. Census Bureau. (Accessed September 30, 2017, via http://www.census.gov/construction/c30/historical_data.html.)
- U.S. Census Bureau, 2017b, Historical data, new residential construction: U.S. Census Bureau. (Accessed September 30, 2017, via http://www.census.gov/construction/nrc/historical_data/.)
- U.S. Census Bureau, 2017c, USA Trade Online: U.S. Census Bureau. (Accessed June 6, 2018, via <https://usatrade.census.gov/index.php?do=login>.)
- U.S. Department of Labor, Mine Safety and Health Administration, 2017, Mine data retrieval system: U.S. Department of Labor, Mine Safety and Health Administration. (Accessed October 2, 2017, via <http://www.msha.gov/drs/drshome.htm>.)
- Ward's Automotive Group, 2017a, North America car and truck production, 1951–2016: Detroit, MI, Ward's Automotive Group, February 23. (Accessed August 9, 2017, via <http://wardsauto.com/datasheet/north-america-car-and-truck-production-1951-2016>.)
- Ward's Automotive Group, 2017b, U.S. car and truck sales, 1931–2016: Detroit, MI, Ward's Automotive Group, February 6. (Accessed August 9, 2017, via <http://wardsauto.com/datasheet/us-car-and-truck-sales-1931-2016>.)
- Whitmire, Andrew, 2017a, US ceramic tile industry update—2016: Anderson, SC, Tile Council of North America, Inc., April 5. (Accessed September 20, 2017, via <http://www.tcnatile.com/resources/market-reports.html>.)
- Whitmire, Andrew, 2017b, US ceramic tile industry update—Q2 2017: Anderson, SC, Tile Council of North America, Inc., 7 p. (Accessed November 2, 2017, via <http://www.tcnatile.com/resources/market-reports.html>.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Feldspar. Ch. in Mineral Commodity Summaries, annual.
 Feldspar. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
 Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
 Silica. Ch. in Minerals Yearbook, annual.
 Soda Ash. Ch. in Minerals Yearbook, annual.

Other

Feldspar. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
 Feldspars. Ch. in Industrial Minerals and Rocks (7th ed.), Society for Mining, Metallurgy, and Exploration, Inc., 2006.
 Nepheline Syenite. Ch. in Industrial Minerals and Rocks (7th ed.), Society for Mining, Metallurgy, and Exploration, Inc., 2006.

TABLE 1
 SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS¹

(Metric tons and thousand dollars unless otherwise specified)

	2012	2013	2014	2015	2016
United States:					
Production, feldspar:^{e,2}					
Quantity ³	560,000	550,000	530,000	520,000	470,000
Value	36,500	40,100	34,800	37,300 ^r	33,100
Exports, feldspar:⁴					
Quantity	13,600	17,700	16,000	15,100	5,890
Value ⁵	4,580	5,310	5,880	4,920	1,520
Imports for consumption:⁴					
Feldspar:					
Quantity	1,640	4,310	7,910	120,000	36,900
Value ⁶	342	1,110	3,120	7,090	3,430
Nepheline syenite:					
Quantity	386,000	491,000	503,000	449,000	572,000
Value ⁶	44,200	59,300	64,000	67,600	73,000
Consumption, apparent ^{e,3,7}	930,000	1,000,000	1,000,000	1,100,000 ^r	1,100,000
World, production ⁸	22,100 ^r	22,400 ^r	24,000 ^r	23,100 ^r	23,400

^eEstimated. ^rRevised.

¹Table includes data available through July 5, 2018. Data are rounded to no more than three significant digits.

²Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite; for use predominantly in the production of ceramics and glass, may differ from sales in table 4.

³Rounded to two significant digits to avoid disclosing company proprietary data.

⁴Source: U.S. Census Bureau.

⁵Free alongside ship value.

⁶Customs value.

⁷Production plus imports minus exports. Includes feldspar and imported nepheline syenite.

⁸Feldspar only. Thousand metric tons.

TABLE 2
ESTIMATED FELDSPAR PRODUCTION IN THE UNITED STATES¹

(Thousand metric tons and thousand dollars)

Year	Flotation concentrate		Other ²		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
2015	120	8,500	410	28,800 ^r	520	37,300 ^r
2016	80	6,860	390	26,300	470	33,100

^rRevised.

