

# **2019 Minerals Yearbook**

# **KYANITE AND RELATED MINERALS [ADVANCE RELEASE]**

## KYANITE AND RELATED MINERALS

#### By Ashley K. Hatfield

#### Domestic survey data and tables were prepared by Tiffany J. Lin, statistical assistant.

In 2019, 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 (table 1) (Virginia Department of Energy, 2019). 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 sillimanitewas estimated to be 394,000 t (tables 1, 7). South Africa and India continued to be the leading producers of andalusite and sillimanite, respectively. 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 anhydrous polymorphic minerals and alusite, kyanite, and sillimanite, all having a formula of Al<sub>2</sub>SiO<sub>5</sub>, and on mullite (calcined kyanite) and synthetic mullite with the chemical formula Al<sub>6</sub>Si<sub>2</sub>O<sub>12</sub>. Andalusite, kyanite, and sillimanite are the primary minerals 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. Topaz and dumortierite often are included as members of the kyanite group of minerals, but they contain considerable amounts of fluorine and boron, respectively. For most end uses of these aluminosilicate minerals, mullite is preferred because of its superior strength and refractory (heat-resistant) properties (it is stable to 1,810 degrees Celsius [°C]), 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. The conversion reaction results in mullite  $(Al_sSi_2O_{12})$  and silica  $(SiO_2)$ .

#### Production

In 2019, the production of kyanite concentrate in the United States increased slightly to 91,300 t, valued at an estimated \$32 million (table 1) (Virginia Department of Energy, 2019). A U.S. Geological Survey (USGS) voluntary canvass was sent to the sole U.S. producer of kyanite and calcined kyanite in 2019, Kyanite Mining Corp. (KMC), which was the world's leading producer of kyanite and calcined kyanite (mullite) (Lassetter, 2020). KMC responded to the survey, but data submitted in response 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. Production capacity was reported by KMC to be about 136,000 metric tons per year (t/yr) of commercialgrade kyanite concentrate and 27,000 t/yr of calcined kyanite. The company's concentrate graded 92% to 98% kyanite containing greater than 57% alumina  $(Al_2O_2)$  and less than 0.75% iron oxide (Fe<sub>2</sub>O<sub>2</sub>); the derived mullite product contained about 80% mullite (Kyanite Mining Corp., 2019a, b; Virginia Department of Energy, 2021). The company shipped its products by rail, truck, and air to domestic customers and port facilities for export; exports accounted for about 44% of KMC's sales (table 1) (Lassetter, 2020).

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, and these data were withheld from publication to avoid disclosing company proprietary data. Mineral Manufacturing Corp. produced synthetic mullite in Eufaula, AL, from materials mined from one site in Alabama and one in Georgia. Mullite Co. of America, Inc. (MCA) (a subsidiary of Imerys Refractory Minerals USA, Inc.) produced synthetic mullite from calcined high-grade ore deposits in Andersonville, GA. The company produced Mulcoa®, which included three mullite products of 47%, 59%, and 69% alumina (Imerys Refractory Minerals USA, Inc., 2014). Piedmont Minerals Co., Inc. (a subsidiary of Resco Products, Inc.) mined a deposit of andalusite combined with pyrophyllite and sericite in 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 for kyanite-group minerals, accounting for as much as 90% of consumption, was refractories and refractory products. Of the minerals used in refractories, an estimated 70% was used in the production of iron and steel and the remaining 30% was used for the manufacture of cement, ceramics, chemicals, glass, nonferrous metals, and other materials. When calcined to mullite, kyanite increases in volume, depending upon particle size, typically by about 3% 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 and expand irreversibly by 6% and 4%, respectively, when subsequently calcined (Lassetter, 2020). 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 contained andalusite, kyanite, or mullite included 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 were 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 7% in 2019 compared with that in 2018, and world pig iron production increased slightly. Crude steel output in the United States increased slightly in 2019 compared with that in 2018; world crude steel output increased by 3% in 2019 (American Iron and Steel Institute, 2020, p. 99, 102; World Steel Association, 2020, p. 9, 18). Changes in pig iron production and steel output can have a corresponding effect on the demand for raw materials used in refractories, such as 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 (O'Driscoll, 2010; Kyanite Mining Corp., 2019a, b). Gemstone quality specimens of the kyanite-group minerals often were used in the jewelry industry (Lassetter, 2020).

