

KYANITE AND RELATED MATERIALS

By Michael J. Potter

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Ronald L. Hatch, international data coordinator.

Kyanite, andalusite, and sillimanite are anhydrous aluminosilicate minerals with the same chemical formula (Al_2SiO_5) but different crystal structures and physical properties. When calcined at high temperatures (in the 1,400°C to 1,500°C range for kyanite and andalusite and 1,550°C to 1,625°C for sillimanite), these minerals are converted to mullite ($\text{Al}_6\text{Si}_2\text{O}_{13}$) and silica (SiO_2) (Harben, 1999). During calcination, 1 metric ton (t) of aluminosilicate concentrate yields about 0.88 t of mullite. Synthetic mullite is made by heating mixtures of bauxite and kaolin or alumina and silica at about 1,550°C to 2,000°C (Roskill Information Services Ltd., 1990, p. 55). Mullite in refractories increases the fired strength, resistance to deformation under load, and thermal resistivity. Refractories are the largest end use of kyanite, andalusite, mullite, and synthetic mullite in the United States and worldwide.

Reported production data collected by the U.S. Geological Survey are withheld to avoid disclosing company proprietary information. However, Dickson (2001) has estimated U.S. kyanite output to be about 90,000 metric tons per year (t/yr), which would make the United States the world's largest producer of this mineral. South Africa continued as the leading producing country of andalusite, with an estimated 140,000 t in 2001. France produced an estimated 65,000 t of andalusite. Sillimanite has had limited production; India has supplied most of the world's output with an estimated 12,000 t/yr in recent years.

Legislation and Government Programs

The U.S. Government stockpile contained a total of 136 t of kyanite at yearend 2001. This material was being offered for sale on the third Thursday of every month (Defense National Stockpile Center, 2001§¹).

Production

Kyanite Mining Corp. operated two open pit mines in Buckingham County, VA, and beneficiated the ore into a marketable kyanite concentrate. The company had two calcining kilns at its Dillwyn, VA, facility for production of calcined kyanite (mullite); further processing and warehousing also were carried out at this site. Company data are proprietary, but Dickson (2001) has estimated U.S. output to be about 90,000 t/yr; an estimated value of kyanite concentrate was calculated to be \$13.4 million (before any material was converted to mullite), using the minimum value of \$149 per

¹References that include a section twist (§) are found in the Internet References Cited section.

metric ton shown in table 1. High-temperature sintered synthetic mullite, made from calcined bauxitic kaolin and known under the trade name Mulcoa, was produced by C-E Minerals, Inc., near Americus, GA. Estimated U.S. production of synthetic mullite was about 40,000 t/yr (Dickson, 2001); an estimated value was calculated to be \$9.7 million, using a value of \$243 per ton from Dickson (2001).

Piedmont Minerals Co., Inc., in Hillsborough, NC, mined a deposit containing andalusite combined with pyrophyllite and sericite. The company sells products containing blends of the three minerals to refractories and ceramics producers. There was no known U.S. output of sillimanite.

Consumption

Examples of refractories that contain andalusite, kyanite, mullite, and/or synthetic mullite include insulating brick, firebrick, kiln furniture, refractory shapes, and monolithic refractories (made of a single piece or as a continuous structure), including castables (refractory concrete), gunning mixes, mortars, plastics, and ramming mixes. The interlocking grain structure of kyanite and mullite gives added mechanical strength to refractories and other nonrefractory ceramic articles. End uses of kyanite and related materials include brake shoes and pads, electrical porcelain, floor and wall tile, foundry use, precision casting molds, sanitaryware, and other products (Kyanite Mining Corp., 2001§). Sillimanite was not known to be used in the United States in 2001.

Foreign Trade

The United States exported kyanite, mullite, and synthetic mullite to countries in Europe, Latin America, the Pacific Rim, and other areas. Most of the imported material in 2001 was from South Africa (3,085 t) and was presumed to be andalusite (table 2). The remaining 177 t was from Germany but may have been misclassified because its unit value, \$337 per metric ton, was much higher than that of kyanite or andalusite concentrates. There were no known U.S. imports of kyanite or sillimanite in 2001.

World Review

China.—A paper on sillimanite-group minerals was given by H. Liu at the fourth Chinese Industrial Minerals Conference (“Qingdao 2001: China in Change”) held in Qingdao in October 2001. The paper reviewed the development and market opportunity of China's andalusite, kyanite, and sillimanite. The chemicals, construction, glass, metallurgy, and porcelain industries reportedly were increasing demand for kyanite and

related materials. The China Association of Refractory Materials called for increased development of these refractory minerals (Industrial Minerals, 2001a).

China was experiencing overcapacity in its refractories production, a situation facing the refractories industry worldwide. China was also facing other challenges, such as higher refractory consumption per ton of steel produced than other steel producing countries. Also, plant equipment and product quality of many middle- and small-scale companies needed upgrading. China was seeking to develop and promote new types of refractory products with longer service lives, including those containing mullite materials (O'Driscoll, 2001).

