



2015 Minerals Yearbook

DIAMOND, INDUSTRIAL [ADVANCE RELEASE]

DIAMOND, INDUSTRIAL

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In 2015, U.S. synthetic diamond production was estimated to be 119 million carats with an estimated value of \$117 million. No natural industrial diamond mining took place in the United States but an estimated 63.7 million carats of used industrial diamond (natural and synthetic) worth about \$3.9 million (table 1) was recycled (secondary production). U.S. imports of natural and synthetic industrial diamond bort, dust, grit, powder, and stone totaled 276 million carats valued at \$77.5 million, and exports totaled 140 million carats valued at \$67.5 million. The estimated U.S. apparent consumption of industrial diamond bort, dust, grit, powder, and stone totaled 319 million carats with an estimated value of \$131 million. Total industrial diamond output worldwide was estimated by the U.S. Geological Survey (USGS) to be 4.43 billion carats valued at between \$1.65 billion and \$2.50 billion. This was the combination of more than 56.5 million carats of natural industrial diamond and about 4.4 billion carats of synthetic industrial diamond (table 1).

Diamond is best known as a gemstone, but some of its unique properties make it ideal for many industrial and research applications. Current information on gem-grade diamond can be found in the USGS Minerals Yearbook, volume I, Metals and Minerals, chapter on gemstones. Diamond that does not meet gem-quality standards for clarity, color, shape, or size is used as industrial-grade diamond. Total production and consumption quantities and values in table 1 are estimated based on past and current reported data. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were calculated using unrounded data.

Production

The USGS conducts an annual survey of domestic synthetic industrial diamond producers and a survey of U.S. firms that recover diamond wastes. Production quantities and values for the nonreporting companies were estimated based on industry production trends, reports from some producers and other industry sources, and discussions with consultants within the industrial diamond industry. The USGS does not conduct surveys of domestic producers of polycrystalline diamond (PCD) or chemical vapor deposition (CVD) diamond for quantity or value of annual production.

During 2015, the United States was one of the world's leading producers of synthetic industrial diamonds. The United States accounted for an estimated output of 119 million carats valued at more than \$117 million. Only two U.S. companies produced synthetic industrial diamond during the year—Microdiamant USA, Inc. (Smithfield, PA) and Sandvik Hyperion (Worthington, OH). By type, primary production was the combination of 39.6 million carats of diamond bort, dust, grit, and powder

valued at \$20.8 million and 79.2 million carats of diamond stone valued at \$96.3 million.

In 2015, at least eight U.S. companies also manufactured PCD from synthetic diamond grit and powder. These companies were Dennis Tool Co. (Houston, TX), Novatek Inc. (Provo, UT), Precorp Inc. (Provo), Sandvik Hyperion, Sii MegaDiamond Inc. (Provo), Tempo Technology Corp. (Somerset, NJ), US Synthetic Corp. (Orem, UT), and Western Diamond Products LLC (Salt Lake City, UT).

During 2015, an estimated 63.7 million carats of used industrial diamond (natural and synthetic) worth about \$3.9 million (table 1) was recycled (secondary production) in the United States. By type, secondary production was made up of 63.5 million carats of bort, grit, dust and powder valued at \$3.4 million and 185,000 carats of diamond stone valued at \$463,000. Recycling firms recovered most of this material from used diamond drill bits, diamond tools, and other diamond-containing wastes. Additional diamond was recovered during the year from residues generated in the manufacture of PCD.

The recovery and sale of industrial diamond was the principal business of three U.S. companies in 2015—Industrial Diamond Laboratory, Inc. (Bronx, NY), International Diamond Services Inc. (Houston, TX), and National Research Co. (Chesterfield, MI). In addition to these companies, other domestic firms may have recovered industrial diamond in smaller secondary operations.

Since the 1950s, when scientists manufactured the first synthetic bits of diamond grit using a high-pressure, high-temperature (HPHT) method, this method of growing diamonds has become relatively commonplace in the world as a technology for synthetic diamond production. Diamonds of 1 carat or more are harder to manufacture because, at that size, it is difficult to consistently produce diamonds of high quality, even in the controlled environment of a laboratory using the HPHT method. After more than 50 years of development, several synthetic diamond companies were able to produce relatively large high-quality industrial diamonds that equaled those produced from mines.

