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2017 Minerals Yearbook

KYANITE AND RELATED MINERALS [ADVANCE RELEASE]

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Kyanite and Related Minerals

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In 2017, the United States continued to be the world's leading producer of kyanite concentrate and mullite (calcined kyanite); 91,300 metric tons (t) of kyanite concentrate was produced (Virginia Department of Mines, Minerals and Energy, 2018; tables 1, 7). South Africa and India continued to be the leading producers of andalusite and sillimanite, respectively. Mullite and synthetic mullite (derived from a calcined mix 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 about 395,000 t (tables 1, 7). In the United States, one company produced kyanite and kyanite-derived mullite (calcined kyanite), 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 but also in the manufacture of chemicals, glass, nonferrous metals, and other materials. Percentages in this report were calculated using unrounded data.

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 the 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 preferred because of its superior refractory (heat-resistant) properties (it is stable to 1,800 ºC) 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 ºC 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 2017, the production of kyanite concentrate in the United States increased by 15% to 91,300 t, valued at $32 million (Virginia Department of Mines, Minerals and Energy, 2018; table 1). A U.S. Geological Survey (USGS) voluntary canvass was sent to the sole U.S. producer of kyanite and calcined kyanite in 2017, Kyanite Mining Corp. (KMC), which was the world's leading producer of high-grade kyanite and calcined kyanite (mullite) (Lassetter, 2018). KMC responded to the survey, but data submitted in response to the survey 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 just south of Dillwyn, Buckingham County, VA, and beneficiated the ore into a marketable kyanite concentrate product at the company's Gieseke Plant near the East Ridge operation. 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. Annual production capacity was reported by KMC to be about 136,000 t of commercial-grade kyanite concentrates and 27,000 t of calcined kyanite. The company's concentrate graded 92% to 96% kyanite containing between 55% and 60% alumina (Al_2O_3) and less than 0.75% iron oxide (Fe_2O_3); the derived mullite product contained about 80% mullite (Kyanite Mining Corp., 2006; Virginia Department of Mines, Minerals, and Energy, 2015). The company shipped its products by rail, truck, and air to domestic customers and port facilities for export; exports accounted for about 50% of KMC's sales (Lassetter, 2018).

Canvasses also were sent to the two U.S. producers of synthetic mullite and the sole U.S. producer of andalusite (within a mineral mixture). One response was received, but these data were withheld from publication to avoid disclosing company proprietary data. Mullite Co. of America, Inc. (MCA) (a subsidiary of Imerys Refractory Minerals USA) produced synthetic mullite from calcined bauxite, bauxitic kaolin, and kaolin clays, in Andersonville, GA. The company produced Mulcoa, which included three mullite products of 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. Piedmont sold products containing blends of the three minerals to the refractory industry, especially for the production of firebrick.

Consumption

The dominant end use, accounting for as much as 90% of consumption, for kyanite group minerals was refractories and refractory products. Of the minerals used in refractories, an estimated 65% was for refractories used in the production of iron and steel, and the remaining 35% was used 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 can be added directly to refractory mixes but expand irreversibly by about 6% and 2% to 4%,

respectively, when subsequently calcined (Lassetter, 2015). In refractory applications where the volume increase of kyanite is not required, kyanite concentrate is first calcined to mullite then added to refractory mixes. Mullite is resistant to abrasion and penetration by harmful dust, 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 increased slightly in 2017 compared with that of 2016; as did world pig iron production (World Steel Association, 2018b). Crude steel output in the United States increased by 4% in 2017 compared with that of 2016; world crude steel output increased by 5.3% in 2017 (World Steel Association, 2018a). Changes in pig iron production and steel output can have a corresponding impact on the demand for raw materials used in refractories, such as kyanite group minerals. Other end uses of kyanite group minerals include 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 decreased slightly in 2017. Published prices for kyanite and andalusite serve only as a general guide; a comparison of yearend prices for 2015–17 as shown in table 2 indicated no overall change during the past 3 years.

Foreign Trade

Exports of kyanite (excluding mullite) increased by 14% to 42,400 t in 2017 from those of 2016; the value of the exports increased by 14% to $14.9 million in 2017 (table 3). Exports in 2017 were to 37 countries. The 10 leading recipients were, in descending order of tonnage, Germany, China, Japan, Mexico, Canada, the Netherlands, the United Kingdom, the Republic of Korea, Belgium, and Italy, which combined accounted for 89% of United States kyanite exports. Exports of mullite (calcined kyanite or synthetic) increased by 23% to 33,100 t valued at about $13.9 million and were shipped to 21 countries (table 4). About 95% of United States mullite exports went to Mexico, Canada, Argentina, Germany, and the United Kingdom, in descending order of quantity.