#### 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 estimated average unit value remained essentially unchanged in 2019 (table 1). Published prices for kyanite and andalusite serve only as a general guide; a comparison of yearend prices for 2017 through 2019, as shown in table 2, indicated that prices for andalusite (minimum 57% Al2O3, free on board, South Africa) increased by approximately 5% in 2019 from those in 2018.

#### **Foreign Trade**

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Exports of kyanite (excluding mullite) decreased by 7% to 40,000 t in 2019 from those in 2018; the value of the exports was \$14.4 million, a 4% decrease from that in 2018 (tables 1, 3). The average unit value of exports in 2019 increased to \$359 per metric ton from \$347 per metric ton in 2018. The United States exported kyanite to 33 countries and localities in 2019. The

10 leading recipients were, in descending order of quantity, Germany, China, Canada, the United Kingdom, Mexico, Japan, the Republic of Korea, the Netherlands, Australia, and Italy, which combined accounted for 88% of United States kyanite exports (table 3). Exports of mullite (calcined kyanite or synthetic) increased by 13% to 29,800 t valued at \$12.6 million and were shipped to 19 countries and localities (table 4). About 95% of United States mullite exports went to Mexico, Canada, Argentina, Germany, and China, in descending order of quantity.

Imports of kyanite-group minerals (mostly andalusite) in 2019 decreased by 19% from those in 2018 to 6,960 t valued at \$1.94 million (tables 1, 5). The average unit value of imports decreased to \$279 per metric ton from \$297 per metric ton in 2018. About 85% of 2019 imports were from South Africa. Imports of mullite (both types) decreased by 27% to 5,230 t valued at \$4.9 million (table 6). Overall, the leading sources of mullite imports were Canada, with 55% of the total; Germany, 16%; and Brazil, 11% (table 6).

#### World Review

The United States continued to be the leading producer of kyanite concentrate, South Africa continued to be the leading producer of andalusite, and India was the leading producer of sillimanite (table 7). Synthetic mullite was thought to be produced in Brazil, Canada, China, Germany, Guyana, Hungary, India, Italy, Japan, Russia, and the United Kingdom.

The irregular availability of inexpensive, refractorygrade 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 the global andalusite supply, although France (verifiable production data have been unavailable for several years) exported a higher quantity than did Peru, indicating possible significant production of andalusite in that country as well (Ghilotti, 2017; United Nations Statistics Division, 2021). 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 and alusite and kyanite, detailed production data have been unavailable since 2003. A production capacity of 40,000 t/yr of andalusite was reported for Xinjiang Xinrong Yilong Andalusite Co., Ltd. [formerly Yilong Andalusite (Xinjiang) Co., Ltd., a subsidiary of Imerys S.A. (Paris, France)] in the Xinjiang Uyghur Autonomous Region of northwestern China (Torrisi, 2014a; Xinjiang Xinrong Yilong Andalusite Co., Ltd., 2018a). The Yilong Mine was thought to have been idled near yearend 2016 to proceed with a \$17 million expansion project at the mine; when completed, it would be the top-producing andalusite mine in China, from which the company planned to export up to 70% of its products. The company reported proven 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).

Nanyang Kaiyuan Cyanite Mining Co., Ltd., Henan Province, reported a production capacity of about 50,000 t/yr of raw kyanite concentrate and 30,000 t/yr of calcined kyanite. The company reported proven reserves of 34 Mt of kyanite ore, averaging 28% Al<sub>2</sub>O<sub>3</sub> and less than 0.5% Fe<sub>2</sub>O<sub>3</sub>. Shijiazhuang Mining Imp&Exp Trade Co., Ltd. reported 213 Mt of andalusite reserves in Xinjiang (Nanyang Kaiyuan Cyanite Mining Co., Ltd., 2017; Lassetter, 2020; Shijiazhuang Mining Imp&Exp Trade Co., Ltd., undated). Although most production was thought to have been consumed within China, primarily by the iron and steel industry, about 2,200 t of kyanite-group minerals was exported from China in 2019, an increase of 25% from that in 2018, mostly to customers in Asia (76% of all exports), Iran (8%), and South Africa (8%) (United Nations Statistics Division, 2021).