In the early 2000s, technology was developed for a method for growing single, extremely pure diamond crystals by CVD. The CVD technique transforms carbon into plasma, which is then precipitated onto a substrate as diamond. CVD had been used for more than a decade to cover large surfaces with microscopic diamond crystals, but in developing this process, synthetic diamond producers discovered the temperature, gas composition, and pressure combination that resulted in the growth of a single diamond crystal and were able to produce synthetic stones that ranged from 1 to 2 carats.

During 2015, Scio Diamond Technology Corp. (Greenville, SC) increased its capacity to produce colorless

single-crystal diamonds at a higher quality and volume than the previous year. Scio Diamond used CVD technology to produce synthetic single-crystal diamond stones that ranged from 3 to 5 carats for finishing into 1- to 2-carat diamond stones for jewelry. Single-crystal diamond stones also were sliced and shaped for use in industrial applications. Scio Diamond prefers to call their diamonds “cultured” rather than synthetic, referring to the fact that the diamonds are grown much like a cultured pearl is grown (Scio Diamond Technology Corp., 2014, 2015a, b).

No commercial diamond mines operated in the United States during 2015. The last commercially operated diamond mine in the United States closed in 2002 and was fully reclaimed.

Consumption

Diamond is the hardest known material and has the highest thermal conductivity of any material at room temperature. Diamond is more than twice as hard as its nearest competitors, cubic boron nitride and silicon nitride. Because of its hardness, diamond has been used for centuries as an abrasive in cutting, drilling, grinding, and polishing. Industrial-grade diamond continues to be used as an abrasive for many applications. Even though it has a higher unit cost than alternative abrasive materials, diamond has proven to be more cost effective in many industrial processes because it cuts faster and lasts longer than alternatives. Diamond also has chemical, electrical, optical, and thermal characteristics that make it the best material available to industry for wear- and corrosion-resistant coatings, special lenses, heat sinks in electrical circuits, wire drawing, computing, and other advanced technologies.

Both natural and synthetic diamonds have industrial uses. Synthetic industrial diamond is superior to its natural diamond counterpart because its properties can be tailored to specific applications, and it can be produced in large quantities.

The United States remained the world’s leading market for industrial diamond in 2015. Based on production estimates and trade data, U.S. apparent consumption of industrial diamond during the year decreased by 54% in quantity to an estimated 319 million carats and decreased slightly in value to \$131 million compared with 690 million carats valued at \$134 million in 2014 (table 1). Apparent consumption was the combination of 32.3 million carats of natural industrial diamond valued at \$21.8 million and 287 million carats of synthetic industrial diamond valued at \$109 million. By type, apparent consumption was the combination of 238 million carats of diamond bort, dust, grit, and powder valued at \$11.4 million and 80.7 million carats of diamond stone valued at \$120 million.

The major consuming industrial sectors of industrial diamond cutting and drilling tools and abrasives in the United States during 2015 were construction, machinery manufacturing, mining services (exploration drilling for minerals, natural gas, and oil), stone cutting and polishing, and transportation systems (infrastructure and vehicles). Within these sectors, highway building and repair and stone cutting, combined, accounted for the majority of the consumption of industrial diamond. Research and high-technology uses included close-tolerance machining of ceramic parts for the aerospace industry, heat sinks in electronic circuits, lenses for laser radiation equipment, polishing

of silicon wafers and disk drives, and other applications in the computer industry.

Diamond tools have numerous industrial functions. Diamond drilling bits and reaming shells are used principally for extraction of minerals, natural gas, and oil. Other applications of diamond bits and reaming shells include foundation testing, inspecting concrete, and masonry drilling. The primary uses of point diamond tools are for dressing and truing grinding wheels and for boring, cutting, finishing, and machining applications. Beveling glass for automobile windows is another application. Cutting dimension stone and cutting and grooving concrete in highway reconditioning are the main uses of diamond saws; other applications include cutting composites and forming refractory shapes for furnace linings. Very fine diamond saws are used to slice brittle metals and crystals into thin wafers for electronic and electrical devices. Diamond wire dies are essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys. The primary uses of diamond grinding wheels include edging plate glass, grinding dies, grinding parts for optical instruments, and sharpening and shaping carbide machine tool tips.

