Kyanite and Related Materials

By Michael J. Potter[1]

Kyanite, andalusite, and sillimanite are anhydrous aluminum silicate minerals that are alike in both composition and use patterns and have the same chemical formula, $Al_2O_3 \cdot SiO_2$. Related materials include synthetic mullite, dumortierite, and topaz, also classified as aluminum silicates, although the last two additionally contain substantial proportions of boron and fluorine, respectively. All of these kyanite-group substances can serve as raw materials for manufacturing special high-performance, high-alumina refractories, but there has been no record in recent years of significant utilization of either dumortierite or topaz for this purpose in the United States.

Although published statistics are incomplete, it appears that the United States, India, and the Republic of South Africa are the leading world producers of kyanite-group minerals. It can be presumed that the U.S.S.R. and perhaps a few other industrialized nations also produce significant quantities of these materials.

U.S. kyanite estimated production in both 1978 and 1979 increased slightly in tonnage and value. Export and import data since 1977 for kyanite and mullite-containing materials are no longer collected as a separate category by the Bureau of the Census.

NL Industries, Inc., announced in late 1978 the sale of its Taylor Refractories Division to Didier Werke of Wiesbaden, Federal Republic of Germany. The sale of the division and related assets amounted to approximately $32 million. Taylor produces mullite and other special refractories, plus a wide range of kiln furniture, shapes, bricks, and monolithic refractories, mainly based on nonbasic materials.

Legislation and Government Programs.—The allowable depletion rates for kyanite, established by the Tax Reform Act of 1969 and unchanged through 1979, were 22% for domestic production and 14% for foreign operations.

DOMESTIC PRODUCTION

Kyanite was produced in the United States in 1978 and 1979 at three open pit mines, two in Virginia and one in Georgia. Kyanite Mining Corp. operated the Willis Mountain and East Ridge mines in Buckingham County, Va. C-E Minerals, Inc., operated the Graves Mountain mine in Lincoln County, Ga.

Estimated output of domestic kyanite in both 1978 and 1979 showed slight increases in tonnage and value. Kyanite production statistics for 1979 (and for all previous years since 1949) are withheld to avoid disclosing company proprietary data.

There are three types of synthetic mullite. Fused synthetic mullite is made by melting Bayer process alumina and silica, or bauxite and kaolin, in an electric furnace at around 3,450°F. High-temperature sintered synthetic mullite is prepared by sintering mixtures of alumina and kaolin, bauxite and kaolin, or alumina, kaolin, and kyanite above 3,180°F. Low-temperature sintered synthetic mullite is made by sintering siliceous bauxite or mixtures of bauxite and kaolin above 2,820°F.

Output of synthetic mullite in 1978 and 1979 was largely of the high-temperature sintered variety, and the four producers of this material were A. P. Green Refractories Co. at Philadelphia, Pa.; C-E Minerals, Inc., at Americus, Ga.; Didier Taylor Refractories Corp. at Greenup, Ky.; and Harbison-Walker Refractories Co. at Eufala, Ala. Electric-furnace-fused mullite was produced by Muscle Shoals, Electrochemical Div., at Tuscumbia, Ala. (in 1978), and The Carborundum Co. at Niagara Falls, N.Y.

Table 1.—Synthetic mullite production in the United States

Year	Quantity (short tons)	Value (thousands)
1975	24,150	$3,350
1976	42,230	5,453
1977	40,280	5,283
1978	38,080	5,442
1979	40,660	6,675

CONSUMPTION AND USES

Conforming to established end use patterns, kyanite and related materials were consumed in 1978 and 1979 mostly in the manufacture of high-alumina or mullite-class refractories and in lesser quantities as ingredients in some ceramic compositions. Domestic kyanite, already ground to minus 35 mesh as required by the flotation process used in its separation and recovery, was marketed either in the raw form or, after heat treatment, as mullite, which was sometimes further reduced in particle size before use. In the 35- to 48-mesh range, the mineral was used mostly in monolithic refractory applications such as for high-temperature mortars or cements, ramming mixes, and castable refractories, or with clays and other ingredients in refractory compositions for making kiln furniture, insulating brick, firebrick, and a wide variety of other articles. More finely ground material, minus 200 mesh, for example, was used in body mixes for sanitary porcelains, wall tile, investment-casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1978 and 1979, listed prices for kyanite, f.o.b. Georgia, ranging from $63 to $117 per short ton for bulk shipments and $9 more per ton for bagged material.

