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KYANITE AND RELATED MINERALS [ADVANCE RELEASE]

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Kyanite and Related Minerals

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In 2014, the United States continued to be the world's leading producer of kyanite and mullite (calcined kyanite), with an increase in combined production to approximately 110,000 metric tons (t) from about 100,000 t in 2013 (tables 1, 7). World production of kyanite and related minerals—andalusite and sillimanite—was estimated to be at least 400,000 t (tables 1, 7). Domestic synthetic mullite (calcined aluminous and siliceous minerals and clays) production data were withheld to avoid disclosing company proprietary data. In the United States, one company produced kyanite and 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, and the remainder was used in the manufacture of chemicals, glass, nonferrous metals, and other materials.

This report includes information on the 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 of 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 more 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 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 more), whereas synthetic or sintered mullite typically refers to mullite made by calcining certain mixtures of alumina- and silica-containing minerals and materials, typically bauxite, bauxite kaolin, and kaolin, at similarly high temperatures.

Production

In 2014, the production of kyanite and mullite in the United States was estimated to have increased to about 110,000 t, up by about 10% from that of 2013 (tables 1, 7). The value of kyanite and mullite produced in the United States in 2013 was estimated to have increased to $38 million (table 1).

A U.S. Geological Survey (USGS) voluntary survey was sent to the sole U.S. producer of kyanite and kyanite-derived mullite in 2014, Kyanite Mining Corp. (KMC), which responded to the survey, but these data are withheld to avoid disclosing company proprietary data. However, employee hours worked as reported to the U.S. Department of Labor's Mine Safety and Health Administration (MSHA) together with other data from the Virginia Department of Mines, Minerals and Energy have been used as an indicator to derive approximate output levels of production in 2013 and 2014. 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. An estimated 15% to 20% of this kyanite concentrate was further processed and converted by calcination into mullite; more than 90% of this conversion was at the company's Willis Mountain plant and the remainder at the Gieseke plant (East Ridge), 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, 2015).

C-E Minerals, Inc. (a subsidiary of Imerys Refractory Minerals SA) produced synthetic mullite from calcined bauxite, bauxitic kaolin, and kaolin clays near Americus, GA. C-E Minerals produced various products that contained 65%, 77%, and 87% mullite constituting a range of between 45% and 70% alumina (C-E Minerals, Inc., 2014). Mineral Manufacturing Corp. produced synthetic mullite in Eufaula, AL, from similiar materials mined from one site in Alabama and one in Georgia.

Piedmont Minerals Co., 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 producers of ceramics and refractories.

Consumption

The dominant end use for kyanite and related minerals was refractories and refractory products. An estimated 65% of the materials used in refractories, accounting for as much as 90% of consumption, was for the production of iron and steel and the remainder 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 those of clays. 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 (Roskill Information Services Ltd., 1990, p. 56, 63).

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).

Crude steel output in the United States increased slightly in 2014 compared with that of 2013; world crude steel output increased by slightly less in 2014. Increased U.S. steel output resulted from growth in manufacturing and construction. The leading steel-producing countries, which also would be leading consumers of refractory products, included China, accounting for more than 49% of the world's steel production in 2014; Japan, 6.7%; the United States, 5.3%; India, 5.0%; Russia, 4.3%; the Republic of Korea, 4.3%; and Germany, 2.6%. These countries accounted for about 77% of world steel production in 2014 (World Steel Association, 2015a).

Other end uses of kyanite and related minerals and materials included high-friction products such as motor vehicle brake shoes and pads and 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

Based on data received in the USGS survey of domestic kyanite production, the unit value of raw kyanite concentrate and calcined kyanite (mullite) is largely dependent on grade and sizing. The average unit value increased slightly in 2014. Prices for kyanite and andalusite serve only as a general guide; as of December 2014 (table 2), published prices were unchanged from those of 2013 and 2012.

Foreign Trade

About 37% of U.S. kyanite and mullite (calcined kyanite and synthetic, unspecified) output was exported in 2014 (tables 1, 3, and 4). Exports of kyanite (excluding mullite) decreased by 5.6% to 40,000 t valued at $13.6 million and were shipped to 33 countries (table 3). China, Germany, Mexico, Japan, the United Kingdom, Belgium, Canada, and the Republic of Korea (in descending order) combined received more than 80% of U.S. kyanite exports. Exports of mullite decreased by 3.6% to 22,300 t valued at $8.7 million and were shipped to 16 countries (table 4). Nearly 90% of U.S. mullite exports went to Canada, Mexico, Germany, and the United Kingdom, in descending order of quantity (table 4).

