



# 2016 Minerals Yearbook

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## KYANITE AND RELATED MINERALS [ADVANCE RELEASE]

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# KYANITE AND RELATED MINERALS

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In 2016, the United States continued to be the world's leading producer of kyanite concentrate and mullite (calcined kyanite); 79,700 metric tons (t) of kyanite concentrate was produced (Virginia Department of Mines, Minerals and Energy, 2017a; tables 1, 7). Mullite and synthetic mullite (a calcined mixture of aluminous and siliceous minerals and clays) production data were withheld to avoid disclosing company proprietary data. World production of kyanite and related minerals—andalusite and sillimanite—was estimated to be 393,000 t (tables 1, 7). In the United States, one company produced kyanite and mullite, two companies produced synthetic mullite, and one company produced andalusite as part of a mineral mixture. No U.S. production of sillimanite was reported. Refractory products continued to be the foremost end use for kyanite and related minerals, predominantly in ironmaking and steelmaking, and the remainder was used in the manufacture of chemicals, glass, nonferrous metals, and other materials.

This chapter includes information on the aluminosilicate minerals andalusite, kyanite, and sillimanite, all with a formula of  $Al_2SiO_5$ , and on mullite (calcined kyanite) and synthetic mullite with the chemical formula  $Al_6Si_2O_{13}$ . Andalusite, kyanite, and sillimanite are the primary minerals that are known as kyanite group minerals, especially in the United States where kyanite is prevalent, but they are also known collectively as the sillimanite minerals, particularly in India where sillimanite is the most common of the group. For most end uses of these aluminosilicate minerals, mullite is the preferred mineral because of its superior refractory (heat-resistant) properties (it is stable to 1,800 °C) and high strength, but it is rarely found in nature in minable quantities. In the United States, the term mullite generally refers to mullite that is produced by calcining kyanite (to a temperature of 1,450 °C or higher), whereas synthetic or sintered mullite typically refers to mullite made by calcining certain mixtures of alumina- and silica-containing minerals and materials, typically bauxite, bauxitic kaolin, and (or) kaolin, at similarly high temperatures.

## Production

In 2016, the production of kyanite concentrate in the United States decreased by about 27% to 79,700 t valued at \$28 million (Virginia Department of Mines, Minerals and Energy, 2017a; table 1). Percentages in this report were computed using unrounded data.

A U.S. Geological Survey (USGS) voluntary survey was sent to the sole U.S. producer of kyanite and kyanite-derived mullite in 2016, Kyanite Mining Corp. (KMC). KMC responded to the survey, but the data were withheld to avoid disclosing company proprietary data. KMC has mined kyanite deposits in central Virginia since 1945. The company operated the East Ridge and Willis Mountain open pit mines in Buckingham County and beneficiated the ore into a marketable kyanite concentrate

product at the company's Gieseke Plant near the East Ridge open pit mine. An estimated 15% to 25% of the kyanite concentrate was further processed and converted by calcination into mullite at the company's Willis Mountain plant. Both mines and plants are just south of Dillwyn, VA. KMC's concentrate graded 92% to 96% kyanite containing between 55% and 60% alumina ( $Al_2O_3$ ); the derived mullite product contained about 80% mullite (Kyanite Mining Corp., 2006; Virginia Department of Mines, Minerals and Energy, 2016b).

Voluntary USGS surveys were sent to the two U.S. producers of synthetic mullite and the sole U.S. producer of andalusite. One of the three known processing operations responded, but the data were withheld to avoid disclosing company proprietary data. Mullite Co. of America, Inc. (MCA) (formerly C-E Minerals, Inc.), a subsidiary of Imerys Refractory Minerals USA, Inc., produced synthetic mullite from calcined bauxite, bauxitic kaolin, and kaolin clays in Andersonville, GA. MCA produced three mullite products that contained 47%, 59%, and 69% alumina (Imerys Refractory Minerals USA, Inc., 2014). Mineral Manufacturing Corp. produced synthetic mullite in Eufaula, AL, from materials mined from one site in Alabama and one in Georgia. Piedmont Minerals Co., Inc. (a subsidiary of Resco Products, Inc.) mined a deposit of andalusite combined with pyrophyllite and sericite at Hillsborough, NC. The company sold products containing blends of the three minerals to the refractory industry, especially for the production of firebrick.