Imports of kyanite group minerals (mostly andalusite) in 2017 nearly tripled from those of 2016 to 7,430 t valued at $2.07 million (tables 1, 5). About 81% of 2017 imports were from South Africa, and 12% were from Peru. Imports of mullite (both types) increased by 12% to 5,910 t valued at $6.4 million (table 6). Overall, the leading sources of mullite imports were Canada, with 50% of the total; Germany, 31%; and Brazil, 10% (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, South Africa, Peru, and China (in descending order of production), continued to expand operations. Peru and South Africa, combined, accounted for most of global andalusite supply, although France (verifiable production data have been unavailable for several years) exported a significantly higher quantity than did Peru, suggesting possible significant production of andalusite in that country as well (Ghilotti, 2017a; United Nations Statistics Division, undated). Production of low-iron, refractory-grade bauxite previously 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 Xinjiang Xinrong Yilong Andalusite Co., Ltd. [formerly Ying Ge Yi Long Andalusite (Xinjiang) Co., Ltd., a subsidiary of Imerys SA (Paris, France)] in the Xinjiang Uyghur Autonomous Region of northwestern China (Torrisi, 2014a; Xinjiang Xinrong Yilong Andalusite Co., Ltd., 2018a). The company's Yilong Mine was thought to have been idled near yearend 2016 to proceed with a $17 million expansion project at the mine; the company reported reserves of more than 8 million metric tons (Mt) of high-grade, low-impurity andalusite ore (Rabothata, 2017; Xinjiang Xinrong Yilong Andalusite Co., Ltd., 2018b).

France.—Imerys Refractory Minerals SA mined andalusite from three pits at its Glomel Mine in Brittany (Imerys Refractory Minerals SA, 2016). As of 2016, Imerys mined about 1 Mt of andalusite ore per year at Glomel from which, through a complex production process that includes beneficiation, calcination, and flotation, Imerys was reported to have 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). In 2017, about 51,500 t of andalusite was exported from France, mostly to customers in Europe (72%) and China and the Republic of Korea (19%) (United Nations Statistics Division, undated).

India.—India was the world's leading producer of sillimanite. Little is known about sillimanite production elsewhere, although India annually imports small quantities from France, Japan, and Nepal. About 63% of India's production of sillimanite in 2017 was produced by the private sector, and the remainder was produced by the public sector. All output in 2017 was from the States of Andhra Pradesh (54%), Odisha (23%), Kerala (14%), and Maharashtra (9%). India exported 14,300 t of sillimanite, with 46% going to China and 45% to Nepal (Indian Bureau of Mines, 2018, p. 17–8, 17–13).

About 3,250 t of kyanite was produced in the State of Maharashtra, 70% of which was produced by the private sector. India had relied on imports of andalusite since 1988 when the mining of andalusite last took place. India imported 10,900 t of andalusite, 95% of which came from South Africa (Indian Bureau of Mines, 2018, p. 17–6, 17–9, 17–11, 17–16).

Peru.—Andalucita S.A., which produced most of Peru's andalusite, continued development and production from its mine in unconsolidated sand and gravel of the Tablazo Mancora flood plain in northwestern Peru, 20 kilometers (km) from the deepwater seaport of Paita. In 2017, the company's andalusite production, estimated to be about 35,000 t, decreased from that in 2016 owing to heavy rains and flooding from February into April. Afterward, production took several months to ramp up to full production capacity, which resulted in decreased production of andalusite. Although customers experienced delays in the delivery of their orders, suppliers fulfilled existing orders, in part from stocks on hand, without price increases to those with contracts already in place (Ghilotti, 2017a, b). The company's primary andalusite product graded 59% to 60% Al_2O_3, with a maximum of 0.85% Fe_2O_3 (Lismore-Scott, 2014). In 2017, about 35,000 t, down from 43,000 t in 2016, of andalusite was exported from Peru, mostly to customers in Europe (United Nations Statistics Division, undated).