Imports of kyanite-group minerals (mostly andalusite) decreased slightly in 2014 to 4,020 t valued at $1.55 million (tables 1, 5). Nearly 87% of these imports were from South Africa and 8% from France (table 5). Imports of mullite (calcined kyanite or synthetic, unspecified) increased by 25% to 7,270 t, with a 16% increase in value to $6 million (table 6). The increase in mullite imports and value was largely attributed to a substantial increase in imports from China along with increases from Canada and Germany. Overall, the leading sources of mullite imports were Canada with 40%; China, 38%; Germany, 11%; and Brazil, 7.5% (table 6).

World Review

South Africa continued to be the leading producing country 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, Russia, and the United States.

Continued growth in the world steel industry and the erratic availability of inexpensive refractory-grade bauxite from China served to increase the demand in refractory production for alternate raw materials such as andalusite. The leading andalusite producers, China, Peru, and South Africa, continued to expand operations. Conversely, 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, 2013a).

China.—Although China was thought to produce kyanite group minerals, detailed production data have been unavailable since 2003. A production capacity of 40,000 metric tons per year (t/yr) 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).

France.—Imerys Refractory Minerals (a member of Imerys Group), which produces andalusite under the trade name Kerphalite™, opened a new andalusite mine pit at its Glomel Mine, in Brittany (Imerys Refractory Minerals SA, 2014).

India.—India was by far 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 74% of India's production of sillimanite was reported by the private sector, and the remaining 26% of production was reported by the public sector. Most of the production was from two States, Andhra Pradesh and Odisha, accounting for 64% and 19% of the country's production, respectively. About 46% of production was exported with 87% of exports going to China. About 1,900 t of kyanite was produced in the State of Maharashtra. India has relied on imports of andalusite since 1988 when the mining of andalusite last took place (Indian Bureau of Mines, 2014, p. 64–65, 114–115).

Peru.—Andalucita S.A. 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 deep seaport of Paita. Upgrades to its processing plant in 2013 increased the operation's production capacity to 37,000 t/yr from its 25,000-t/yr capacity in 2012, 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). Spurred by demand in Europe, the company reported that sales increased by 70% year on year. Its primary andalusite product graded 59% to 60% Al_2O_3, with a maximum of 0.85% iron oxide (Lismore-Scott, 2014). In 2014, 29,000 t of andalusite was exported from Peru to customers in Europe, North America, and South America (United Nations Statistics Division, undated).

Latin Resources Ltd. (Perth, Western Australia, Australia) continued exploration and development at the Guadalupito iron and mineral sands project 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 of the Guadalupito project, was estimated to contain an estimated 1.1 billion metric tons of heavy-mineral sands containing mostly andalusite (21% to 24%) and magnetite (22% to 25%) and lesser quantities of ilmenite, rutile, and zircon. The andalusite is found mostly as highly liberated particles in the deposit, more than 90% of which is below the water table making it amenable to dredge mining. Based on testing performed in 2014, the deposit was expected to produce an andalusite product grade of greater than 60% Al_2O_3 with less than 0.2% iron oxide, which Latin Resources was planning to produce for the refractory and technical ceramics markets. Bulk processing of andalusite samples by gravity concentration, using classifiers and magnetic separation to remove magnetic minerals such as magnetite, was planned for early 2015. The company expected to start production in 2016 at an estimated initial rate of 15,000 t/yr with a mine life of 56 years (Proactive Investors Australia Pty Ltd., 2014; Torrisi, 2014a; Latin Resources Ltd., 2015; Lismore-Scott, 2015).