## Consumption

The dominant end use for kyanite group minerals was refractories and refractory products, accounting for as much as 90% of consumption. Of the minerals used in refractories, an estimated 65% was for the production of iron and steel, and the remaining 35% was for the manufacture of chemicals, glass, nonferrous metals, and other materials. When calcined to mullite, kyanite increases in volume, depending upon particle size, typically by 2% for very fine particles (325 mesh) to as much as 25% for coarser particle fractions (35 mesh), and thus can be used as a raw concentrate in a refractory mixture to offset the shrinkage on firing of other components, especially certain types of clay. Andalusite and sillimanite expand irreversibly, by about 6% and 2% to 4%, respectively, when calcined and individually can be used directly in refractories in their raw state (Lassetter, 2015). In refractory applications where the volume increase of kyanite is not required, kyanite concentrate is first calcined to mullite and added to refractory mixes. Mullite is resistant to abrasion and penetration by deleterious dusts, gases, and slags, and has beneficial creep resistance, which limits physical deformation under load at high temperatures.

Examples of refractories that contain andalusite, kyanite, or 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. Monolithic refractories are supplied in unfired and unshaped form, in contrast to prefired and preshaped brick products, and may be gunned, hand packed, molded, poured, pumped, rammed, or vibrated into place (Moore, 2004).

Pig iron production in the United States decreased by 12% in 2016 compared with that of 2015; world pig iron production increased slightly in 2016 (World Steel Association, 2017b). Crude steel output in the United States decreased slightly in 2016 compared with that of 2015; world crude steel output increased slightly in 2016 (World Steel Association, 2017a). Changes in pig iron production and steel output can have corresponding impacts on the demand for raw materials used in refractories, such as the kyanite group minerals.

Other end uses of kyanite group minerals included high-friction products such as motor vehicle brake shoes and pads; abrasive products such as grinding and cutting wheels; ceramic products such as electrical insulating porcelains, sanitaryware, and whiteware; foundry products and precision casting molds; and other products (Kyanite Mining Corp., 2006).

## Prices

According to data received through the USGS survey of domestic kyanite production, the unit value of raw kyanite concentrate and calcined kyanite (mullite) was largely dependent on grade and particle sizing. The average unit value increased slightly in 2016. Published prices for kyanite and andalusite serve only as a general guide; a comparison of yearend prices for 2014–16 is shown in table 2 and indicates no overall change in 2016.

## Foreign Trade

Exports of kyanite (excluding mullite) decreased by 7% to 37,100 t in 2016 from those of 2015; the value of the exports decreased by 6.3% to \$13 million in 2016 (table 3). Exports were to 34 countries. The 10 leading recipients were, in descending order of tonnage, China, Germany, Japan, Mexico, the Republic of Korea, the Netherlands, Canada, the United Kingdom, Sweden, and Belgium, accounting for 86% of United States kyanite exports. Exports of mullite (calcined kyanite or synthetic) increased slightly to 27,000 t valued at about \$11.6 million and were shipped to 18 countries (table 4). About 90% of United States mullite exports went to Mexico, Canada, Germany, and the United Kingdom, in descending order of quantity.

Imports of kyanite group minerals (mostly andalusite) in 2016 decreased by 78% from the recent record set in 2015 to 2,510 t valued at \$710,000 (tables 1, 5). About 75% of the 2016 imports were from South Africa, 15% from France, and 8% from Peru. Imports of mullite (calcined kyanite or synthetic, unspecified) increased slightly to 5,290 t valued at \$5.52 million (table 6). Overall, the leading sources of mullite imports were Canada with 56%; Germany, 28%; Hungary, 6%; and Brazil, 6% (table 6).

## World Review

South Africa continued to be the leading producer of andalusite, and India was the leading producer of sillimanite

(table 7). Countries thought to be producers of synthetic mullite included Brazil, Canada, China, Germany, Guyana, Hungary, Japan, and Russia.

The irregular availability of inexpensive, refractory-grade bauxite from China served to increase the demand for refractories made from alternate raw materials such as andalusite. The leading andalusite producers, China, Peru, and South Africa, continued to expand operations. Production of low-iron, refractory-grade bauxite was reported from mines in Brazil, Guyana, and Russia, potentially representing competition for the kyanite group minerals, especially andalusite (Saxby, 2013).

**China.**—Although China was thought to produce andalusite and kyanite, detailed production data have been unavailable since 2003. A production capacity of 40,000 metric tons per year (t/yr) of andalusite was reported for Yilong Andalusite Mineral Co. [a subsidiary of Imerys SA (Paris, France)] in the Xinjiang Uyghur Autonomous Region of northwestern China (Torrisi, 2014a; Lismore-Scott, 2015). However, the company's Yilong Mine was reported to have been closed near yearend 2016 (Sello, 2017).