Latin Resources Ltd. (West Leederville, Western Australia, Australia) continued to seek a joint-venture partner to invest in the development of the Guadalupito heavy-mineral-sand project, which includes andalusite, and bring it 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 consists of two resource areas, Los Conchales and Tres Chosas, the former having a thicker formation of higher grade mineralization. The Los Conchales resource, which covers 1,350 hectares, was estimated to contain 1.3 billion metric tons of heavy-mineral sands (heavy-mineral content of 8% above the water table and 6% below it) containing mostly andalusite (23%), magnetite with low titanium content (24%), and lesser quantities of apatite, garnet, ilmenite, monazite, rutile, and zircon. More than 90% of the deposit is below the water table, making that portion amenable to dredge mining. The andalusite is amenable to recovery by basic gravity and magnetic separation as well as an electrostatic process (Torrisi, 2014a; Syrett, 2015; Latin Resources Ltd., 2017).

South Africa.—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 fine-, medium-, and coarse-grained andalusite. Damrec planned to increase output to 250,000 t/yr over the next several years. Rhino Minerals (Pty.) Ltd. operated three of the company's mines in South Africa: the Annesley, Havercroft, and Rhino Mines in Limpopo Province. The fourth site, operated by Samrec (Pty.) Ltd., was the Krugerspost Mine near Lydenburg, Mpumalanga Province; it remained idle in 2017 (Lassetter, 2018). Imerys temporarily closed the Krugerspost Mine in 2013 to concentrate on production from the company's other mines in order to increase the output and quality of Damrec's Purusite andalusite products, expand its mineral reserves, and emphasize coarse-size products (Torrisi, 2014b; Modiselle, 2016, p. 148). Damrec's main markets were Europe, China, India, and South Africa (Torrisi, 2014a).

Andalusite Resources (Pty.) Ltd. mined andalusite at its Maroelasfontein Mine in Thabazimbi, Limpopo Province, about 220 km northwest of Johannesburg. The 70,000-t/yr mine had reserves estimated to last up to 100 years at that production rate (Lassetter, 2018). Further development at the mine continued with work ultimately aimed at increasing capacity to between 90,000 and 120,000 t/yr. 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; Torrisi, 2014a). Andalusite Resources marketed fine- to medium-grade Marlusite andalusite products with an alumina content of 57% (Lassetter, 2018).

In 2017, South Africa's andalusite producers were negatively affected by heavy rains and flooding, bringing temporary halts in production. Damrec could not access its mines between December 2016 and February 2017. Andalusite Resources was similarly affected during the first quarter of 2017. After the rain-induced disruptions to mining, it took several months for the operations to ramp up to full capacity (Ghilotti, 2017a). As with Peru, suppliers for both companies fulfilled contracts in part from stocks on hand in response to the shortages of andalusite resulting from the break in production. Prices related to contracts already underway reportedly remained unchanged, but suppliers indicated that they might seek shorter contracts in the future (Ghilotti, 2017a, b).

In March, the South African Competition Tribunal Appeal Court dismissed an appeal made by Imerys South Africa (Pty.) Ltd. and Andalusite Resources Ltd. to overturn the Competition Tribunal's September 2016 rejection of the proposed merger between the two companies. The Court reaffirmed the Tribunal's earlier decision that the merger, in the absence of an alternative domestic supplier, would lead to a monopoly in the mining, processing, and sale of andalusite within South Africa and result in the mineral becoming more expensive to local consumers by removing competition in the fine-grade and medium-grade andalusite markets. The Court deemed that certain self-imposed restrictions on company business transactions, which the companies had proposed in their appeal to address Tribunal concerns with the merger, were inadequate and impractical from a monitoring and compliance perspective. The Court also reasoned that the merger would lead to a near monopoly in the global sales, as it would give Imerys control of an estimated 80% or more of global andalusite supply (Greve, 2015; Ghilotti, 2017a; Kilian, 2017). Local steel producers and other andalusite consumers in South Africa had opposed the merger (Gyekye, 2015;

Syrett and McCormick, 2016). In 2017, about 145,000 t of andalusite was exported from South Africa to many countries worldwide (United Nations Statistics Division, undated).

Outlook

Kyanite group minerals have become increasingly sought after as alternative materials to calcined bauxite in specific 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 output from Peru, and as refractory-grade bauxite from China becomes less available (Torrisi, 2014a, b; Modiselle, 2016, p. 150). Owing to the adverse weather conditions that curtailed andalusite mining operations in Peru and South Africa during the first quarter of 2017, followed by several months for the operations to return to full production capacity, shortages of the mineral resulted and are expected to continue until 2019. Suppliers fulfilled contracts as written but indicated that future contracts might be structured differently, such as 1-year supply with 6-month pricing, instead of 1-year supply and price contracts as had been typical (Ghilotti, 2017a, b).