¹Table includes data available through July 5, 2018. Quantity data are rounded to two significant digits, and value data are rounded to three significant digits; may not add to totals shown.

²Includes hand-cobbed feldspar, feldspar content of feldspar-quartz mixtures, and aplite; excludes nepheline syenite.

TABLE 3
U.S. PRODUCERS OF FELDSPAR IN 2016

Company	Location	Product
APAC-Central, Inc.	Muskogee, OK	Feldspar-quartz mixture.
G3 Enterprises Inc.	Byron, CA	Do.
Graniterock Co.	Felton, CA	Do.
Pacer Corp.	Custer, SD	Potassium feldspar.
Quartz Corp., The	Spruce Pine, NC	Sodium-potassium feldspar.
Do.	do.	Sodium-potassium feldspar; feldspar-quartz mixture.
Unimin Corp.	Emmett, ID	Feldspar-quartz mixture.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
Do.	do.	Sodium-potassium feldspar; feldspar-quartz mixture.
U.S. Silica Holdings, Inc.	Montpelier, VA	Aplite.
Do., do. Ditto.		

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

(Thousand metric tons and thousand dollars)

Use	2015		2016	
	Quantity	Value	Quantity	Value
Glass ³	300 ^r	22,800 ^r	300	20,700
Ceramics/pottery and miscellaneous	220	14,500 ^r	170	12,500
Total	520	37,300 ^r	470	33,100

^rRevised.

¹Table includes data available through July 5, 2018. Quantity data are rounded to two significant digits, and value data are rounded to three significant digits; may not add to totals shown.

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

³Includes container glass, fiberglass, and other glass.

TABLE 5
U.S. EXPORTS OF FELDSPAR, BY COUNTRY OR LOCALITY¹

(Metric tons and dollars)

Country or locality	2015		2016	
	Quantity	Value ²	Quantity	Value ²
Brazil	--	--	9	2,840
Canada	2,650	798,000	2,030	666,000
Chile	256	67,300	--	--
China	4	3,060	--	--
Colombia	990	200,000	637	106,000
Costa Rica	180	30,100	80	21,900
El Salvador	78	26,900	--	--
French Polynesia	4	5,660	7	6,380
Honduras	120	38,500	140	41,200
Korea, Republic of	18	8,160	18	12,900
Malaysia	18	8,960	18	9,600
Mexico	45	9,350	36	6,820
Norway	7,420	2,860,000	--	--
Panama	160	54,800	180	69,800
Trinidad and Tobago	--	--	69	14,200
Venezuela	3,200	804,000	2,670	565,000
Total	15,100	4,920,000	5,890	1,520,000

-- Zero.

¹Table includes data available through July 5, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY OR LOCALITY^{1,2}

(Metric tons and dollars)

Country or locality	2015		2016	
	Quantity	Value ³	Quantity	Value ³
Australia	9	9,000	--	--
Brazil	--	--	103	54,100
Canada	--	--	4	2,000
Germany	659	230,000	520	161,000
India	532	173,000	536	142,000
Malawi	--	--	1	450
Mexico	843	179,000	671	187,000
Spain	1,310	343,000	927	253,000
Turkey	117,000	6,150,000	34,200	2,630,000
Total	120,000	7,090,000	36,900	3,430,000

-- Zero.

¹Table includes data available through July 5, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Excludes nepheline syenite (mostly from Canada), which is listed in table 1.

³Customs value.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 7
FELDSPAR: WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons)

