



2012 Minerals Yearbook

KYANITE AND RELATED MINERALS

KYANITE AND RELATED MINERALS

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The United States continued to be the world's leading producer of kyanite and mullite (calcined kyanite), with a combined estimated production of 98,500 metric tons (t) in 2012 (Virginia Department of Mines, Minerals and Energy, 2013) (tables 1, 7). Domestic production of synthetic mullite (calcined aluminous and siliceous minerals and clays) was estimated to be 40,000 t. Andalusite was mined and marketed as part of a mineral mixture at one U.S. operation, but data were withheld to avoid disclosing company proprietary data. No U.S. production of sillimanite was reported. Refractory products continued to be the dominant end use for kyanite and related minerals. Of the refractory usage, an estimated 65% was in ironmaking and steelmaking, the remainder in the manufacture of chemicals, glass, nonferrous metals, and other materials. World production of kyanite and related minerals was estimated to be at least 408,000 t (tables 1, 7).

This report includes information on the polymorphs andalusite, kyanite, and sillimanite, all of which have the same chemical formula, Al_2SiO_5 , and on mullite (calcined and synthetic) that has the chemical formula $\text{Al}_6\text{Si}_2\text{O}_{13}$. Andalusite, kyanite, and sillimanite are the primary minerals of what is referred to as the kyanite group minerals, especially in the United States where kyanite is prevalent, but are also known collectively as the sillimanite minerals where that mineral is more common, particularly in India. Of these aluminosilicate minerals, mullite is preferred because of its superior refractory (heat-resistant) properties (it is stable to 1,800 °C) and high strength, but it is rarely found in nature in minable quantities. Each of the kyanite group minerals is composed of 63% alumina and 37% silica, which when "calcined" or heated to 1,250 to 1,500 °C, and depending upon which mineral, grain size, impurities present, and rate of temperature increase, they convert to about 88% mullite and 12% silica. In the United States, the term mullite generally refers to mullite that is produced by calcining kyanite (to a temperature of 1450 °C or more), whereas synthetic mullite typically refers to mullite made by calcining certain mixtures of alumina- and silica-containing minerals and materials, including bauxite and kaolin, at similarly high temperatures.

Production

In 2012, an estimated 98,500 t of kyanite and mullite was produced in the United States, up slightly from production in 2011 (Virginia Department of Mines, Minerals and Energy, 2013) (tables 1, 7). The estimated value of kyanite and mullite produced in the United States in 2012 was about \$31 million (table 1).

The Kyanite Mining Corp. (KMC) has mined the kyanite deposits in central Virginia since 1945 and was the sole U.S. producer of kyanite and kyanite-derived mullite in 2012.

The company operated two open pit mines in Buckingham County, the East Ridge Mine and the Willis Mountain Mine, and beneficiated the ore into a marketable kyanite concentrate, an estimated 30% to 35% of which then was converted by calcination into mullite at its Gieseke Plant (East Ridge), at Dillwyn, VA. Actual production data for KMC reported to the U.S. Geological Survey (USGS) were withheld to avoid disclosing company proprietary data. 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. Reserves at the two Virginia mines were estimated by KMC as sufficient for 50 to 75 years at current output levels. If operated on a 24-hour basis, KMC's annual integrated mining and processing capacity was more than 135,000 t of commercial-grade kyanite concentrate, a portion of which could be calcined to more than 45,000 t of mullite (Kyanite Mining Corp., 2006).

In an ongoing legal dispute regarding KMC corporate management brought by minority stockholders, the Virginia State Supreme Court in September left intact liquidation proceedings of the Disthene Group, Inc., the holding company for KMC. In August, the Fairfax County Circuit Court ruled that company assets had been mismanaged and minority shareholders treated unfairly and subsequently ordered the liquidation of KMC. The circuit court assigned a Maryland-based consulting firm, Protiviti, Inc., to sell KMC's assets, reputedly worth \$200 million. Day-to-day operation of the mine continued with current employees. Awaiting a decision concerning an appeal filed with the Virginia Supreme Court near yearend, liquidation activities remained pending (Hughes, 2012).