Price ranges quoted for kyanite-group materials in Ceramic Industry magazine, January 1979 and 1980, follow:

	Per short ton	
	1978	1979
Mullite, calcined kyanite	$105-$114	$105-$114
Mullite, calcined	105- 139	139
Mullite, fused	725- 810	725- 810

The December 1978 and 1979 issues of Industrial Minerals (London) quoted kyanite-group price ranges approximately equivalent to the following (converted from pounds sterling per metric ton to dollars per short ton):

	Per short ton	
	1978	1979
Andalusite, Transvaal, bagged, c.i.f. main European port	$164	$190
Kyanite, South African, graded, c.i.f. main European port	NA	220
Kyanite, Indian, f.o.b.	140	NA
Sillimanite, Indian, natural, bagged, f.o.b.	195	NA
Kyanite, Indian, calcined, f.o.b. Calcutta	240	NA

NA Not available.

FOREIGN TRADE

Export data of kyanite and mullite-containing materials are no longer collected as a separate category by the Bureau of the Census. Data had been collected up until 1977, and these export figures were published in this section in what was then table 2 (U.S. exports and imports for consumption of kyanite and related minerals). However, these Census figures did not distinguish between synthetic mullite and materials that were in part mullite.

Import data for kyanite-group minerals have likewise not been collected as a separate category since 1977. From 1972 through 1976, 100 to 200 tons per year was imported, largely from India and the Republic of South Africa. In 1977, imports totaled 53 tons.

WORLD REVIEW

Brazil.—Government approval to proceed with full-scale mining was received by Cianita Serra das Araras Ltda., the company developing the kyanite deposit near Anapolis in Goias State in central Brazil. The deposit consists of kyanite boulders lying close to the surface. Measured reserves are reported as 2 million tons. The property also holds large reserves of a coarse-grained kyanite-quartz rock. Trial shipments of crushed boulder material were sent to Europe, and tests conducted by refractory manufacturers were reportedly encouraging.[2]

Germany, Federal Republic of.—Imports of kyanite-group minerals in 1976 amounted to 36,500 tons. Principal countries of origin and the share supplied were the United States, 51%; France, 14%; the Republic of South Africa, 10%; India, 10%; and the United Kingdom, 9%. In 1977, imports of kyanite-group minerals were 59,900 tons. Principal countries of origin and the amounts supplied were the United States, 48%; France, 14%; the Republic of South Africa, 14%; India, 10%; and the United Kingdom, 6%.[3]

India.—The formation of a science research complex at a cost of $10 million was authorized by the Government. The project, to be set up in Orissa State under the supervision of the Government-owned company, Indian Rare Earths, will investigate the possibility of mining and processing beach sands to produce sillimanite and other minerals.[4]

The Government of India established a working group to assess important nonmetallic minerals and suggest the most feasible program for their development. The working group has opposed indiscriminate export of kyanite and sillimanite, and has recommended that production of kyanite should match the domestic requirements.[5]

Rhodesia, Southern.—Northeastern Rhodesia may contain significant resources of kyanite in four main localities: Inyanga North, Ky Mine, Madecheche, and Masterpiece. The mineral is in the form of bladed crystals at all four locations; small occurrences of massive kyanite are found only at Inyanga North.