As the production of andalusite returns to more normal levels, interest in the mineral may increase. Andalusite is able to 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 compete with andalusite and kyanite in some applications, such as linings for steel furnaces and industrial boilers (Saxby, 2013). For durable refractories, technological advances are likely to include increased use of synthetic mullite.

The Asia and the 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 leading market and represent the majority of global consumption.

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TABLE 1
SALIENT KYANITE AND RELATED MINERALS STATISTICS[1]

		2013	2014	2015	2016	2017
United States:						
Production:						
Kyanite concentrate:						
Quantity[2]	metric tons	110,000 [3]	88,600	109,000	79,700	91,300
Value[e]	thousands	$33,100	$29,300	$38,000	$28,200	$32,000
Mullite (calcined kyanite and synthetic), quantity[e]	metric tons	W	W	W	W	W
Exports of kyanite concentrate:[4]						
Quantity	do.	42,400	40,000	39,900	37,100	42,400
Value[5]	thousands	$13,100	$13,600	$13,900	$13,000	$14,900
Imports for consumption, all kyanite minerals:[4]						
Quantity	metric tons	4,110	4,020	11,500	2,510	7,430
Value[6]	thousands	$1,610	$1,550	$3,680	$710	$2,070
World, production[e]	metric tons	363,000 [r]	372,000 [r]	402,000 [r]	393,000	394,000

[e]Estimated. [r]Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through October 10, 2018. Data are rounded to no more than three significant digits.
[2]Source: Virginia Department of Mines, Minerals and Energy, 2018, DMM report TNPR.06—Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed April 13, 2018, via http://www.dmme.virginia.gov/DMM/miningdata.shtml.)
[3]Data may include calcined kyanite.
[4]Source: U.S. Census Bureau.
[5]Free alongside ship (f.a.s.) value.
[6]Customs value.

TABLE 2
PRICES OF KYANITE AND RELATED MINERALS[1]

		Price range at yearend		
Material		2015	2016	2017
Andalusite, South Africa, 57% to 58% alumina, 2,000-metric-ton bulk lots	euros per metric ton	240–290	240–290	240–290
Andalusite, free on board, South Africa, 55% to 59% alumina, 2,000-metric-ton bulk lots, European port	do.	355–425	355–425	355–425
Kyanite, United States, ex-works, raw, 55% to 60% alumina	dollars per short ton	225–320	225–320	225–320
Kyanite, United States, ex-works, calcined (mullite), 55% to 60% alumina, 22-short-ton lots	do.	375–440	375–440	375–440

do. Ditto.
[1]Table includes data available through October 10, 2018. Data are rounded to no more than three significant digits.

Source: Industrial Minerals magazine (London) via http://www.indmin.com.

TABLE 3
U.S. EXPORTS OF KYANITE, BY COUNTRY OR LOCALITY[1, 2]

Country or locality	2016 Quantity (metric tons)	2016 Value[3] (thousands)	2017 Quantity (metric tons)	2017 Value[3] (thousands)
Argentina	40	$12	62	$19
Australia	412	138	551	179
Bangladesh	20	9	--	--
Belgium	730	253	980	344
Brazil	20	6	60	21
Canada	1,480	559	2,620	731
Central African Republic	--	--	10	3
Chile	100	28	100	29
China	8,660	2,990	9,420	3,230
Colombia	78	23	39	11
Denmark	120	41	80	29
Egypt	200	59	200	62
France	40	15	84	33
Germany	7,590	2,710	9,870	3,540
Guatemala	--	--	20	5
Hungary	180	64	40	15
India	523	167	481	152
Indonesia	220	61	220	63
Ireland	--	--	2	3
Italy	616	215	878	319
Japan	3,330	1,280	3,990	1,400
Korea, Republic of	2,820	902	2,190	762
Latvia	--	--	20	5
Malaysia	200	60	100	29
Mexico	3,060	1,110	3,160	1,240
Netherlands	2,080	724	2,270	818
Philippines	20	6	20	6
Poland	220	58	100	36
Qatar	--	--	40	13
Russia	80	21	80	22
Slovenia	200	49	--	--
Spain	579	183	420	140
Sweden	740	250	740	262
Taiwan	535	138	664	179
Thailand	280	80	125	38
Turkey	520 r	160 r	440	142
United Arab Emirates	80	24	80	25
United Kingdom	1,310	612	2,220	943
Vatican City	--	--	20	6
Venezuela	1	3	--	--
Total	37,100	13,000	42,400	14,900

rRevised. -- Zero.
[1]Table includes data available through October 10, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States code 2508.50.0000 for kyanite concentrate.
[3]Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS OF MULLITE, BY COUNTRY OR LOCALITY[1, 2]