C-E Minerals (part of Imerys SA Group) produced synthetic mullite products from calcined bauxitic kaolin near Americus, GA, including products that contained 65%, 77%, and 87% mullite (C-E Minerals, 2012). Estimated U.S. production of synthetic mullite in 2012 was about 40,000 t with an estimated value of about \$12 million (table 1).

Piedmont Minerals Co., Inc. (Hillsborough, NC) mined a deposit of andalusite combined with pyrophyllite and sericite. The company sold products containing blends of the three minerals to producers of ceramics and refractories.

Consumption

As much as 90% of kyanite and related minerals are used in the production of refractories and refractory products, about two-thirds of this is used in the production of iron and steel. Kyanite increases in volume, depending upon particle size, typically by 3% for very fine particles (325 mesh) to as much as 25% for coarser particle fractions (35 mesh) when calcined to mullite and thus can be used as a raw concentrate in a refractory

mixture to offset the shrinkage on firing of other components, especially clays. Andalusite expands irreversibly by about 4% to 6% when calcined and can be used directly in refractories in its raw state (Lassetter, 2012). In other refractory applications, kyanite concentrate is calcined to mullite and added to refractory mixes if the volume increase of kyanite is not required. Upon further heating, mullite exhibits no further expansion beyond normal thermal expansion. 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).

The iron and steel industry continued to be the leading user of refractories, including those containing kyanite and mullite. World and U.S. crude steel output slowed, increasing by 1.2% and 2.5%, respectively, in 2012 from that of 2011, following increases of about 6% and 7%, respectively, in 2011 from 2010. The leading steel-producing countries, which also would be leading consumers of refractory products, include China, accounting for 46.3% of the world's steel production in 2012; Japan, 6.9%; the United States, 5.7%; India, 5.0%; Russia, 4.6%; the Republic of Korea, 4.5%; and Germany, 2.8%. These countries accounted for nearly 76% of world steel production in 2012 (World Steel Association, 2013a). Other prominent refractories users were the nonferrous metal and glass industries.

Other end uses of kyanite and related materials included abrasive products such as brake shoes and pads and 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

Published prices for kyanite serve only as a general guide. For raw kyanite concentrate and calcined kyanite (mullite), largely dependent on grade sizing, U.S. domestic prices increased slightly. Prices for imported andalusite rose by 2% to 5% in early 2012 and were unchanged to yearend. The increase resulted from increased refractory industry demand, in part because refractory companies made efforts to substitute andalusite for bauxite in their refractory products, and also because Imerys increased prices on its imported andalusite. The value of andalusite, (South Africa) 57% to 58% alumina in 2,000-metric-ton-bulk lots, increased to \$311 to \$370 per ton from \$311 to \$358 per ton in 2011. The value of andalusite, (South Africa) f.o.b. (free on board) 55% to 59% alumina in 2,000-metric-ton-bulk lots, European port, increased to \$463 to \$562 per ton from \$466 to \$540 per ton in 2011 (Industrial Minerals, 2012; Lismore, 2012) (table 2).

Foreign Trade

Nearly 45% of U.S. kyanite and mullite (calcined kyanite or synthetic, unspecified) output was exported in 2012 (tables 1, 3, and 4). Exports of kyanite (excluding mullite) shipped to more than 30 countries decreased 4.4% overall to 36,400 t, valued at \$11.7 million (table 3). Exports of mullite shipped to about 30 countries increased by 17% to 24,800 t, valued at \$9.9 million (table 4). Germany, China, Japan, Netherlands, and the Republic of Korea, combined, received 53% of kyanite exports, and 85% of mullite exports went to Canada, Germany, Mexico, and the United Kingdom, in descending orders of quantity (tables 3, 4).