Russia.—The mining company JSC Central Kola Expedition announced the discovery of about 950 million metric tons of kyanite resources in the Murmansk region of the Kola Peninsula of northwestern Russia (BarentsNova, 2014). The deposit, lying at depths not exceeding 100 meters, was thought to be amenable to economical open pit mining and may eventually offer alumina producers new opportunities to reduce dependence on bauxite. According to the Kola Scientific Centre of the Russian Academy of Sciences, about 90% of Russian kyanite was concentrated in the Large Keivy Massif in the Murmansk region. However, owing to the location and the type of material, development of the deposit was likely to be delayed by as much as 20 years because the discovery was far away from large industrial centers and powerplants with no potential consumer anticipated in the near future. In the Murmansk region, JSC Apatit, a subsidiary of Russian phosphate producer OJSC PhosAgro and the only producer of nepheline concentrate in Russia, processed nepheline ore into nepheline concentrate from which the company produced phosphate and sufficient quantities of byproduct alumina to produce aluminum. Bauxite, an oxide ore, remained the most cost-effective mineral from which to produce alumina because silicates such as kyanite are very energy intensive to process (BarentsNova, 2014).

South Africa.—Andalusite Resources (Pty.) Ltd. mined andalusite at its Maroeloesfontein Mine in Thabazimbi, Limpopo Province. In 2013, the company produced at near capacity, which was about 70,000 t/yr. Although severe rains early in 2014 disrupted production for about 1 month, Andalusite Resources continued with plans to expand to 90,000 t/yr by yearend and to as much as 120,000 t/yr in 2015. 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).

Denain-Anzin Mineraux Refractarie 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 about 250,000 t/yr over the next few years. Rhino Minerals (Pty.) Ltd. operated three of Damrec's four mines in South Africa, the Annesley, Havercroft, and Rhino Mines in Limpopo Province. Samrec (Pty.) Ltd. operated the fourth mine, the Krugerspost Mine near Lydenburg, Mpumalanga Province. Near midyear, Imerys mothballed the Krugerspost Mine to concentrate on production from the company's other mines and plants, especially to increase the output and quality of its purusite andalusite product, to expand its mineral reserves, and emphasize coarse-size products (Torrisi, 2014b). Damrec's main markets were China, Europe, India, and South Africa (Carmichael and Lismore-Scott, 2013; Torrisi, 2014a; Modiselle, 2015, p. 203–208).

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. Rising production and energy costs for lower grade bauxite ores may lessen the availability of refractory-grade bauxite (Saxby, 2013b). When compared to raw materials with higher alumina content, andalusite is expected to be an increasingly attractive alternative especially as the availability of the mineral increases from expansion of operations in South Africa and anticipated increases in production from Peru (Torrisi, 2014a, b). Andalusite is able to be fired at a lower temperature than most alternative materials when used to produce a dense and shrinkage-resistant refractory aggregate. This reduces energy consumption and greenhouse gas emissions (Feytis, 2011). Nevertheless, inexpensive refractory-grade bauxite that becomes available for export from developments in Brazil, Guyana, and Russia may become competitive with andalusite and kyanite in some applications, such as steel furnaces and industrial boilers (Saxby, 2013a). For durable refractories, technological advances are likely to include increased use of synthetic mullite.

In the United States, apparent consumption of steel, the leading industrial market for refractories, is projected to increase slightly in 2015–16 following the 11% increase from 2013 to 2014 that resulted from higher than anticipated growth in manufacturing and construction (World Steel Association, 2015b). The improving global economy, continued momentum in the automotive markets and energy sectors, and slowing yet continued growth in the construction sector indicate that the demand for and consumption of steel in the United States is likely to grow, and with this, the need for more refractories will expand accordingly (Zacks Investment Research, Inc., 2014).

World steel consumption is expected to to increase by only about 0.5% in 2015 and by 1.4% in 2016, following slower-than-expected growth of 0.6% in 2014. Because of continuing efforts by the Government of China to moderate domestic growth, especially in its real estate sector, and to rebalance its economy, China's steel consumption is expected to begin to stabilize and decrease by 0.5% in 2015 and 2016, following a decrease of 3.3% in 2014 (World Steel Association, 2015b). Although a small deceleration in apparent steel consumption

is expected, China's more than 2-billion-metric-ton-per-year cement industry continues to require raw materials such as kyanite-group minerals for refractory products used in cement plants. Continued growth is expected in China's cement industry.