Country or locality	2016 Quantity (metric tons)	2016 Value[3] (thousands)	2017 Quantity (metric tons)	2017 Value[3] (thousands)
Argentina	--	--	4,740	$2,060
Austria	1	$4	--	--
Bangladesh	40	19	40	19
Belgium	134	72	200	97
Brazil	174	110	32	37
Canada	7,800	2,460	7,870	2,620
China	413	194	351	187
Czechia	--	--	40	16
Denmark	--	--	24	25
France	30	30	65	39
Germany	2,640	2,170	2,650	1,740
Hong Kong	1	3	--	--
Hungary	420	215	136	96
India	20	11	--	--
Italy	524	254	343	182
Japan	10	10	23	4
Mexico	11,400	4,510	15,000	5,400
Netherlands	632	292	95	43
Peru	--	--	44	9
Romania	--	--	83	41
Taiwan	141	66	137	67
Thailand	--	--	6	3
United Kingdom	2,590	1,130	1,220	1,180
Uruguay	20	9	10	5
Total	27,000	11,600	33,100	13,900

-- Zero.
[1]Table includes data available through October 10, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite (calcined kyanite or synthetic).
[3]Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF ANDALUSITE, KYANITE, AND SILLIMANITE[1, 2, 3]

Country or locality	2016 Quantity (metric tons)	2016 Value[4] (thousands)	2017 Quantity (metric tons)	2017 Value[4] (thousands)
China	--	--	239	$66
France	378	$207	252	143
Peru	210	69	867	248
South Africa	1,880	398	6,010	1,570
United Kingdom	44	32	39	23
Other	1	5	23	27
Total	2,510	710	7,430	2,070

-- Zero.
[1]Table includes data available through October 10, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Most material is thought to be andalusite.
[3]Harmonized Tariff Schedule of the United States code 2508.50.0000 for concentrates of andalusite, kyanite, and sillimanite.
[4]Customs value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MULLITE[1, 2]

Country or locality	2016 Quantity (metric tons)	2016 Value[3] (thousands)	2017 Quantity (metric tons)	2017 Value[3] (thousands)
Brazil	307	$313	603	$589
Canada	2,950	2,160	2,970	2,570
China	74	116	36	50
Germany	1,480	2,340 r	1,810	2,650
Hungary	323	410	285	327
Japan	113	99	171	137
Other	43	73	37	59
Total	5,290	5,520	5,910	6,380

rRevised.
[1]Table includes data available through October 10, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite; calcined kyanite; or synthetic, unspecified.
[3]Customs value.

Source: U.S. Census Bureau.

TABLE 7
KYANITE AND RELATED MINERALS: WORLD PRODCTION, BY COUNTRY OR LOCALITY[1]

(Metric tons)

Country or locality[2]	2013	2014	2015	2016	2017
Cameroon, kyanite	220	220	220	200	200
India:[3]					
Kyanite	1,090 r	6,680 r	2,300 r	3,000	3,000 e
Sillimanite	56,830 r	73,661 r	65,243 r	64,923 r	65,000 e
Total	57,900 r	80,300 r	67,500 r	67,900	68,000
Nepal	1	1	(4)	--	--
Peru, andalusite	20,000	30,000	35,000	45,000 r	35,000 e
South Africa, andalusite	175,328	172,657	190,000 e	200,000 e	200,000 e
United States, kyanite concentrate	110,000	88,600	109,000	79,700	91,300
Grand total	363,000 r	372,000 r	402,000 r	393,000	394,000

eEstimated. rRevised. -- Zero.
[1]Table includes data available through June 26, 2018. 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.
[2]In addition to the countries and (or) localities listed, China and France produced andalusite and China produced kyanite and related materials, but available information was inadequate to make reliable estimates of output.
[3]Production is based on fiscal year, with a starting date of April 1 of the year shown.
[4]Less than ½ unit.