U.S. imports of kyanite group minerals (thought to be mostly andalusite) decreased by 39% to 3,260 t, valued at \$1.61 million in 2012 (tables 1, 5). Of these 2012 imports, 78% was from South Africa, 11% from Peru, and nearly 6% from France (table 5). Imports of mullite (calcined kyanite or synthetic, unspecified) decreased by 14% to 6,280 t, but the value increased to nearly \$9.2 million (table 6). The majority of mullite imports were from Canada and Germany, with 57% and 25%, respectively, and 8% from Brazil and 6% from Hungary.

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 [sintered mullite and (or) fused mullite] included Brazil, China, Germany, Hungary, and Japan (Taylor, 2005).

The continued growth in the world's steel industry and the sporadic 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 in China, Peru, and South Africa continued to expand operations, and a new mine was under development in Spain (Feytis, 2011a). Andalusite Resources (Pty.) Ltd. of South Africa worked with researchers to adjust refractory compositions to assist customers in changing from bauxite to andalusite (Modiselle, 2012, p. 204). Conversely, production began at low-iron, refractory-grade bauxite mines in Brazil, Guyana, and Russia, potentially representing new 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. Damrec SA (a subsidiary of Imerys) reported increased production capacity to 40,000 metric tons per year (t/yr) at its Yilong Andalusite Mineral Co. facilities in the Xinjiang Region of northwestern China (Dyson, 2012).

Guyana.—In March, Chinese-owned Bosai Minerals Group Guyana Inc. announced plans to invest more than \$100 million to diversify and expand its bauxite operations at Linden, \$57 million of which was to construct a third kiln to produce synthetic mullite for the glass and steel industries and proppants for hydraulic fracturing, \$40 million to expand the mine, and more than \$6 million to resolve the Linden operation's longstanding dust pollution problems. The construction of dust collector systems on the two existing kilns was more than 50% complete by midyear, serving to improve the mine and local

environment and trap valuable bauxite dust previously going up the smokestacks (Marshall, 2012).

Peru.—In northwestern Peru, Andalucita S.A. (sister company of Refractorios Peruanos S.A.) continued development and production from its andalusite resources within unconsolidated sand and gravels of the Tablazo Mancora flood plain and evaluation of other mineral resources in northwestern Peru. In mid-2012, Andalucita, located 20 kilometers from the deep sea port of Piata, increased its production capacity rate for andalusite ore from 15,000 t/yr to 25,000 t/yr and revised plans to increase that rate to 48,000 t/yr by mid-2013. A primary andalusite grade of 59% to 60% Al_2O_3 and a maximum of 0.85% iron oxide was produced for refractory consumers. About 50% was sold for use in steel manufacturing and 50% for cement, glass, and aluminum products, with a high percentage going to customers in Europe and the Americas. The company also began production of a coarser 3 to 8-millimeter andalusite product mainly for use in castables. Imerys separately owned an extension of the same andalusite deposit, thought to have reserves of similar tonnage to Andalucita's, but had yet to develop a mine (Feytis, 2011a; Dyson, 2012).

Latin Resources Ltd. (Perth, Australia) announced significantly increased resource estimates for its Guadalupito iron and mineral sands project. The company stated that the project's 40-meter-thick Los Conchales zone resource graded 6.1% heavy minerals, dominated by andalusite (21% to 24%) and magnetite (22% to 25%). An estimated 60% of the andalusite was found as liberated particles. The Los Conchales resource is more than 90% below the water table, making it amenable to dredging if a mine is developed at the deposit (Ollett, 2013).

South Africa.—Andalusite Resources (Pty.) Ltd. mined andalusite near capacity at its Maroeloesfontein Mine in Thabazimbi, Limpopo Province. In 2012, the company achieved a production rate of about 72,000 t/yr at midyear, and depending upon market growth, expected to expand to 80,000 to 100,000 t/yr by yearend 2012 and as much as 290,000 t/yr by 2014. Andalusite Resources revised expected mine life to 60 years at 70,000 t/yr, and to 80 years for its additional reserves. The company's main markets were in China, Europe, India, and South Africa (Feytis, 2011a; Dyson, 2012).