*France.*—Imerys Refractory Minerals S.A. mined andalusite from several pits near Glomel in Brittany (Imerys Refractory Minerals S.A., 2016). As of 2016, Imerys had mined about 1 million metric tons per year of andalusite ore from which, through a complex production process that included beneficiation, calcination, and flotation, Imerys was reported to have extracted as much as 80,000 t/yr of andalusite to produce its Kerphalite<sup>TM</sup> KF product, a specialty foundry sand with low thermal expansion and high surface quality (Foundry-Planet Ltd., 2016). In 2019, about 52,100 t of andalusite was exported from France, mostly to customers in Europe (73% of all exports), China (10%), and the Republic of Korea (5%) (United Nations Statistics Division, 2021).

*India.*—India was the world's leading producer of sillimanite (table 7). Little is known about sillimanite production elsewhere, although India reported importing small quantities from Ukraine, Hong Kong, Japan, China, the United States, and Taiwan (in descending order of quantity). About 65% of India's production of sillimanite in 2018–19 was produced by the private sector, and the remainder was produced by the public sector. All output in 2018–19 was from the States of Andhra Pradesh (45%), Odisha (25%), Maharashtra (19%), Kerala (11%), and Meghalaya (<1%). In 2018–19, India exported 10,000 t of sillimanite, with 83% of all exports going to China, 5% each to Japan and Germany, and 3% to Nepal (Indian Bureau of Mines, 2020, p. 17–7, 17–8, 17–11, 17–12).

India was the world's second-ranked producer of kyanite (table 7). In 2018–19, 4,900 t of kyanite was produced in the State of Maharashtra, 62% of which was produced by the private sector. India has relied on imports of andalusite since 1988 when the mining of andalusite last took place. India imported 14,300 t of andalusite in 2018–19, 82% of which came from South Africa (Indian Bureau of Mines, 2020, p. 17–5, 17–6, 17–9, 17–12).

India's industrial minerals industry faced several challenges. In 2019, the Government of India launched the National Mineral Policy 2019, a new policy governing the mining sector, that included incentives to attract private investment. Many mining leases for various commodities, including kyanite, were due to lapse by 2020 and the new mining law required auctioning of mines with expiring leases. Also in 2019, private sector beach sand mining (which included sillimanite) was banned by Government authorities, owing to concerns about private companies mining within coastal areas. Additional factors affecting the industry included environmental issues, high taxes, and high transport costs owing to infrastructural difficulties (Dash, 2018; Industrial Minerals, 2018, 2019a, b; Patel, 2018; Times of India, The, 2018).

**Peru.**—Andalucita S.A. (Lima, Peru), which produced most of Peru's andalusite, continued development of and production from its mine in unconsolidated sand and gravel of the Tablazo Mancora flood plain in northwestern Peru, 20 kilometers (km) from the seaport of Paita (Andalucita, S.A., 2014). Market conditions continued to stabilize in 2019, although contract prices reportedly increased from those in 2018 (Ghilotti, 2019b). Andalucita's primary andalusite product graded 59% to 60%  $Al_2O_3$ , with a maximum of 0.85%  $Fe_2O_3$  (Lismore-Scott, 2014). In 2019, about 41,000 t of andalusite was exported from Peru, a decrease from 50,000 t in 2018, mostly to customers in Europe (United Nations Statistics Division, 2021).