The geological environment is similar at all localities; however, there are certain important differences. The Ky Mine deposit contains biotite-kyanite schist. Since biotite is the only primary gangue mineral, beneficiation is not difficult. Average Al_2O_3 content is 61%. At Madecheche, the ore is biotite-garnet-kyanite schist with various amounts of quartz. Beneficiation is required to remove the garnets, and the kyanite contains from 58% to 62% Al_2O_3. The grade of kyanite at Masterpiece is variable along an 11-mile strike, and beneficiation or fine grinding would be necessary to remove surface coatings of iron oxide and inclusions of graphite and biotite. Although the Inyanga North deposits are not well known, their grade is reported to be commercially acceptable.[6]

South Africa, Republic of.—Kyanite is one of several nonmetallic minerals considered to have a degree of promise for potential production in the State of Kwazulu in Natal Province.[7]

United Kingdom.—Imports of kyanite-group minerals in 1977 amounted to 69,970 tons. Principal countries of origin and the share supplied were the Republic of South Africa, 67%; the United States, 21%; and France, 11%.[8]

Table 2.—Kyanite, sillimanite and related materials: World production, by country[1]

(Short tons)

Country[2] and commodity	1976	1977	1978[p]	1979[e]
Australia: Sillimanite[3]	625	606	780	800
Brazil: Kyanite	282	121	[e]1,500	1,500
France: Kyanite-andalusite	19,986	[r e]22,000	[e]22,000	NA
India:				
Andalusite	--	427	248	250
Kyanite	[r]53,770	46,433	31,101	30,000
Sillimanite	16,379	16,560	14,655	15,000
Korea, Republic of: Andalusite	573	127	67	50
South Africa, Republic of:				
Andalusite	85,389	124,645	123,503	[4]147,905
Sillimanite	28,366	17,036	10,516	[4]21,577
Spain: Andalusite[e]	[r]6,330	[r]7,300	6,600	6,600
United States:				
Kyanite	W	W	W	W
Synthetic mullite	42,230	40,280	38,080	[4]40,660

[e]Estimate. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Owing to incomplete reporting, this table has not been totaled.

[2]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.

[3]In addition, sillimanite clay (also called kaolinized sillimanite) is produced, but output is not reported quantitatively, and available information is inadequate for the formulation of reliable estimates of output levels.

[4]Reported figure.

TECHNOLOGY

The expansion of kyanite when calcined to form mullite was studied in laboratory work. The apparent linear expansion of 35-mesh kyanite is approximately 28%. This value decreases gradually as the mesh size decreases until it becomes about 7% for 325-mesh kyanite.[9]

New Mexico kyanite samples assaying 23% kyanite or higher can, reportedly, be treated to give a high-grade concentrate. The flowsheet is relatively simple but is sensitive to mesh size and pH control. The deposit, near Petaca, N. Mex., appears to involve a considerable tonnage of high-grade kyanite.[10]

[1]Physical scientist, Section of Nonmetallic Minerals.

[2]Industrial Minerals (London). Green Light For Kyanite. No. 133, October 1978, p. 11.

[3]——. Industrial Minerals of West Germany. No. 131, August 1978, p. 17.

[4]——. Company News and Mineral Notes. No. 129, June 1978, p. 57.

[5]——. Indian Minerals. No. 140, May 1979, p. 13.

[6]——. Industrial Minerals of Rhodesia. No. 126, March 1978, p. 105.

[7]Page 56 of work cited in footnote 3.

[8]Industrial Minerals (London). UK Mineral Processors, Merchants, and Agents. No. 127, April 1978, p. 18.

[9]Brown, J. J., Jr. Effect of Particle Size on the Apparent Expansion of Kyanite During Conversion. Am. Ceram. Soc. Bull., v. 58, No. 6, June 1979, pp. 617, 619.

[10]Purcell, G., L. Lee, and R. Mattis. Beneficiation of Kyanite Ore from Rio Arriba County. New Mexico Energy Inst., Socorro, N. Mex., 1977, 35 pp.