Two types of natural diamond are used by industry—diamond stone (generally larger than 60 mesh, 250 micrometers) and diamond bort, dust, grit, and powder (smaller, fragmented material). Diamond stone is used mainly in drill bits and reaming shells used by mining companies; it also is incorporated in single- or multiple-point diamond tools, diamond saws, diamond wheels, and diamond wire dies. Diamond bort, dust, grit, and powder are used for drill bits and as a loose grain abrasive for polishing. Other tools that incorporate natural diamond include bearings, engraving points, glass cutters, and surgical instruments.

Synthetic diamond grit and powder are used in diamond grinding wheels, saws, impregnated bits and tools, and as a loose abrasive for polishing. Diamond grinding wheels can be as large as 1 meter in diameter.

Loose dust and powders made with synthetic diamond for polishing are used primarily to finish cutting tools, drill bits, gemstones, jewel bearings, optical surfaces, reaming shells, silicon wafers, and wire-drawing dies for computer chips. Hundreds of other products made from ceramics, glass, metals, and plastics also are finished with diamond powders.

Consumption quantity and value data are not available for PCD or for CVD diamond. Two types of PCDs used by industry are polycrystalline diamond compacts (PDCs) and polycrystalline diamond shapes (PDSs). The use of PDCs and PDSs continues to increase for many of the applications cited above, including some of those that employ natural diamond. PDCs and PDSs are used in the manufacture of single- and multiple-point tools, and PDCs are used in a majority of the diamond wire-drawing dies.

Since its introduction in the mid-1980s, CVD diamond has seen strong growth and has been increasingly accepted by multiple industries as an enhanced material of choice owing to its properties of exceptional strength, durability, stiffness, high thermal conductivity, and electrical isolation.

Early applications for CVD diamond focused largely around thin- and thick-film PCD for cutting tools and dressing

applications because of the mechanical properties of diamond. Newer applications that take advantage of CVD diamond's mechanical properties include wear parts, such as watch gears and chemical mechanical polishing pad conditioners. Diamond has tremendous potential for electronics applications because it significantly improves upon current strategies for thermal management while remaining highly cost competitive with other approaches. CVD diamond is used in microelectronic components, such as high-speed processors, medical devices, wide bandgap radio frequency (RF) devices, power conversion devices, and opto-electronic devices (light-emitting diodes, laser diodes) that generate exceptionally high heat densities requiring innovative approaches to thermal management. Diamond coatings are increasingly being used in these applications because the thermal conductivity of diamond is 10 times that of silicon. In the manufacture of semiconductors, wafer-scale diamond offers enhanced mechanical properties, such as significantly higher stiffness, strength, hardness, thermal conductivity, and chemical inertness, compared with silicon and most other commonly used thin-film materials. Micro-electro-mechanical systems (MEMS), such as RF MEMS resonators, have design needs that can be met by the use of diamond as a base material because of its very high resistance to being deformed elastically when a force is applied and because of its durability in harsh environments. Researchers are investigating the use of boron-doped diamond (BDD) electrodes for water treatment owing to diamond's potential as an environmentally friendly, high-performance electrode material. BDD electrodes have many characteristics that make them ideal for eliminating organic contaminants from water (Zimmer, 2011).

Historically, diamond has been perceived as an expensive material. Advances in CVD diamond manufacturing, such as the development of microwave carbon plasma technology and the development of higher throughput hot filament CVD diamond reactors, have significantly reduced diamond costs. This led many industries to revisit development activities and actively pursue the use of CVD diamond for an increasing number of applications (Zimmer, 2011).

In addition to the existing opportunities for their cultured diamond gemstones, Scio Diamond was developing the use of single-crystal CVD diamond materials in high-voltage power switches, lasers, quantum communications and computing, and water treatment and purification. Scio Diamond reported that these projects could translate into high-value market opportunities and high-volume technology applications (Scio Diamond Technology Corp., 2012).

Prices

Natural and synthetic industrial diamonds differ significantly in price. Natural industrial diamond normally had a more limited range of values, from about \$0.50 per carat for bort-size material to about \$2.50 to \$10 per carat for most stones, with some larger stones having sold for several hundred dollars per carat. Prices of synthetic diamond vary according to size, shape, crystallinity, and the absence or presence of metal coatings. In general, prices for synthetic diamond for grinding and polishing ranged from as low as \$0.26 per carat to \$2.65 per carat. Strong and blocky material for sawing and drilling sold for \$2.35 to \$4.00 per

carat. Large, synthetic crystals with excellent structure for specific applications sold for several hundred dollars per carat. During 2015, U.S. imports of all types of industrial diamond had an average unit value of \$0.28 per carat. These imports were a combination of diamond bort, dust, grit, and powder (natural and synthetic) that had an average value of \$0.20 per carat and diamond stone (natural and synthetic) that had an average value of \$17.46 per carat. These average unit values for imported diamond bort, dust, grit, and powder (natural and synthetic) were lower than the average reported prices for the same size fractions of domestically produced diamond listed above.