**France.**—Imerys Refractory Minerals SA mined andalusite from three pits at its Glomel Mine in Brittany, France (Imerys Refractory Minerals SA, 2015; Lismore-Scott, 2015). Imerys mined about 1 million metric tons per year of andalusite ore at Glomel from which, through a complex production process that includes beneficiation, calcination, and flotation, Imerys extracted as much as 80,000 t/yr of andalusite to produce its Kerphalite™ KF product. The Kerphalite™ KF product is a specialty foundry sand with low thermal expansion and high refractoriness (Foundry-Planet Ltd., 2016).

**India.**—India was the world's leading producer of sillimanite. Little is known about sillimanite production elsewhere, although India annually imports very small quantities from France, Japan, and Nepal. About three-quarters of India's production of sillimanite was reported by the private sector, and the remainder of production was reported by the public sector. Most of the production was from the States of Andhra Pradesh and Odisha, which accounted for 61% and 19% of the country's production, respectively. About 2,900 t of kyanite was produced in the State of Maharashtra, and most of the kyanite was mined by the public sector. India has relied on imports of andalusite since 1988 when the mining of andalusite last took place (Indian Bureau of Mines, 2017, p. 29–30, 57–58).

**Peru.**—Andalucita S.A., which produced most of Peru's andalusite, continued development and production from its mine in unconsolidated sand and gravels of the Tablazo Mancora flood plain in northwestern Peru, 20 kilometers (km) from the deepwater seaport of Paita. Upgrades to its processing plant in 2013 increased the operation's production capacity to 37,000 t/yr, and the planned addition of more screens would increase the plant's capacity to between 48,000 and 60,000 t/yr (Carmichael and Lismore-Scott, 2013; Torrisi, 2014a). In 2016, the company's andalusite production was estimated to be more than 40,000 t. The company's primary andalusite product graded 59% to 60% Al<sub>2</sub>O<sub>3</sub>, with a maximum of 0.85% iron oxide (Lismore-Scott, 2014). In 2016, about 43,000 t of andalusite

was exported from Peru, mostly to customers in Europe (United Nations Statistics Division, undated).

Latin Resources Ltd. (Perth, Western Australia, Australia) continued to seek a joint-venture partner to bring its Guadalupito andalusite and heavy-mineral-sand project into production. The Guadalupito project is on the eastern inland portion of the coastal plain of Peru about 25 km from the port city of Chimbote. The project's Los Conchales resource, which covers 1,350 hectares, was estimated to contain 1.1 billion metric tons (Gt) of heavy-mineral sands (heavy-mineral content of 8% to 10%) containing mostly andalusite (21% to 24%) and magnetite (22% to 25%) and lesser quantities of apatite, garnet, ilmenite, monazite, rutile, and zircon. The andalusite is found mostly as individual crystals. More than 90% of the deposit is below the water table, making it amenable to dredge mining (Torrison, 2014a; Latin Resources Ltd., 2015a, 2015b, p. 16–19; Syrett, 2015).

**Russia.**—The Bolshie Keivy [big caves] area in the Murmansk region of the Kola Peninsula of northwest Russia accounts for 90% of Russia's kyanite resources. The area contains 23 kyanite deposits with total estimated resources of 11 Gt. Besides its importance as a refractory mineral, kyanite can potentially be used as an alternative to bauxite from which to produce alumina for the production of aluminum. Bauxite is the most cost-effective source mineral because alumina production from silicates such as kyanite is more energy intensive. Sources of alumina have become increasingly important to Russia, the world's second-ranked producer of aluminum. Russia has few high-quality bauxite deposits, and more than half of the bauxite consumed by the country's alumina plants is imported. Since the discovery of the kyanite resource in the past few decades, the profitability of developing the resource was doubtful owing to the remote location and the type of material. The Government of Russia, however, indicated support for a project focused on demonstrating the economic feasibility of substituting kyanite for bauxite in the production of aluminum (Vorotnikov, 2016).