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 included andalusite, to bring it into production. The Guadalupito project consisted of two resource areas, Los Conchales and Tres Chosas, about 25 km from the port city of Chimbote in northern Peru. The Los Conchales resource, on the eastern inland portion of the coastal plain, has a thick formation of high-grade mineralization. Los Conchales, which covers 1,350 hectares, was estimated to contain inferred resources of 1.1 billion metric tons of heavy-mineral sands (heavy-mineral content of 8% above the water table and 6% below it) containing mostly and alusite (23%), magnetite with low titanium content (24%), and lesser quantities of apatite, garnet, ilmenite, monazite, rutile, and zircon. More than 90% of the deposit was below the water table, making that portion amenable to dredge mining. The company's conceptual "Guadalusite" and alusite product (grading 60% Al<sub>2</sub>O<sub>2</sub> and 0.2%  $Fe_2O_2$ ) was processed by basic gravity and magnetic separation as well as by an electrostatic method (Torrisi, 2014a; Syrett, 2015; Latin Resources Ltd., undated).

South Africa.—Imerys South Africa (Pty.) Ltd. [formerly Denain-Anzin Minéraux Réfractaire Céramique (Damrec)], a subsidiary of Imerys S.A. (Paris, France), produced about 70% of the andalusite in South Africa. The company's andalusite mining operations included the Annesley Mine near Burgersfort and the Rhino Mine near Thabazimbi, in Limpopo Province (Imerys Refractory Minerals S.A., 2016). Imerys' Krugerspost Mine near Lydenburg, Mpumalanga Province, was closed in 2013 to focus on production from the company's other mines to increase the output and quality of its Purusite<sup>™</sup> and alusite products, expand its mineral reserves, and emphasize coarsesize products (Torrisi, 2014a, b; Modiselle, 2019, p. 176, 179; Lassetter, 2020). Imerys' main markets for its andalusitebased products (including the Durandal<sup>™</sup>, Purusite<sup>™</sup>, and Randalusite<sup>TM</sup> products from South Africa) were Asia and Europe (Imerys S.A., 2019, p. 40).

Andalusite Resources (Pty.) Ltd. (Johannesburg, South Africa) mined andalusite at its Maroeloesfontein Mine near Thabazimbi, Limpopo Province, about 220 km northwest of Johannesburg. The 70,000-t/yr mine had reserves estimated to be sufficient to last up to 100 years at that production rate (Lassetter, 2020).

Further development at the mine continued with work aimed at increasing capacity to at least 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 andalusite products (trade name: Marlusite) with an alumina content greater than 57% (Lassetter, 2020).

In June 2019, Andalusite Resources temporarily suspended production owing to business rescue proceedings attributed to financial problems; the 1-month closure resulted in an estimated 10,000 t of lost output and shipment delays. After the decision by the South Africa Competition Tribunal to prohibit the proposed merger of Imerys South Africa and Andalusite Resources was confirmed by the South Africa Competition Appeal Court in March 2017, Andalusite Resources was considering the possibility of finding a different investor (Ghilotti, 2019a, c, d, e). In 2019, 156,000 t of andalusite was exported from South Africa to many countries worldwide, a 6% decrease from exports in 2018 (United Nations Statistics Division, 2021).

#### Outlook

Kyanite-group minerals have become increasingly sought after as alternative materials to calcined bauxite in specific refractory applications. When compared with raw materials containing a 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, especially as refractory-grade bauxite from China becomes less available (Torrisi, 2014a, b; Modiselle, 2019, p. 175).

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 may become available for export from projects under development in China and Guyana 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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#### **GENERAL SOURCES OF INFORMATION**

#### **U.S. Geological Survey Publications**

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#### 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>

		2015	2016	2017	2018	2019
United States:						
Production:						
Kyanite concentrate:						
Quantity <sup>2</sup>	metric tons	109,000	79,700	91,300	89,200	91,300
Value <sup>e</sup>	thousands	\$38,000	\$28,200	\$32,000	\$31,000	\$32,000
Mullite (calcined kyanite and synthetic), quantity	metric tons	W	W	W	W	W
Exports of kyanite concentrate: <sup>3</sup>						
Quantity	do.	39,900	37,100	42,400	43,000	40,100
Value <sup>4</sup>	thousands	\$13,900	\$13,000	\$14,900	\$14,900	\$14,400
Imports for consumption, all kyanite-group minerals:	3					
Quantity	metric tons	11,500	2,510	7,420	8,590	6,960
Value <sup>5</sup>	thousands	\$3,680	\$710	\$2,070	\$2,550	\$1,940
World, production	metric tons	402,000	353,000	395,000	419,000 <sup>r</sup>	394,000

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

<sup>1</sup>Table includes data available through August 10, 2020. Data are rounded to no more than three significant digits.