Foreign Trade

The United States continued to lead the world in industrial diamond trade in 2015; imports were received from 32 countries and exports and reexports were sent to 27 countries (tables 2–5). Although the United States has been a major producer of synthetic diamond for decades, expanding domestic markets have become more reliant on foreign sources of industrial diamond in recent years. U.S. markets for natural industrial diamond have always been dependent on imports and secondary recovery operations because natural diamond has not been produced domestically.

During 2015, U.S. imports of industrial-quality diamond stones (natural and synthetic) decreased by 39% from those of 2014 to 1.3 million carats valued at \$22.9 million (table 2). Imports of natural diamond bort, dust, grit, and powder increased by 54% from those of 2014 to 5.3 million carats valued at \$2.4 million. Imports of synthetic diamond bort, dust, grit, and powder decreased by 60% from those of 2014 to 270 million carats valued at \$52.2 million owing to a 66% decrease of imports from China (table 3).

Reexports accounted for a significant portion of total exports; therefore, exports and reexports are listed separately in tables 4 and 5 so that U.S. trade and consumption can be calculated more accurately. During 2015, the United States did not export industrial diamond stones, unchanged from 2014. U.S. reexports of industrial diamond stone decreased by 31% from those of 2014 to 569,000 carats valued at \$21.5 million and an average value of \$37.79 per carat (table 4). U.S. exports of industrial diamond bort, dust, grit, and powder (natural and synthetic) decreased by 14% from those of 2014 to 140 million carats valued at \$67.5 million and an average value of \$0.48 per carat. Reexports of industrial diamond bort, dust, grit, and powder (natural and synthetic) increased by 34% from those of 2014 to 17.3 million carats valued at \$7 million and an average value of \$0.41 per carat (table 5). Trade quantity and value data are not available for PCD or for CVD diamond.

World Industry Structure

Global natural diamond production increased slightly during 2015 to 127 million carats from 125 million carats in 2014. The world's rough diamond producers were as follows: Russia, producing 41.9 million carats or 33% of total world production; Botswana, with 20.8 million carats (16%); Congo (Kinshasa), with 16.0 million carats (13%); Australia, with 13.6 million carats (11%); Canada, with 11.7 million carats (9.2%); Angola,

with 9.02 million carats (7.1%); South Africa, with 7.22 million carats (5.7%); Zimbabwe, with 3.49 million carats (2.7%); and other countries, with 3.73 million carats (2.9%) (table 6). Of the 127 million carats of total natural diamond production, 70.9 million carats (56% of total diamond production) was gemstone diamond and 56.5 million carats (44% of total diamond production) was industrial diamond. Total combined natural and synthetic industrial diamond output worldwide was estimated by the USGS to be about 4.43 billion carats (table 1). In 2015, rough diamond production was valued at more than \$17.5 billion, a decrease of 10% compared with that of 2014 (De Beers Group UK Ltd., 2016, p. 28).

During 2015, OJSC ALROSA and De Beers Group remained the two leading diamond producers by quantity and value. ALROSA's production was 27% of total global quantity and 25% of total global value; De Beers' production was 20% of total global quantity and 31% of total global value. The third-ranked company was Rio Tinto Ltd., which produced 12% of total global production quantity and approximately 5% of global production value. Some older operating mines expected production costs to increase because of increasingly deep mines, which were more complex and costly to operate, and higher costs for energy and labor (De Beers Group UK Ltd., 2016, p. 11, 26, 28).