**South Africa.**—In September, the South African Competition Tribunal rejected the proposed merger between Imerys South Africa (Pty.) Ltd. and Andalusite Resources (Pty.) Ltd. The Tribunal determined that the merger would lead to a monopoly in the mining, processing, and sale of andalusite within South Africa, making the mineral more expensive to local consumers by removing competition in the fine- and medium-grade andalusite markets with no alternative domestic supplier in South Africa. The merger would also have given Imerys control of an estimated 80% or more of the global andalusite supply (Greve, 2015; Lismore-Scott, 2015; Ghilotti, 2016a, b). Local steel producers and other andalusite consumers in South Africa were opposed to the merger (Gyekye, 2015; Syrett and McCormick, 2016). In 2016, about 118,000 t of andalusite was exported from South Africa to many countries worldwide (United Nations Statistics Division, undated).

Andalusite Resources (Pty.) Ltd. mined andalusite at its Maroelasfontein Mine in Thabazimbi, Limpopo Province. Development at the mine, which had a production capacity of 70,000 t/yr in 2014, continued with work aimed at increasing capacity to between 90,000 and 120,000 t/yr during the next several years. More than 25% of the company's annual

production went to domestic markets, between 30% and 40% to Europe, and the remainder to Japan (Carmichael and Lismore-Scott, 2013; Torrison, 2014a).

Denain-Anzin Mineraux Refractaire Ceramique (Damrec), a subsidiary of Imerys SA, produced about 70% of the andalusite in South Africa at four mines, which had a combined capacity of 195,000 t/yr of andalusite. Damrec planned to increase output to 250,000 t/yr over the next several years. Rhino Minerals (Pty.) Ltd. operated three of Damrec's mines in South Africa: the Annesley, Havercroft, and Rhino Mines in Limpopo Province. Samrec (Pty.) Ltd. was the operator of the Krugerspost Mine, near Lydenburg, Mpumalanga Province, which had been idle since 2013. Imerys temporarily mothballed the Krugerspost Mine to concentrate on production from the company's other mines in order to increase the output and quality of its Purusite™ andalusite products, expand its mineral reserves, and emphasize coarse-size products (Torrison, 2014b; Modiselle, 2016, p. 148). Damrec's main markets were China, Europe, India, and South Africa (Torrison, 2014a).

## Outlook

Natural raw aluminosilicate minerals, such as andalusite and kyanite, have become increasingly sought after as alternative materials to calcined bauxite in certain refractory applications. When compared to raw materials with higher alumina content, andalusite is expected to be an increasingly attractive alternative especially as the availability of andalusite increases from the expansion of operations in South Africa and anticipated increases in production from Peru and as refractory-grade bauxite from China becomes less available (Torrison, 2014a, b; Modiselle, 2016, p. 150). Andalusite can be fired at a lower temperature than most alternative materials when used to produce a dense, shrinkage-resistant refractory aggregate, which reduces energy consumption and greenhouse gas emissions (Feytis, 2011). Nevertheless, inexpensive refractory-grade bauxite that becomes available for export from projects under development in Brazil, Guyana, and Russia may become competitive with andalusite and kyanite in some applications, such as steel furnaces and industrial boilers (Saxby, 2013). For durable refractories, technological advances are likely to include increased use of synthetic mullite.

After increasing globally by 1% in 2016, the consumption of steel, the leading industrial market for refractories, is expected to increase by 1.3% in 2017 and 0.9% in 2018. The consumption of finished steel products in the United States, second only to China, is expected to increase by about 3% in 2017 and again in 2018. China's steel consumption is expected to remain flat in 2017 and decrease slightly in 2018 (World Steel Association, 2017c). The Asia-Pacific region remains the largest market for refractories and, although growth has slowed slightly in China's economy, China is anticipated to continue to be the single leading market and represent the majority of global consumption.

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## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

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- 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.

TABLE 1  
SALIENT U.S. KYANITE AND RELATED MINERALS STATISTICS<sup>1</sup>

		2012	2013	2014	2015	2016
<b>Production:</b>						
<b>Kyanite concentrate:</b>						
Quantity <sup>2</sup>	metric tons	98,500 <sup>3</sup>	110,000 <sup>3</sup>	88,600 <sup>r</sup>	109,000 <sup>r</sup>	79,700
Value <sup>e</sup>	thousands	\$29,600 <sup>r</sup>	\$33,100 <sup>r</sup>	\$29,300 <sup>r</sup>	\$38,000 <sup>r</sup>	\$28,200
Mullite (calcined kyanite and synthetic), quantity <sup>e</sup>	metric tons	W	W	W	W	W
<b>Exports of kyanite concentrate:<sup>4</sup></b>						
Quantity	do.	36,400	42,400	40,000	39,900	37,100
Value <sup>5</sup>	thousands	\$11,700	\$13,100	\$13,600	\$13,900	\$13,000
<b>Imports for consumption, all kyanite minerals:<sup>4</sup></b>						
Quantity	metric tons	3,260	4,110	4,020	11,500	2,510
Value <sup>6</sup>	thousands	\$1,610	\$1,610	\$1,550	\$3,680	\$710
World, production <sup>c</sup>	do.	327,000 <sup>r</sup>	377,000 <sup>r</sup>	364,000 <sup>r</sup>	408,000	393,000

