



2018 Minerals Yearbook

KYANITE AND RELATED MINERALS [ADVANCE RELEASE]

KYANITE AND RELATED MINERALS

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In 2018, the United States continued to be the world's leading producer of kyanite concentrate and mullite (calcined kyanite); 89,200 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 430,000 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 anhydrous polymorphic 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. Topaz and dumortierite are often included as members of the kyanite group of minerals, but they contain considerable proportions of fluorine and boron, respectively. For most end uses of these aluminosilicate minerals, mullite is preferred because of its superior refractory (heat-resistant) properties [it is stable to about 1,810 degrees Celsius (°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. The conversion reaction results in mullite, $Al_6Si_2O_{13}$, and silica, SiO_2 .

Production

In 2018, the production of kyanite concentrate in the United States decreased slightly to 89,200 t, valued at an estimated \$31 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 2018, 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. Production capacity was reported by KMC to be about 136,000 metric tons per year (t/yr) of commercial-grade kyanite concentrates and 27,000 t/yr of calcined kyanite. The company's concentrate graded 92% to 98% kyanite containing greater than 57% alumina (Al_2O_3) and less than 0.75% iron oxide (Fe_2O_3); the derived mullite product contained about 80% mullite (Virginia Department of Mines, Minerals and Energy, 2015; Kyanite Mining Corp., 2019a, b). The company shipped its products by rail, truck, and air to domestic customers and port facilities for export; exports accounted for about 48% of KMC's sales (Lassetter, 2018; table 1).

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); historically obtained 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 at Hillsborough, NC. Piedmont sold products containing blends of the three minerals to the refractory industry, especially for 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 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 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 and expand irreversibly by about 6% and 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 by 7% in 2018 compared with that of 2017; and world pig iron production increased by 5%. Crude steel output in the United States increased by 6% in 2018 compared with that of 2017; world crude steel output increased by 7% in 2018 (Tuck, 2021). 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 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 (O'Driscoll, 2010; Kyanite Mining Corp., 2019a, b). Gemstone quality specimens of the kyanite group minerals are often used in the jewelry industry (Lassetter, 2018).

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 decreased slightly in 2018. Published prices for kyanite and andalusite serve only as a general guide; a comparison of yearend prices for 2016 through 2018 as shown in table 2 indicated no overall change during 2016–17, but these price data were discontinued in 2017.

Foreign Trade

Exports of kyanite (excluding mullite) increased slightly to 43,000 t in 2018 from those of 2017; the value of the exports was \$14.9 million, virtually unchanged from that of 2017 (tables 1, 3). Exports in 2018 were to 36 countries and localities. The 10 leading recipients were, in descending order of tonnage, China, Germany, the United Kingdom, Canada, Mexico, Japan, the Republic of Korea, Italy, Taiwan, and India,

which combined accounted for 87% of United States kyanite exports. Exports of mullite (calcined kyanite or synthetic) decreased by 18% to 26,300 t valued at \$11.3 million and were shipped to 20 countries and localities (table 4). About 91% of United States mullite exports went to Mexico, Canada, Germany, Argentina, and China, in descending order of quantity.

Imports of kyanite group minerals (mostly andalusite) in 2018 increased by 16% from those of 2017 to 8,590 t valued at \$2.55 million (tables 1, 5). About 75% of 2018 imports were from South Africa, and 19% were from Peru. Imports of mullite (both types) increased by 20% to 7,110 t valued at \$6.8 million (table 6). Overall, the leading sources of mullite imports were Canada, with 68% of the total; Germany, 15%; and Brazil, 8% (table 6).

World Review

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, 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 slightly higher quantity than did Peru, indicating possible significant production of andalusite in that country as well (Ghilotti, 2017a; United Nations Statistics Division, 2020). 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 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 (Torrissi, 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; once complete, 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).

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 mined about 1 million metric tons per year of andalusite ore 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 surface quality (Foundry-Planet Ltd., 2016). In 2018, about 50,300 t of andalusite was exported from France, mostly to customers in Europe (76% of all exports), China (9%), and the Republic of Korea (5%) (United Nations Statistics Division, 2020).