Damrec SA (a subsidiary of Imerys) produced more than 70% of the andalusite in South Africa and planned to increase output by 30% within the next 2 years. Rhino Minerals (Pty.) Ltd. operated three of Damrec's four South African mines: the Annesley, Havercroft, and Rhino Mines in Limpopo Province. Samrec (Pty.) Ltd. operated the fourth mine, the Krugerspost Mine near Lydenburg, Mpumalanga Province (Modiselle, 2012, p. 203).

Carborundum Universal Ltd. (through its subsidiary CUMI International Ltd., Cyprus) entered into a binding agreement to purchase RHI Isithebe Pty. Ltd. of South Africa, producer of 30,000 t/yr of fused mullite and zircon mullite. The plant was to be renamed Thugela Refractories, Isithebe and it would focus on its electromineral and refractory business (Ollett, 2012).

Spain.—Picobello Andalucita SL, which was permitted to develop its Picobello andalusite project, 15 km from El Ferrol port northwest of Galicia and nearly adjacent to the Fragas

do Eume National Park, proceeded with mine development. The company planned to extract ore to a depth of 20 to 40 meters (m) during a 15-year mine life at a rate of 65,000 t/yr, of which 50,000 t/yr would be refractory grade andalusite and the remainder used for metallurgical applications. Development of the mine was a source of continuing contention owing to its proximity to the park (Feytis, 2011a).

Outlook

In the United States, apparent consumption of steel, the refractories market's leading industrial customer, was projected to increase by 2.7% in 2013 and by 2.9% in 2014, following an 8.4% increase from 2011 to 2012 that resulted mostly from growth in the automotive and energy sectors. Future increases assume a continuation of the slow, yet steady, construction sector recovery (World Steel Association, 2013b).

World steel consumption growth is expected to stabilize, increasing by 2.9% in 2013 and by 3.2% in 2014, after a 1.2% increase in 2012, much of which resulted from the Eurozone crisis. Because of efforts by the Chinese Government to moderate growth, especially in its real estate sector, and to rebalance its economy, China's steel consumption was expected to increase by 3.5% in 2013 and 2.5% in 2014 (World Steel Association, 2013b). China's 2-billion-metric-ton-per-year cement industry also was in need of sources of raw materials like the kyanite group minerals for the manufacture of refractory products. Continued growth was expected in China's cement industry, as evidenced by the building of a significant number of new kilns—all of which are refractory lined.

Natural raw aluminosilicate minerals, such as andalusite and kyanite, have become increasingly sought after as alternative materials to bauxite in certain refractory applications. The Chinese Government reduced its export license quotas for bauxite in 2012 to 700,000 t from 830,000 t in 2011, decreasing its availability for export. Rising production and energy costs for bauxite ore and the nearly exclusive licensing of metallurgical-grade bauxite mines by the Chinese Government since 2003 may serve to lessen the availability of refractory-grade bauxite (Saxby, 2013b). The dependence on bauxite developed during the past two decades may lessen for many countries depending on, (1) the ability of refractories producers to use or substitute andalusite, kyanite, and similar raw materials for bauxite in refractory applications, (2) the quantities and prices of andalusite and similar materials produced at new and expanded mines, and (3) and the quantities of bauxite available for mullite production from such projects as the mine expansion and kiln construction in Guyana. Additionally, inexpensive refractory-grade bauxite that becomes available for export from new or future mines in Brazil, Guyana, and Russia may become sources of competition for andalusite and kyanite in some applications, such as steel furnaces and industrial boilers (Saxby, 2013a). Although other refractory materials are available as substitutes for bauxite in various applications, the kyanite minerals group of aluminosilicates commonly have better thermo-mechanical properties than many other materials, although they may contain slightly less alumina than bauxite. When compared to higher alumina raw materials, andalusite is expected to be an increasingly attractive alternative because it requires firing at a lower temperature than most other

alternative materials when used to produce a dense and shrinkage resistant refractory aggregate. This reduces energy consumption and greenhouse gas emissions (Feytis, 2011b). For durable refractories, technological advances are likely to include increased use of synthetic mullite (Feytis, 2011a). Available andalusite supplies are expected to increase owing to mine expansions and new mines in France, Peru, South Africa, and Spain.