<sup>c</sup>Estimated. <sup>r</sup>Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Table includes data available through July 18, 2017. Data are rounded to no more than three significant digits.

<sup>2</sup>Source: Virginia Department of Mines, Minerals and Energy, 2017, DMM report TNPR.06—Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed April 13, 2017, via <http://www.dmme.virginia.gov/dmm/miningdata.shtml>.)

<sup>3</sup>Data may include calcined kyanite.

<sup>4</sup>Source: U.S. Census Bureau.

<sup>5</sup>Free alongside ship (f.a.s.) value.

<sup>6</sup>Customs value.

TABLE 2  
PRICES OF KYANITE AND RELATED MINERALS<sup>1</sup>

Material		Price range at yearend		
		2014	2015	2016
Andalusite, South Africa, 57% to 58% alumina, 2,000-metric-ton bulk lots	euros per metric ton	248–306	240–290	240–290
Andalusite, free on board, South Africa, 55% to 59% alumina, 2,000-metric-ton bulk lots, European port	do.	375–449	355–425	355–425
Kyanite, United States, ex-works, raw, 54% to 60% alumina	dollars per metric ton	225–290	225–320	225–320
Kyanite, United States, ex-works, calcined (mullite), 54% to 60% alumina, 22-ton lots	do.	340–399	375–440	375–440
do. Ditto.				

<sup>1</sup>Table includes data available through July 18, 2017.

Source: Industrial Minerals.

TABLE 3  
U.S. EXPORTS OF KYANITE, BY COUNTRY OR LOCALITY<sup>1,2</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>3</sup> (thousands)	Quantity (metric tons)	Value <sup>3</sup> (thousands)
Argentina	160	\$47	40	\$12
Australia	520	173	412	138
Bangladesh	20	9	20	9
Belgium	2,700	917	730	253
Brazil	120	37	20	6
Canada	1,690	644	1,480	559
Chile	88	26	100	28
China	6,540	2150	8,660	2,990
Colombia	62	17	78	23
Denmark	100	34	120	41
Dominican Republic	3	3	--	--
Egypt	200	59	200	59
France	--	--	40	15
Germany	6,850	2,420	7,590	2,710
Greece	20	7	--	--
Guatemala	42	11	--	--
Hungary	260	92	180	64
India	561	187	523	167
Indonesia	300	77	220	61
Ireland	3	4	--	--
Italy	1,810	615	616	215
Japan	3,300	1,350	3,330	1,280
Korea, Republic of	1,800	582	2,820	902
Malaysia	340	98	200	60
Mexico	3,640	1,350	3,060	1,110
Netherlands	3,940 <sup>r</sup>	1,380 <sup>r</sup>	2,080	724
Peru	20	6	--	--
Philippines	40	12	20	6
Poland	--	--	220	58
Russia	60	16	80	21
Slovenia	300	74	200	49
South Africa	29	9	--	--
Spain	982	272	579	183
Sweden	919	313	740	250
Taiwan	440	116	535	138
Thailand	220	62	280	80
Turkey	479	155	540	166
United Arab Emirates	60	18	80	24
United Kingdom	1,310	554	1,310	612
Venezuela	4	3	1	3
Vietnam	20	6	--	--
Total	39,900	13,900	37,100	13,000

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through July 18, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States code 2508.50.0000 for kyanite concentrate.