Country or locality ²	2012	2013	2014	2015	2016
Algeria	163,000	259,000	230,372	245,000 ^r	240,000 ^e
Argentina	273,896	226,435	164,000 ^{r,e}	220,000 ^e	200,000 ^e
Australia, includes nepheline syenite	50,000 ^e	45,000 ^e	45,000 ^e	45,000 ^{r,e}	40,000
Austria ^e	32,000	35,000	35,000	35,000 ^r	30,000
Brazil, beneficiated, processed, marketable	247,152	294,357	418,000 ^{r,e}	420,000 ^{r,e}	400,000
Chile	6,399	3,874	4,233	6,577 ^r	5,000 ^e
China ^e	3,350,000 ^r	3,500,000 ^r	3,670,000 ^r	2,680,000 ^r	3,800,000
Cuba ^e	3,800	3,200	3,600	3,300	3,900
Czechia	445,000	411,000	422,000	433,000 ^r	454,000
Ecuador	153,590 ^r	210,142 ^r	183,259 ^r	253,253 ^r	149,000
Egypt ^e	400,000 ^r	400,000 ^r	400,000 ^r	421,000 ^r	400,000
Ethiopia ^e	500	550 ^r	596 ^r	600 ^r	600 ^e
Finland	43,124	47,636	46,233	38,026 ^r	40,000 ^e
Germany ^e	205,000	200,000	200,000	200,000	200,000
Greece	33,800	--	--	--	--
Guatemala	19,356	19,611	10,410	10,340	30,428
India	1,066,752 ^r	1,224,773 ^r	1,634,240 ^r	1,400,000 ^{r,e}	1,500,000
Indonesia	19,000 ^e	18,000 ^e	18,000 ^e	18,000 ^e	--
Iran	1,100,000 ^{r,e}	1,313,233	1,128,569 ^r	1,003,354 ^{r,e}	750,005 ^e
Italy ^e	4,700,000	4,700,000 ^r	4,700,000 ^r	4,500,000 ^r	4,000,000
Korea, Republic of	360,413	343,241	528,958 ^r	601,030 ^r	600,000 ^e
Macedonia	17,168 ^r	15,168 ^r	18,076 ^r	20,289	19,919
Malaysia	482,906	314,399 ^r	378,446 ^r	442,980 ^r	326,648
Mexico	380,441	164,484	150,726	159,372	145,323
Morocco ^e	45,000	45,000	45,000	45,000	40,000
Nigeria	9,080	12,880 ^r	52,080 ^r	26,400 ^{r,e}	34,144
Norway	--	--	154,000	76,000 ^r	50,000
Pakistan ³	53,235	77,134 ^r	38,126 ^r	141,582 ^r	305,308
Peru	26,359	22,695	18,019	16,979 ^r	16,629
Philippines	24,969	30,388	34,232	38,067 ^r	46,630
Poland, processed	487,200 ^r	483,000 ^r	519,900 ^r	539,900 ^r	540,000
Portugal	109,273	70,057	70,865	93,789 ^r	132,105
Romania ^{e, 4}	6,500	6,800	9,200 ^r	8,200 ^r	4,500
Russia	400,000	390,000	400,000	400,000	400,000
Saudi Arabia	227,000	160,000	168,000	176,000 ^{r,e}	160,000
Slovakia ^e	--	5,000	6,000	4,000 ^r	4,000
South Africa	94,458	191,443	102,541	130,184 ^r	131,023
Spain, includes pegmatite	530,238	592,908 ^r	533,328 ^r	558,273 ^r	634,519
Sri Lanka ^e	87,300 ^r	96,000 ^r	96,000 ^r	96,000 ^r	95,000
Sudan	26,283	31,700	50,680	94,354 ^r	92,172
Sweden, marketable, crude and ground ^e	27,000	30,000	27,000	27,000 ^r	--
Thailand	1,100,723	1,072,656	1,413,428	1,331,916	1,300,000
Turkey	4,524,943	4,545,197	5,120,000 ^{r,e}	5,500,000 ^r	5,500,000
Ukraine	146,000	134,000	94,506 ^r	44,460 ^r	33,627
United States ^{e, 4, 5}	560,000	550,000	530,000	520,000	470,000
Venezuela	85,115 ^r	91,100 ^r	93,900 ^r	75,500 ^r	80,000 ^e
Total	22,100,000 ^r	22,400,000 ^r	24,000,000 ^r	23,100,000 ^r	23,400,000

^eEstimated. ^rRevised. -- Zero.

¹Table includes data available through November 22, 2017. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²In addition to the countries listed, Bulgaria, Burma, Colombia, France, Japan, Kenya, Namibia, the United Arab Emirates, and Yemen may produce feldspar, but output is not officially reported and available information was inadequate to make reliable estimates of output levels.

³Data are for fiscal year ending June 30 of the following year.

⁴Rounded to two significant digits to avoid disclosing company proprietary data.

⁵Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.