The Asia-Pacific region is the largest market for refractories, and China is anticipated to remain the leading single market, comprising the majority of global consumption. Above-average growth is expected to take place in India. For the next several years, increases in the market for refractories are likely to take place in Eastern Europe, North America, and Western Europe, with Eastern Europe having the highest growth of these regions. North America may have continued refractory market growth, resulting from recovery in manufacturing and steel producing, but in the longer term, North American growth is expected to lag behind the global average, as a result of a shift in steel production to developing countries. Finding and procuring a consistent supply of refractory raw materials, especially at affordable prices, is likely to remain a challenge for refractory producers, particularly those in Europe and the Western Hemisphere (Deneen, 2011).

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GENERAL SOURCES OF INFORMATION

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Other

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TABLE 1
SALIENT U.S. KYANITE AND RELATED MINERALS STATISTICS¹

		2008	2009	2010	2011	2012
Production						
Kyanite:						
Quantity ²	metric tons	97,200	71,000	93,400 ^r	98,200 ^r	98,500
Value ^c	thousands	\$26,000	\$21,000	\$29,000 ^r	\$31,000 ^r	\$31,000
Synthetic mullite:^c						
Quantity	metric tons	40,000	40,000	40,000	40,000	40,000
Value	thousands	\$10,000	\$10,000	\$12,000	\$12,000	\$12,000
Exports:³						
Quantity	metric tons	36,100	25,800	37,900	38,100	36,400
Value ⁴	thousands	\$10,400	\$7,510	\$11,300	\$11,600	\$11,700
Imports for consumption:³						
Quantity	metric tons	5,580	4,880	2,180	5,390	3,260
Value ⁵	thousands	\$1,930	\$2,060	\$938	\$2,230	\$1,610
Consumption, apparent ⁶	metric tons	107,000	90,100	97,200	105,000	105,000
World, production ^{c, 7}	do.	423,000 ^r	340,000 ^r	391,000 ^r	393,000 ^r	408,000

^cEstimate. ^rRevised. do. Ditto.

¹Data are rounded to no more than three significant digits.

²Source: Virginia Department of Mines, Minerals and Energy, 2013, DMM report TNPR.06: comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed April 2, 2013, via <http://www.dmme.virginia.gov/DMM/miningdata.shtml>.)

³Source: U.S. Census Bureau.

⁴Free alongside ship (f.a.s.) value.

⁵Customs value.

⁶Includes kyanite and synthetic mullite production + imports – exports.

⁷In addition to the countries in table 6, a number of other countries produce kyanite and related materials, but output is not reported quantitatively, so these total world output levels are a minimum.

TABLE 2
PRICES OF KYANITE AND RELATED MINERALS IN 2012

(Dollars per metric ton)

	Price
Andalusite, South Africa, 57% to 58% alumina, 2,000-metric-ton bulk lots	311–370
Andalusite, free on board, South Africa, 55% to 59% alumina, 2,000-metric-ton bulk lots, European port	463–562
Kyanite, United States, ex-works, raw, 54% to 60% alumina	247–353
Kyanite, United States, ex-works, calcined (mullite), 54% to 60% alumina, 22-ton lots	411–484

Source: Industrial Minerals, December 2012, p. 61–62.

TABLE 3
U.S. EXPORTS OF KYANITE, BY COUNTRY^{1,2}

Country	2011		2012	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Argentina	124	\$34	140	\$37
Australia	676 ^r	204	425	130
Belgium	4,450	1,340	2,640	812
Canada	2,580	842	2,410	816
China	3,400	884	3,960	1,100
Egypt	340	80	280	70
Germany	5,640	1,670	5,700	1,820
Hungary	262	80	264	77
India	282	81	481	122
Indonesia	80	18	118	31
Italy	2,130	585	1,650	454
Japan	3,850	1,360	3,510	1,270
Korea, Republic of	2,710	765	2,740	942
Malaysia	648	158	220	53
Mexico	518	173	2,300	774
Netherlands	3,230	950	3,360	1,030
Poland	352	92	352	90
South Africa	178	138	386	299
Spain	482	146	420	118
Sweden	1,120	303	928	263
Taiwan	707	186	638	231
Thailand	413	99	360	91
Turkey	547	127	682	169
United Kingdom	1,850	649	2,040	721
Other	1,530 ^r	623 ^r	433	159
Total	38,100	11,600	36,400	11,700

^rRevised.