<sup>3</sup>Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

TABLE 4  
U.S. EXPORTS OF MULLITE, BY COUNTRY OR LOCALITY<sup>1,2</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>3</sup> (thousands)	Quantity (metric tons)	Value <sup>3</sup> (thousands)
Austria	7	\$10	1	\$4
Bangladesh	60	28	40	19
Belgium	308	156	134	72
Brazil	16	12	174	110
Canada	9,840	2,950	7,800	2,460
China	408	209	413	194
France	33	35	30	30
Germany	2,590	2,090 <sup>r</sup>	2,640	2,170
Hong Kong	--	--	1	3
Hungary	400	206	420	215
India	20	13	20	11
Italy	400	182	524	254
Japan	5	4	10	10
Mexico	9,910	3,890	11,400	4,510
Netherlands	567	257	632	292
Taiwan	118	52	141	66
Thailand	6	3	--	--
United Kingdom	2,240 <sup>r</sup>	932 <sup>r</sup>	2,590	1,130
Uruguay	16	7	20	9
Total	26,900	11,000	27,000	11,600

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through July 18, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite (calcined kyanite or synthetic).

<sup>3</sup>Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

TABLE 5  
U.S. IMPORTS FOR CONSUMPTION OF ANDALUSITE,  
KYANITE, AND SILLIMANITE, BY COUNTRY OR LOCALITY<sup>1,2,3</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>4</sup> (thousands)	Quantity (metric tons)	Value <sup>4</sup> (thousands)
France	165	\$88	378	\$207
Peru	3,590	1,030	210	69
South Africa	7,650	2,510	1,880	398
United Kingdom	38	28	44	32
Other	105	16	1	5
Total	11,500	3,680	2,510	710

<sup>1</sup>Table includes data available through July 18, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Most material is thought to be andalusite.

<sup>3</sup>Harmonized Tariff Schedule of the United States code 2508.50.0000 for kyanite concentrate.

<sup>4</sup>Customs value.

Source: U.S. Census Bureau.

TABLE 6  
U.S. IMPORTS FOR CONSUMPTION OF MULLITE, BY COUNTRY OR LOCALITY<sup>1,2</sup>

Country or locality	2015		2016	
	Quantity (metric tons)	Value <sup>3</sup> (thousands)	Quantity (metric tons)	Value <sup>3</sup> (thousands)
Brazil	642	\$585	307	\$313
Canada	2,650	2,150	2,950	2,160
China	115	112	74	116
Germany	1,130	2,130	1,480	2,350
Hungary	498	546	323	410
Japan	101	99	113	99
Other	62	114 <sup>r</sup>	43	73
Total	5,190	5,740	5,290	5,520

<sup>r</sup>Revised.

<sup>1</sup>Table includes data available through July 18, 2017. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite; calcined kyanite; or synthetic, unspecified.

<sup>3</sup>Customs value.

Source: U.S. Census Bureau.

TABLE 7  
 KYANITE AND RELATED MINERALS: WORLD PRODUCTION, BY COUNTRY OR LOCALITY<sup>1</sup>

(Metric tons)

Country or locality <sup>2</sup>	2012	2013	2014	2015	2016
Australia, kyanite <sup>c</sup>	-- <sup>r</sup>	-- <sup>r</sup>	-- <sup>r</sup>	--	--
Cameroon, kyanite	325	220	220	220	200 <sup>e</sup>
India: <sup>3</sup>					
Kyanite	1,048 <sup>r</sup>	3,679 <sup>r</sup>	6,255 <sup>r</sup>	2,901 <sup>r</sup>	3,000 <sup>e</sup>
Sillimanite	43,736 <sup>r</sup>	67,265 <sup>r</sup>	66,273 <sup>r</sup>	70,447 <sup>r</sup>	70,000
Total	44,800 <sup>r</sup>	70,900 <sup>r</sup>	72,500 <sup>r</sup>	73,300 <sup>r</sup>	73,000
Peru, andalusite <sup>c</sup>	20,000	20,000	30,000	35,000	40,000
South Africa, andalusite	163,801	175,328 <sup>r</sup>	172,657 <sup>r</sup>	190,000 <sup>r,e</sup>	200,000 <sup>e</sup>
United States, kyanite concentrate <sup>4</sup>	98,500	110,000	88,600 <sup>r</sup>	109,000 <sup>r</sup>	79,700
Grand total	327,000 <sup>r</sup>	377,000 <sup>r</sup>	364,000 <sup>r</sup>	408,000	393,000

<sup>c</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Table includes data available through May 1, 2017. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>In addition to the countries listed, France may have produced andalusite and Brazil and China may have produced kyanite and related materials, but available information was inadequate to make reliable estimates of output.

<sup>3</sup>Data are for fiscal year ending March 31 of the following year.

<sup>4</sup>Source: Virginia Department of Mines, Minerals and Energy, 2017, DMM report TNPR.06—Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed April 13, 2017, via <http://www.dmme.virginia.gov/dmm/miningdata.shtml>.)