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 Japan, the United States, and Taiwan (in descending order of quantity). About 70% of India's production of sillimanite in 2018 was produced by the private sector, and the remainder was produced by the public sector. All output in 2018 was from the States of Andhra Pradesh (66%), Odisha (20%), Kerala (9%), Maharashtra (4%), and Meghalaya (1%). India exported 16,000 t of sillimanite, with 78% of all exports going to China and 7% each to Germany and Nepal (Indian Bureau of Mines, 2019, p. 17–7 to 17–8, 17–11 to 17–12).

India was the world's second-ranked producer of kyanite (table 7). About 7,800 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 14,400 t of andalusite, 94% of which came from South Africa (Indian Bureau of Mines, 2019, p. 17–5, 17–9, 17–11).

India's industrial minerals industry faced several challenges, such as the mining law requirement for the State auctioning of mines with expiring leases. Many mining leases for various commodities, including kyanite, were due to lapse by 2020. Additional factors affecting the industry included environmental issues and high transport costs owing to infrastructural difficulties (Dash, 2018; Industrial Minerals, 2018; Patel, 2018; Times of India, The, 2018).

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 seaport of Paita (Andalucita, S.A., 2014). In 2018, the company's andalusite production, estimated to be 50,000 t, increased significantly from that in 2017. Heavy rains and flooding from February into April 2017, followed by a prolonged rampup to full production capacity, resulted in a shortage of andalusite; some of the 2018 production fulfilled outstanding 2017 orders. In 2018, contract renewals were characterized by higher prices and shorter contract terms (Ghilotti, 2017a, b, c, 2018a, 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 2018, about 50,000 t, an increase from 35,000 t in 2017, of andalusite was exported from Peru, mostly to customers in Europe (United Nations Statistics Division, 2020).

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 consists 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 thicker formation of higher 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 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 was below the water table, making that portion amenable to dredge mining. The andalusite (grading 60% Al_2O_3 and 0.2% Fe_2O_3) was processed by basic gravity and magnetic separation as well as an electrostatic process (Torrise, 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., produced about 70% of the andalusite in South Africa. The company's andalusite mining operations included the Rhino Mine near Thabazimbi and the Annesley Mine near Burgersfort, in Limpopo Province (Imerys Refractory Minerals S.A., 2016). The mines had an estimated combined production capacity of 195,000 t/yr of fine-, medium-, and coarse-grained andalusite, which could be expanded to 250,000 t/yr (Carmichael and Lismore-Scott, 2013). Imerys' Krugerspost Mine near Lydenburg, Mpumalanga Province, remained idled; it was closed in 2013 to focus 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 (Torrise, 2014b; Lassetter, 2018; Modiselle, 2018, p. 179). Imerys' main markets for its andalusite-based products were Asia and Europe (Imerys S.A., 2019, p. 40).

Andalusite Resources (Pty.) Ltd. mined andalusite at its Maroeloesfontein Mine in 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, 2018). Further development at the mine continued with work ultimately 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; Torrise, 2014a). Andalusite Resources marketed fine- to medium-grade Marlusite andalusite products with an alumina content greater than 57% (Lassetter, 2018).

In March 2017, the South Africa Competition Tribunal Competition Appeal Court confirmed the earlier decision of the South Africa Competition Commission to prohibit the proposed merger of Imerys South Africa (Pty.) Ltd. and Andalusite Resources (Kilian, 2017; Modiselle, 2018, p. 182). The proposed merger was prohibited to prevent monopolization of andalusite supply within the local and global markets (Greve, 2015; Gyekye, 2015). Andalusite Resources was considering the possibility of finding another partner that would not raise concerns of a possible monopoly situation (Syrett and McCormick, 2016).

In 2017, South Africa's andalusite producers were negatively affected by bad weather conditions, including heavy rain and flooding. Mines were inaccessible from December 2016 to February 2017, and a prolonged rampup to full production capacity resulted in a shortage of andalusite. Production increased in 2018, but the supply shortage continued because delivery of some 2017 shipments was deferred to 2018. Andalusite suppliers reportedly increased prices by about 10% and moved from 1-year to 6-month terms for 2018 contracts (Ghilotti, 2017a, b, c, 2018a, b). In 2018, about 166,000 t of andalusite was exported from South Africa to many countries worldwide (United Nations Statistics Division, 2020).