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

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

³Free alongside ship (f.a.s.) value.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS OF MULLITE, BY COUNTRY^{1,2}

Country	2011		2012	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Belgium	633	\$292	389	\$182
Brazil	200	82	340	125
Canada	12,900	3,520	10,500	2,990
China	1,200	332	1,950	596
Germany	975	474	3,870	2,230
Hungary	132	55	132	55
Italy	325	131	64	27
Mexico	2,870	1,300	3,630	1,720
Netherlands	153	58	519	287
United Kingdom	1,500	733	3,090	1,530
Other	267	107	319	150
Total	21,200	7,080	24,800	9,890

¹Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite (calcined kyanite or synthetic).

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

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	2011		2012	
	Quantity (metric tons)	Value ⁴ (thousands)	Quantity (metric tons)	Value ⁴ (thousands)
France	703	\$360	183	\$137
Peru	342	130	342	155
South Africa	4,320	1,740	2,530	1,220
Other	20	7	208	103
Total	5,390	2,230	3,260	1,610

¹Most material is thought to be andalusite.

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

³Data are rounded to no more than three significant digits; may not add to totals shown.

⁴Customs value.

Source: U.S. Census Bureau.

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

Country	2011		2012	
	Quantity (metric tons)	Value ³ (thousands)	Quantity (metric tons)	Value ³ (thousands)
Brazil	761	\$952	481	\$439
Canada	2,680	2,160	3,600	3,360
China	1,400	434	223	89
Germany	2,210	3,260	1,560	4,720
Hungary	193	244	397	489
Japan	91	119	9	39
Other	9	15	11	20
Total	7,340	7,180	6,280	9,160

¹Harmonized Tariff Schedule of the United States code 2508.60.0000 for mullite, calcined kyanite or synthetic, unspecified.

²Data are rounded to three significant digits; may not add to totals shown.

³Customs value.

Source: U.S. Census Bureau.

TABLE 7
KYANITE AND RELATED MINERALS: WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country and commodity ³	2008	2009	2010	2011	2012 ^c
Brazil, kyanite ^c	600	600	600	600	600
France, andalusite ^c	65,000	65,000	65,000	65,000	65,000
India:					
Kyanite	4,982 ^r	4,839 ^r	5,513 ^r	5,500 ^{r, c}	5,600
Sillimanite	38,469 ^r	33,699 ^r	37,183 ^r	37,000 ^{r, c}	38,000
Total	43,451 ^r	38,538 ^r	42,696 ^r	42,500 ^{r, c}	43,600
Peru, andalusite	--	--	262	276	375 ⁴
South Africa, andalusite	216,667	165,217	189,185 ^r	186,242 ^r	200,000
United States, kyanite ^{4, 5, 6}	97,200	71,000	93,400 ^r	98,200 ^r	98,500
Grand total ^c	423,000 ^r	340,000 ^r	391,000 ^r	393,000 ^r	408,000

^cEstimated. ^rRevised. -- Zero.

¹World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through July 8, 2013.

³In addition to the countries listed, Australia and China produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

⁴Reported figure.

⁵Excludes synthetic mullite.

⁶Virginia Department of Mines, Minerals and Energy, 2013, DMM report TNPR.06: Comparison of annually reported tonnage data: Charlottesville, VA, Virginia Department of Mines, Minerals and Energy. (Accessed April 2, 2013, via <http://www.dmme.virginia.gov/DMM/miningdata.shtml>.)