<sup>2</sup>Source: Virginia Department of Energy, 2019, DMM report TNPR.06—Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Energy. (Accessed July 30, 2020, via https://www.energy.virginia.gov/mineral-mining/mineralmining.shtml.)

<sup>3</sup>Source: U.S. Census Bureau.

<sup>4</sup>Free alongside ship (f.a.s.) value.

<sup>5</sup>Customs value.

#### TABLE 2

#### PRICES OF KYANITE AND RELATED MINERALS $^{\rm 1}$

	Price range at yearend			
Material		2017	2018	2019
Andalusite, South Africa, 57% to 58% alumina, 2,000-metric-ton bulk lots	euros per metric ton	240-290	NA <sup>2</sup>	NA <sup>2</sup>
Andalusite, free on board, South Africa, 55% to 59% alumina,				
2,000-metric-ton bulk lots, European port	do.	355-425	NA <sup>2</sup>	NA <sup>2</sup>
Andalusite, minimum 57% Al <sub>2</sub> O <sub>3</sub> , free on board, South Africa	do.	NA	260-320	270-340
Andalusite, minimum 57% Al <sub>2</sub> O <sub>3</sub> , cost, insurance and freight, Europe	do.	NA	390-430	320-430
Kyanite, United States, ex-works, raw, 55% to 60% alumina	dollars per short ton	225-320	NA <sup>2</sup>	NA <sup>2</sup>
Kyanite, United States, ex-works, calcined (mullite), 55% to 60% alumina, 22-ton lots	do.	375-440	NA <sup>2</sup>	NA <sup>2</sup>
4 Web 577.57 H 444				

do. Ditto. NA Not available.

<sup>1</sup>Table includes data available through August 10, 2020. Data are rounded to no more than three significant digits. <sup>2</sup>Price data were discontinued in 2017.

Source: Industrial Minerals magazine (London) via Fastmarkets IM.

 TABLE 3

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

	2018			2019			
	Quantity	Value <sup>3</sup>	Unit	Quantity	Value <sup>3</sup>	Unit	
Country or locality	(metric tons)	(thousands)	value	(metric tons)	(thousands)	value	
Argentina	82	\$24	\$293	100	\$33	\$330	
Australia	562	198	352	905	197	218	
Belgium	500	175	350	21	6	286	
Brazil	40	14	350	80	29	363	
Canada	4,300	1,170	272	4,930	1,300	264	
Central African Republic				20	6	300	
Chile	140	42	300	60	18	300	
China	8,810	2,820	320	5,130	1,840	359	
Colombia	84	24	286	39	13	333	
Denmark	120	43	358				
Dominican Republic				6	14	2,333	
Egypt	200	65	325				
Finland				1	7	7,000	
France	580	213	367	430	158	367	
Germany	8,110	3,020	372	9,750	3,590	368	
Guatemala	20	6	300	20	6	300	
Hong Kong	1	7	7,000				
India	664	219	330	774	288	372	
Indonesia	320	99	309	320	98	306	
Ireland				638	204	320	
Italy	1,480	479	324	785	393	501	
Japan	2,980	1,160	389	2,690	1,150	428	
Korea, Republic of	2,040	712	349	2,150	750	349	
Latvia	20	5	250	80	22	275	
Malaysia	140	42	300	60	18	300	
Mexico	3,900	1,620	415	3,220	1,270	394	
Netherlands	419	161	384	951	300	315	
Philippines	80	26	325				
Poland	140	41	293				
Russia	79	35	443	128	43	336	
Singapore	40	12	300				
South Africa	61	27	443	126	51	405	
Spain	580	192	331	418	153	366	
Sweden	560	197	352	660	244	370	
Taiwan	859	246	286	500	143	286	
Thailand	159	50	314	220	71	323	
Turkey	380	128	337	85	34	400	
United Arab Emirates	120	40	333	20	7	350	
United Kingdom	4,370	1,590	364	4,830	1,930	400	
Vietnam	52	20	385				
Total	43,000	14,900	347	40,100	14,400	359	

-- Zero.

