KYANITE AND RELATED MATERIALS

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Kyanite, andalusite, and sillimanite are anhydrous aluminosilicate minerals that have the same chemical formula, Al_2SiO_5, but differ in crystal structure and physical properties. When calcined at high temperatures, these minerals are converted to mullite, $3Al_2O_3 \cdot 2SiO_2$, and silica, SiO_2, which are refractory materials. In the conversion to mullite, 1 metric ton (t) of mineral concentrate yields about 0.88 t of mullite. Andalusite and sillimanite are not mined in the United States, except for a pyrophyllite/andalusite/sericite deposit that is mined by Piedmont Minerals Co., Inc., near Hillsborough, NC. In processing this ore, andalusite is not separated, but remains in various combinations with the pyrophyllite and sericite to produce blends of products. U.S. imports of andalusite in 1998 were about 9,600 t from South Africa.

Production

In 1998, kyanite was mined by Kyanite Mining Corp. at two open-pit locations in Buckingham County, VA. The company also operated beneficiation plants, and calcining facilities for the conversion of kyanite to mullite. Company data are proprietary, but an estimate of the total output is 90,000 t (Dickson, 1998); a corresponding value was estimated to be $13 million (before any material was converted to mullite). High-temperature sintered synthetic mullite, made from calcined bauxite, was produced by C-E Minerals Inc. near Americus, GA. Production data are proprietary, but an estimate of output is 39,000 t (Dickson, 1998).

Consumption

The U.S. Geological Survey estimated that the end usage of kyanite/mullite (including exported material) was 50,000 t ($8.3 million) in refractories and 40,000 t ($6.7 million) in ceramics. Refractories included monolithics such as ramming mixtures, castables, gunning mixes, and plastics. Ceramic and other end uses included whitewares, kiln furniture, acoustical tiles, catalytics, electrical insulators, shell castings, foundry uses, and investment casting procedures. Imported andalusite has refractory end uses similar to those of kyanite and mullite.

The iron and steel and glass industries are two of the largest users of mullite-based products in refractories. In glassmaking, mullite-based refractories are used in burner blocks, ports, and checker brick, as well as in the furnace proper. In the iron and steel industry, many refractories have varying amounts of sintered, mullite-based aggregates. A major use of high-mullite-based products is in hot blast furnace stove checker brick. Other refractory uses include linings for torpedo and steel ladles, lances, reheat furnaces, and slide gates. Other user industries are aluminum (alumina reduction cells) and petrochemicals (furnaces) (Jain, 1998).

Foreign Trade

The United States exported kyanite, mullite, and synthetic mullite to such areas as Europe, Latin America, and the Pacific Rim. In recent years, imports of andalusite have been largely from South Africa. There were no known U.S. imports of kyanite or sillimanite in 1998.

World Review

In August 1998, Anglovaal Minerals Ltd. (Avmin) in South Africa stated its intention to deemphasize its noncore assets and to concentrate on its precious, ferrous, and base metals businesses. Noncore Avmin assets included Rhino Minerals (Pty.) Ltd., producer of andalusite, alumina, and zircon. In 1997, Rhino had invested $6.9 million on commissioning its Havercroft andalusite operation near Burgersfort in Northern Province. A further capital expenditure of $2.9 million was made during that year to complete process and plant infrastructure. The company had a $1.9 million loss for the year ending June 30, 1998. Decreased sales in 1998 were attributed to poor market conditions (Industrial Minerals, 1998).

Outlook

For refractories in general, future trends may include more automated refractory installation procedures, as well as better equipment for monitoring the process conditions and the refractory lining. In steelmaking, the life of ladle linings has progressively increased, especially with the increased use of precast monolithic shapes in the sidewall and bottom (Semler, 1998b).

For the past several years, there has been a shift from production-based growth to value-based growth in refractories. Higher quality, longer lasting refractories are giving significantly increased lining life, resulting in reduced refractories usage for replacement (Semler, 1998a). Compared with those of 1997, U.S. raw steel production and European Union and Japanese steel production were projected to decrease by 1%, 2%, and 11%, respectively (Michael Fenton, U.S. Geological Survey, written commun., 1999). Refractory output and consumption by these countries for this end use could show proportionate trends.

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SOURCES OF INFORMATION

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

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TABLE 1
PRICE OF KYANITE AND RELATED MATERIALS IN 1998

(Dollars per metric ton)

	Price
Andalusite, South Africa, 57.5% alumina, 2,000-metric-ton bulk, f.o.b. 1/	180 - 200
Andalusite, South Africa, 59.5% alumina, 2,000-metric-ton bulk, f.o.b. 1/	200 - 240
Kyanite, USA (VA), 54% to 60% alumina, 35-325 mesh, 18-ton lots:	
Raw	141 - 174
Calcined	251 - 284
Sillimanite, South Africa, 70% alumina, bags, c.i.f. 2/ main European port	314 - 330

1/ Free on board.
2/ Cost, insurance, and freight.

Source: Industrial Minerals, December 1998, no. 375, p. 79.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ANDALUSITE 1/ 2/ 3/

Year	Quantity (metric tons)	Value 4/ (thousands)
1997	8,170	$1,680
1998	9,610	1,850

1/ Most material is from South Africa.
2/ Harmonized Tariff System (HTS) code: 2508.50.0000.
3/ Data are rounded to three significant digits.
4/ Customs value.

Source: U.S. Bureau of the Census.

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

(Metric tons)

Country and commodity 3/	1994	1995	1996	1997	1998
Australia:					
Kyanite	800	800	800	800	800
Sillimanite 4/	100	100	100	100	100
Brazil: Kyanite	600	600	600	600	600
China: Unspecified	2,500	2,500	2,500	2,500	2,500
France: Andalusite	50,000	45,000	45,000	45,000	45,000
India:					
Kyanite	6,265 5/	6,772 5/	6,715 5/	6,700	6,700
Sillimanite	10,378 5/	9,687 5/	7,521 5/	7,500	7,500
Kenya: Kyanite	(6/)	(6/)	(6/)	--	--
South Africa:					
Andalusite	206,291 5/	206,378 5/	234,000 r/ 5/	251,000 r/ 5/	250,000
Sillimanite	525 5/	317 5/	-- 5/	-- 5/	--
Spain: Andalusite	3,500	3,500	3,500	3,500	3,500
United States:					
Kyanite	W	W	W	W	90,000
Mullite, synthetic	W	W	W	W	39,000
Zimbabwe	567 5/	875 5/	141 5/	150 r/	50

r/ Revised. W Withheld to avoid disclosing company proprietary data.
1/ Estimated data have been rounded to three significant digits.
2/ Owing to incomplete reporting, this table has not been totaled. Table includes data available through March 1, 1999.
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 of sillimanite clay (also called kaolinized sillimanite) is produced annually containing 40% to 48% Al2O3.
5/ Reported figure.
6/ Less than 1/2 unit.