The Asia-Pacific region remains the largest market for refractories, and China is anticipated to continue to be the single leading market and represent the majority of global consumption. Above-average growth in India is expected to continue. For the next several years, increases in the market for refractories are likely to continue in Eastern Europe, North America, and Western Europe, although growth in the refractory market in North America, in the longer term, may lag behind the global average, in part owing to a shift in steel production to developing countries. Finding and acquiring a consistent supply of refractory raw materials, especially at affordable prices, is likely to remain a challenge for producers of refractory products, particularly those in Europe and the Western Hemisphere (Deneen, 2011). Another challenge for producers in Europe, Japan, and North America is an increased use of higher quality, longer lasting refractories with longer inservice life cycles leading to reductions in consumption per ton of steel. In these regions, consumption of refractories per ton of steel in recent years has decreased, in the range of 8 to 10 kilograms per ton, less than one-half the use in China. However, during the next 5 years or more, current consumption levels of refractories per ton of steel are expected to decline in developing countries as they begin to shift to similar refractory materials and more advanced steelmaking practices (Industrial Minerals, 2013).

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TABLE 1
SALIENT U.S. KYANITE AND RELATED MINERALS STATISTICS[1]

		2010	2011	2012	2013	2014
Production						
Kyanite:						
Quantity (includes calcined kyanite)	metric tons	93,400 [2]	98,200 [2]	98,500 [2]	100,000 [r, 3]	110,000 [3]
Value[e]	thousands	$29,000	$31,000	$31,000	$35,000	$38,000
Synthetic mullite:						
Quantity	metric tons	W [r]	W [r]	W [r]	W [r]	W [r]
Value	thousands	W [r]	W [r]	W [r]	W [r]	W [r]
Exports of kyanite concentrate:[4]						
Quantity	metric tons	37,900	38,100	36,400	42,400	40,000
Value[5]	thousands	$11,300	$11,600	$11,700	$13,100	$13,600
Imports for consumption, all kyanite minerals:[4]						
Quantity	metric tons	2,180	5,390	3,260	4,120 [r]	4,020
Value[6]	thousands	$938	$2,230	$1,610	$1,630 [r]	$1,550
Consumption, apparent[7]	metric tons	W [r]	W [r]	W [r]	W [r]	W [r]
World, production[e, 8]	do.	344,000 [r]	357,000 [r]	333,000 [r]	360,000 [r]	400,000

[e]Estimated. [r]Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Source: Virginia Department of Mines, Minerals and Energy, 2015.
[3]Production data for 2013 and 2014 were estimated based on worker hours reported to the U.S. Department of Labor, Mine Safety and Health Administration (MSHA) and other data from the Virginia Department of Mines, Minerals and Energy.
[4]Source: U.S. Census Bureau.
[5]Free alongside ship (f.a.s.) value.
[6]Customs value.
[7]Includes kyanite and synthetic mullite production plus imports minus exports.
[8]A number of countries produce kyanite and related minerals; output for some countries is not reported quantitatively and cannot be included in the world total.

TABLE 2
PRICES OF KYANITE AND RELATED MINERALS IN 2014[1]

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

do. Ditto.
[1]Industrial Minerals 2014, IM December Price Movements: Industrial Minerals, December 1. (Accessed December 14, 2014, via http://indmin.com).

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

Country	2013 Quantity (metric tons)	2013 Value[3] (thousands)	2014 Quantity (metric tons)	2014 Value[3] (thousands)
Argentina	160	$45	160	$44
Australia	492	142	483	144
Bangladesh	22	8	20	8
Belgium	2,610	817	2,420	796
Brazil	81	29	180	54
Canada	2,600	840	2,060	782
Chile	120	29	100	25
China	7,810	2,210	9,600	3,080
Colombia	85	20	100	26
Denmark	69	26	109	41
Egypt	400	109	220	57
Finland	20	6	--	--
Germany	6,490	2,070	7,280	2,520
Greece	--	--	22	7
Guatamala	--	--	42	10
Hungary	40	13	--	--
India	389	102	347	119
Indonesia	80	19	361	91
Ireland	6	5	5	3
Italy	1,320	411	1,380	451
Japan	3,080	1,130	3,040	1,220
Korea, Republic of	3,040 r	896	1,920	603
Lithuania	22	4	--	--
Malaysia	380	95	300	77
Mexico	3,270	1,120	3,190	1,150
Netherlands	2,200 r	702 r	922	324
Philippines	20	5	20	5
Russia	22	5	--	--
Slovenia	204	43	--	--
South Africa	12	3	22	5
Spain	486	145	625	196
Sweden	896	263	852	272
Taiwan	700	172	625	152
Thailand	338	86	300	80
Turkey	694	179	527	152
Ukraine	--	--	22	6
United Arab Emirates	110	30	62	18
United Kingdom	4,090 r	1,340 r	2,680	1,060
Venezuela	20	5	--	--
Total	42,400	13,100	40,000	13,600

rRevised. -- Zero.