<sup>1</sup>Table includes data available through June 18, 2020. 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>

	2018		2019			
	Quantity	Quantity Value <sup>3</sup>		Value <sup>3</sup>		
Country or locality	(metric tons)	(thousands)	(metric tons)	(thousands)		
Argentina	1,620	\$647	4,610	\$1,780		
Belgium	61	33				
Brazil	84	70	149	119		
Canada	5,790	1,830 <sup>r</sup>	7,910	2,240		
Chile			5	3		
China	580	285	495	279		
Colombia	91	34				
Ecuador	215	127				
France	278	159	259	185		
Germany	2,120	1,090	2,070	1,140		
India	179	107	108	62		
Italy	486	242	349	184		
Japan	14	14	20	17		
Malaysia			1	3		
Mexico	13,900	6,240	13,300	6,280		
Netherlands	300	119	8	3		
Norway	10	6				
Poland			3	6		
Russia	24	18	104	59		
Taiwan	175	84	90	47		
Thailand	10	6	11	6		
United Kingdom	309	204	280	155		
Uruguay	10	5	10	5		
Total	26,300	11,300	29,800	12,600		

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

<sup>1</sup>Table includes data available through June 22, 2020. 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. <sup>3</sup>Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

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

	2018			2019			
	Quantity	Value <sup>4</sup>	Unit	Quantity	Value <sup>4</sup>	Unit	
Country or locality	(metric tons)	(thousands)	value	(metric tons)	(thousands)	value	
France	520	\$244	\$469	333	\$224	\$673	
Peru	1,590	519	326	215	117	544	
South Africa	6,420	1,740	272	5,910	1,470	248	
United Kingdom	59	35	593	506	128	253	
Other	2	7	3,500	2	6	3,000	
Total	8,590	2,550	297	6,960	1,940	279	

<sup>1</sup>Table includes data available through September 1, 2020. 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 concentrates of andalusite, kyanite, and sillimanite.

<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>

	20	18	2019		
	Quantity	Value <sup>3</sup>	Quantity	Value <sup>3</sup>	
Country or locality	(metric tons)	(thousands)	(metric tons)	(thousands)	
Brazil	602	\$493	584	\$323	
Canada	4,820	3,940	2,850	2,280	
China	378	547	548	592	
Germany	1,080	1,590	837	1,250	
Hungary	95	101	117	121	
Japan	87	78	211	181	
Other	49	58	80	152	
Total	7,110	6,800	5,230	4,900	

<sup>1</sup>Table includes data available through June 22, 2020. 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.

<sup>3</sup>Customs value.

Source: U.S. Census Bureau.

### TABLE 7 KYANITE AND RELATED MINERALS: WORLD PRODUCTION, BY COUNTRY OR LOCALITY $^{\rm 1}$

#### (Metric tons)

Country or locality <sup>2</sup>	2015	2016	2017	2018	2019
Cameroon, kyanite <sup>e</sup>	220	200	200	200	200
India:					
Kyanite	2,300	2,932	7,094	5,827 <sup>r</sup>	2,681
Sillimanite	65,243	64,923	81,044	84,215 <sup>r</sup>	70,000 °
Total	67,543	67,855	88,138	90,042 <sup>r</sup>	72,681
Peru, andalusite <sup>e</sup>	35,000	45,000	35,000	40,000	40,000
South Africa, andalusite <sup>e</sup>	190,000	160,000	180,000	200,000	190,000
United States, kyanite, concentrate	109,000	79,700	91,300	89,200	91,300
Grand total	402,000	353,000	395,000	419,000 r	394,000

<sup>e</sup>Estimated. <sup>r</sup>Revised.

<sup>1</sup>Table includes data available through September 22, 2020. All data are reported unless otherwise noted. Grand 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 and (or) localities 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.