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 (Torrison, 2014a, b; Modiselle, 2018, p. 183). 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, although increased production in 2018 is expected to alleviate some of the supply issues. In 2018, andalusite suppliers reportedly increased prices by about 10% and structured contracts differently, such as implementing a 1-year supply with 6-month pricing, instead of 1-year supply and price contracts as had been typical previously (Ghilotti, 2017a, b, c, 2018a, b).

As the production of andalusite returns to more normal levels, interest in the mineral may increase. 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. 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 U.S. KYANITE AND RELATED MINERALS STATISTICS¹

		2014	2015	2016	2017	2018
United States:						
Production:						
Kyanite concentrate:						
Quantity ²	metric tons	88,600	109,000	79,700	91,300	89,200
Value ^c	thousands	\$29,300	\$38,000	\$28,200	\$32,000	\$31,000
Mullite (calcined kyanite and synthetic), quantity ^c	metric tons	W	W	W	W	W
Exports of kyanite concentrate: ³						
Quantity	do.	40,000	39,900	37,100	42,400	43,000
Value ⁴	thousands	\$13,600	\$13,900	\$13,000	\$14,900	\$14,900
Imports for consumption, all kyanite minerals: ³						
Quantity	metric tons	4,020	11,500	2,510	7,420 ^r	8,590
Value ⁵	thousands	\$1,550	\$3,680	\$710	\$2,070	\$2,550
World, production	metric tons	372,000	402,000	353,000 ^r	395,000 ^r	430,000

^cEstimated. ^rRevised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through July 1, 2020. Data are rounded to no more than three significant digits.

²Source: Virginia Department of Mines, Minerals and Energy, 2018, DMM report TNPR.060—Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed July 30, 2019, via <http://www.dmme.virginia.gov/DMM/miningdata.shtml>.)

³Source: U.S. Census Bureau.

⁴Free alongside ship (f.a.s.) value.

⁵Customs value.

TABLE 2
PRICES OF KYANITE AND RELATED MINERALS¹

Material		Price range at yearend		
		2016	2017	2018
Andalusite, South Africa, 57% to 58% alumina, 2,000-metric-ton bulk lots	euros per metric ton	240–290	240–290	NA ²
Andalusite, free on board, South Africa, 55% to 59% alumina, 2,000-metric-ton bulk lots, European port	do.	355–425	355–425	NA ²
Andalusite, minimum 57% Al ₂ O ₃ , free on board, South Africa	do.	NA	NA	260–320
Andalusite, minimum 57% Al ₂ O ₃ , customs, insurance and freight, Europe	do.	NA	NA	390–430
Kyanite, United States, ex-works, raw, 55% to 60% alumina	dollars per short ton	225–320	225–320	NA ²
Kyanite, United States, ex-works, calcined (mullite), 55% to 60% alumina, 22-ton lots	do.	375–440	375–440	NA ²

do. Ditto. NA Not available.

¹Table includes data available through July 1, 2020. Data are rounded to no more than three significant digits.

²Price data were discontinued in 2017.

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	2017		2018	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Argentina	62	\$19	82	\$24
Australia	551	179	562	198
Belgium	980	344	500	175
Brazil	60	21	40	14
Canada	2,620	731	4,300	1,170
Central African Republic	10	3	--	--
Chile	100	29	140	42
China	9,420	3,230	8,810	2,820
Colombia	39	11	84	24
Denmark	80	29	120	43
Egypt	200	62	200	65
France	84	33	580	213
Germany	9,870	3,540	8,110	3,020
Guatemala	20	5	20	6
Hong Kong	--	--	1	7
Hungary	40	15	--	--
India	481	152	664	219
Indonesia	220	63	320	99
Ireland	2	3	--	--
Italy	878	319	1,480	479
Japan	3,990	1,400	2,980	1,160
Korea, Republic of	2,190	762	2,040	712
Latvia	20	5	20	5
Malaysia	100	29	140	42
Mexico	3,160	1,240	3,900	1,620
Netherlands	2,270	818	419	161
Philippines	20	6	80	26
Poland	100	36	140	41
Qatar	40	13	--	--
Russia	80	22	79	35
Singapore	--	--	40	12
South Africa	--	--	61	27
Spain	420	140	580	192
Sweden	740	262	560	197
Taiwan	664	179	859	246
Thailand	125	38	159	50
Turkey	440	142	380	128
United Arab Emirates	80	25	120	40
United Kingdom	2,220	943	4,370	1,590
Vatican City	20	6	--	--
Vietnam	--	--	52	20
Total	42,400	14,900	43,000	14,900