[1] Harmonized Tariff Schedule of the United States code 2508.50.0000 for kyanite concentrate.

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

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

Country	2013 Quantity (metric tons)	2013 Value[3] (thousands)	2014 Quantity (metric tons)	2014 Value[3] (thousands)
Bangladesh	86	$39	44	$17
Belgium	271	124	251	123
Brazil	238	96	3	11
Bulgaria	--	--	20	8
Canada	9,410	2,680	10,500	3,290
China	907	353	968	464
France	8	13	3	7
Germany	5,400	3,430	1,800	944
India	32	15	20	9
Italy	66	29	324	159
Japan	--	--	1	6
Malaysia	62	24	--	--
Mexico	4,350 r	2,160	6,260	2,630
Netherlands	817 r	369 r	804	373
South Africa	240	25	--	--
Taiwan	152	66	207	93
Trinidad and Tobago	11	10	--	--
United Kingdom	1,070 r	535 r	1,040	546
Uruguay	8	3	6	3
Total	23,100 r	9,970	22,300	8,680

rRevised. -- Zero.
[1]Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite (calcined kyanite or synthetic).
[2]Data are rounded to no more than three significant digits; may not add to totals shown.
[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	2013 Quantity (metric tons)	2013 Value[4] (thousands)	2014 Quantity (metric tons)	2014 Value[4] (thousands)
France	236	$176	303	$219
Peru	302	131	99	44
South Africa	3,490	1,260	3,500	1,230
United Kingdom	19	14	55	45
Other	57 r	34 r	68	10
Total	4,110	1,610	4,020	1,550

rRevised.
[1]Most material is thought to be andalusite.
[2]Harmonized Tariff Schedule of the United States code 2508.50.0000 for kyanite concentrate.
[3]Data are rounded to no more than three significant digits; may not add to totals shown.
[4]Customs value.

Source: U.S. Census Bureau.

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

Country	2013 Quantity (metric tons)	2013 Value[3] (thousands)	2014 Quantity (metric tons)	2014 Value[3] (thousands)
Brazil	698	$744	548	$576
Canada	2,610	2,070	2,940	2,230
China	1,450	571	2,760	1,160
Germany	557	1,150	768	1,630
Hungary	449	554	203	254
Japan	49	67	42	118
Other	8	20	11	28
Total	5,820	5,180	7,270	6,000

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

Source: U.S. Census Bureau.

TABLE 7
KYANITE AND RELATED MINERALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and commodity[3]	2010	2011	2012	2013	2014[e]
Australia, kyanite[e]	1,000	1,000	1,000	1,000	1,000
India:					
Kyanite	5,866 [r]	4,537	1,816 [r]	1,708 [r]	2,000
Sillimanite	45,010	56,601 [r]	47,604 [r]	57,132 [r]	60,000
Total	50,876 [r]	61,138 [r]	49,420 [r]	58,840 [r]	62,000
Peru, andalusite[e]	10,000 [r]	10,000 [r]	20,000 [r]	20,000 [r]	30,000
South Africa, andalusite	189,185	186,242	163,801 [r]	180,000 [r, e]	200,000
United States, kyanite[4]	93,400 [5]	98,200 [5]	98,500 [5]	100,000 [r, e, 6]	110,000 [6]
Grand total[e]	344,000 [r]	357,000 [r]	333,000 [r]	360,000 [r]	400,000

[e]Estimated. [r]Revised.
[1]Grand totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes data available through September 16, 2015.
[3]In addition to the countries listed, France produced andalusite and Brazil and China produced kyanite and related minerals. Output is not reported quantitatively, and no reliable basis is available for estimation of output levels.
[4]Does not include synthetic mullite.
[5]Source: Virginia Department of Mines, Minerals and Energy, 2014, DMM report TNPR.06—Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed April 2, 2014, via http://www.dmme.virginia.gov/DMM/miningdata.shtml).
[6]Estimated using several prior-years' output as reported to the Virginia Department of Mines, Minerals and Energy adjusted based upon changes in worker-hours reported to the U.S. Department of Labor's Mine Safety and Health Administration.