A new sintered mullite plant in the Kuang Wu Zu District of Datong was slated to begin production in 2001. This joint venture between Jersey Minerals Processing Co. of Tianjin and a Chinese financial investment company was to have initial production of 30,000 t/yr. Bauxite and clays were to be stockpiled for blending and crushing and then processed, including slurring, filtration, extrusion, drying, and calcining up to 1,700°C (O'Driscoll, 2001).

Outlook

Difficult challenges facing the iron and steel industry have had an impact on the refractories industry, especially in the United States. Crude steel production in North America (including Canada and Mexico) decreased by more than 11% in 2001, compared with that of 2000, according to preliminary information. World crude steel production in 2001 was projected to be about 1% less than in 2000 (International Iron and Steel Institute, 2002§). Demand for refractory products and refractory raw materials has declined.

Some possible options for refractories producers might include consolidations and mergers with competitors; focusing only on specialty lines of products; offering the whole refractories package of supply, installation, and maintenance; and contracting out refractory manufacture to such cheaper production sources as China (Industrial Minerals, 2001b).

References Cited

- Dickson, Ted, 2001, Sillimanite minerals: Mining Journal Industrial Minerals Annual Review Supplement CD-ROM, 5 p.
- Harben, P.W., 1999, Sillimanite minerals, *in* The industrial minerals handybook—A guide to markets, specifications, & prices (3d ed.): Surrey, United Kingdom, Industrial Minerals Information Ltd., p. 191-193.
- Industrial Minerals, 2001a, CIMC4 updates magnesite, sillimanite, and graphite status: Industrial Minerals, no. 410, November, p. 17.
- Industrial Minerals, 2001b, Comment—Irons in the fire: Industrial Minerals, no. 411, December, p. 7.
- O'Driscoll, Mike, 2001, China's refractories market: Industrial Minerals, no. 406, July, p. 53-59.
- Roskill Information Services Ltd., 1990, The economics of kyanite: London, Roskill Information Services Ltd., 118 p. plus appendices.

Internet References Cited

- Defense National Stockpile Center, 2001 (December 10), Kyanite, accessed February 12, 2002, at URL <https://www.dnsc.dla.mil/kyanite.htm>.
- International Iron and Steel Institute, 2002 (January 18), IISI releases the provisional crude steel production statistics for 2001, accessed February 6, 2002, at URL <http://www.worldsteel.org/article/iisi20020118>.
- Kyanite Mining Corp., 2001, How our products are used, accessed February 6, 2002, at URL <http://www.kyanite.com/howused.html>.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Kyanite and Related Minerals. Ch. in Mineral Commodity Summaries, annual.
- Kyanite and Related Minerals. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Other

- Kyanite and Related Minerals. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
- Sillimanite Group—Kyanite and Related Minerals. Ch. in Industrial Minerals and Rocks, Society for Mining, Metallurgy, and Exploration, 6th ed., Donald Carr, ed., 1994.

TABLE 1
PRICE OF KYANITE AND RELATED MATERIALS IN 2001

(Dollars per metric ton)

	Price
Andalusite, South Africa, 57% alumina, 2,000-metric-ton bulk, f.o.b. 1/	161
Andalusite, South Africa, 58% alumina, 2,000-metric-ton bulk, f.o.b. 1/	189
Kyanite, USA (VA), 54% to 60% alumina, 35-325 mesh, 18-ton lots:	
Raw	149-182
Calcined	262-295

1/ Free on board.

Source: Industrial Minerals, no. 411, December 2001, p. 83.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ANDALUSITE,
KYANITE, AND SILLIMANITE 1/ 2/ 3/

Year	Quantity (metric tons)	Value 4/ (thousands)
2000	6,440	\$1,320
2001	3,260	569

1/ Most material is from South Africa.

2/ Harmonized Tariff System (HTS) code: 2508.50.0000.

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

4/ Customs value.

Source: U.S. Census Bureau.

TABLE 3
KYANITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country and commodity 3/	1997	1998	1999	2000	2001
Australia:					
Kyanite	800	800	1,000	1,000	1,000
Sillimanite 4/	100	100	100	100	100
Brazil, kyanite	600	600	600	600	600
China, unspecified	3,000 r/	3,050 r/	3,000	3,100 r/	3,150
France, andalusite	67,000	70,000 r/	70,000 r/	65,000	65,000
India:					
Kyanite	6,035 5/	5,169 5/	5,000	5,000	5,000
Sillimanite	12,299 5/	11,936 5/	12,000	12,000	12,000
South Africa:					
Andalusite	251,203 5/	236,200 5/	136,900 r/ 5/	182,674 r/ 5/	140,000
Sillimanite	-- 5/	65 5/	--	--	--
Spain, andalusite	3,500	3,000	2,500	2,500	2,500
United States:					
Kyanite	W	90,000	90,000	90,000	90,000
Mullite, synthetic	W	39,000	39,000	40,000	40,000
Zimbabwe	1,113 5/	3,780 5/	4,000	4,000	4,000

r/ Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

1/ U.S. and estimated data are rounded to no more than three significant digits.

2/ Owing to incomplete reporting, this table has not been totaled. Table includes data available through March 23, 2002.

3/ In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

4/ In addition, about 7,000 metric tons per year of sillimanite clay (also called kaolinized sillimanite) containing 40% to 48% Al₂O₃ is produced.

5/ Reported figure.