-- Zero.

¹Table includes data available through July 1, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States code 2508.50.0000 for kyanite concentrate.

³Free 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	2017		2018	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Argentina	4,740	\$2,060	1,620	\$647
Bangladesh	40	19	--	--
Belgium	200	97	61	33
Brazil	32	37	84	70
Canada	6,710 ^r	2,190 ^r	5,790	1,820
China	351	187	580	285
Colombia	--	--	91	34
Czechia	40	16	--	--
Denmark	24	25	--	--
Ecuador	--	--	215	127
France	65	39	278	159
Germany	2,650	1,740	2,120	1,090
Hungary	136	96	--	--
India	--	--	179	107
Italy	343	182	486	242
Japan	23	4	14	14
Mexico	15,000	5,400	13,900	6,240
Netherlands	95	43	300	119
Norway	--	--	10	6
Peru	44	9	--	--
Romania	83	41	--	--
Russia	--	--	24	18
Taiwan	137	67	175	84
Thailand	6	3	10	6
United Kingdom	1,220	1,180	309	204
Uruguay	10	5	10	5
Total	31,900 ^r	13,400 ^r	26,300	11,300

^rRevised. -- Zero.

¹Table includes data available through July 1, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite.

³Free 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	2017		2018	
	Quantity (metric tons)	Value ⁴ (thousands)	Quantity (metric tons)	Value ⁴ (thousands)
China	239	\$66	--	--
France	252	143	520	\$244
Peru	867	248	1,590	519
South Africa	6,010	1,570	6,420	1,740
United Kingdom	39	23	59	35
Other	21 ^r	25 ^r	2	7
Total	7,420 ^r	2,070	8,590	2,550

^rRevised. -- Zero.

¹Table includes data available through July 1, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

²Most material is thought to be andalusite.

³Harmonized Tariff Schedule of the United States code 2508.50.0000 for concentrates of andalusite, kyanite, and sillimanite.

⁴Customs value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MULLITE^{1,2}

Country or locality	2017		2018	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Brazil	603	\$589	602	\$493
Canada	2,970	2,570	4,820	3,940
China	36	50	378	547
Germany	1,810	2,650	1,080	1,590
Hungary	285	327	95	101
Japan	171	137	87	78
Other	37	59	49	58
Total	5,910	6,380	7,110	6,800

¹Table includes data available through July 1, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite.

³Customs value.

Source: U.S. Census Bureau.

TABLE 7
KYANITE AND RELATED MINERALS: WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons)

Country or locality ²	2014	2015	2016	2017	2018
Cameroon, kyanite	220	220	200 ^e	200	200 ^e
India:					
Kyanite	6,680	2,300	2,932 ^r	7,094 ^r	7,000 ^e
Sillimanite	73,661	65,243	64,923	81,044 ^r	94,000 ^e
Total	80,341 ^r	67,543 ^r	67,855 ^r	88,138 ^r	101,000 ^e
Peru, andalusite ^e	30,000	35,000	45,000	35,000	40,000
South Africa, andalusite	172,657	190,000 ^e	160,000 ^{r,e}	180,000 ^{r,e}	200,000 ^e
United States, kyanite, concentrate	88,600	109,000	79,700	91,300	89,200
Grand total	372,000	402,000	353,000 ^r	395,000 ^r	430,000

^eEstimated. ^rRevised.

¹Table includes data available through July 3, 2019. 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.

²In 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.