In 2002, the international rough diamond certification system, the Kimberley Process Certification Scheme (KPCS), was agreed upon by United Nations (UN) member nations, the diamond industry, and involved nongovernmental organizations to prevent the shipment and sale of conflict diamonds. Conflict diamonds are diamonds that originate from areas controlled by forces or factions opposed to legitimate and internationally recognized Governments and are used to fund military action in opposition to those Governments or in contravention of the objectives of the UN Security Council. The KPCS monitors rough diamond trade in both gemstone and industrial diamond. The KPCS includes the following key elements: the use of forgery-resistant certificates and tamper-proof containers for shipments of rough diamonds; internal controls and procedures that provide credible assurance that conflict diamonds do not enter the legitimate diamond market; a certification process for all exports of rough diamonds; the gathering, organizing, and sharing of import and export data on rough diamonds with other participants of relevant production; credible monitoring and oversight of the international certification scheme for rough diamonds; effective enforcement of the provisions of the certification scheme through dissuasive and proportional penalties for violations; self-regulation by the diamond industry that fulfills minimum requirements; and sharing information with all other participants on relevant rules, procedures, and legislation as well as examples of national certificates used to accompany shipments of rough diamonds. Angola assumed the chair of KPCS from January 1 through December 31, 2015. As of December 31, 2015, the 54 participants represented 81 nations (including the 28 member nations of the European Union counted as a single participant) plus the rough diamond trading entity of Taipei (Taiwan). In July, the temporary suspension of the Central African Republic's exports and imports of rough diamonds was lifted. Venezuela continued its

voluntary suspension of exports and imports of rough diamonds with no indication of when it planned to re-enter the market. The participating nations in the KPCS account for approximately 99.8% of the global production and trade of rough diamonds (Kimberley Process, 2017).

In 2015, natural industrial diamond production was reported from 13 countries (table 6). Natural industrial diamond production worldwide was estimated to be about 56.5 million carats, a 7% increase compared with 52.8 million carats in 2014. Russia was the leading natural-industrial-diamond-producing country with 18.4 million carats or 33% of total world production; followed by Australia, with 13.3 million carats (24%); Congo (Kinshasa), with 12.8 million carats (23%); Botswana, with 6.23 million carats (11%); and Zimbabwe, with 3.14 million carats (6%). These five countries produced 96% of the world's natural industrial diamond (table 6). Synthetic industrial diamond production worldwide was estimated to be more than 4.4 billion carats, a slight decrease compared with that of 2014. China was the leading producing country, followed by the United States, Russia, Ireland, and South Africa, in descending order of quantity. These five countries produced about 98% of the world's synthetic industrial diamond.

In 2015, 97% of the total global combined output of natural and synthetic industrial diamond was produced in China, Ireland, Russia, South Africa, and the United States. Synthetic diamond accounted for more than 99% of global diamond production and consumption. Worldwide diamond exploration spending decreased by 18% in 2015 with 52 companies allocating \$367 million, compared with 48 companies allocating \$447 million during 2014. The diamond share of overall worldwide mineral exploration spending remained 4.2% (SNL Metals Economics Group, 2015, p. 20). In 2015, worldwide average diamond values decreased by 6% to \$108.96 per carat from the 2014 average value of \$116.17 per carat (Danilov, 2016).

World Review

Russia.—Diamond production in Russia was 41.9 million carats during 2015, a 9% increase compared with that of 2014, accounting for 33% of total global production.

The Botuobinskaya Mine in the Nakyen ore field in Yakutia, Russia, was wholly owned by ALROSA and began production in 2015. Beginning as an open pit, the mine was expected to produce more than 2 million carats per year during its projected 40-year mine life. The Botuobinskaya Mine was expected to offset the anticipated decrease in production of the Nyurbinskaya pipe 3 kilometers away. Together, these operations were expected to sustain the production of 7.5 million carats of rough diamonds per year. The Botuobinskaya Mine reserves were estimated to contain 93 million carats of rough diamonds, with an average diamond grade of 5.65 carats per ton (OJSC ALROSA, 2015).

The Karpinsky-1 Mine, in Russia's Lomonosov diamond field, was owned and operated by Severalmaz, a subsidiary of ALROSA, and had its first full year of production in 2015. Production was expected to be about 3 million carats per year after reaching full working in 2015 (Klein, 2014; Mackenzie, 2014).

Outlook

China is expected to remain the world's leading producer of synthetic industrial diamond, with annual production exceeding 4 billion carats. The United States is likely to continue to be one of the world's leading markets for industrial diamond into the next decade and likely will remain a significant producer and exporter of synthetic industrial diamond as well. U.S. industrial diamond production and apparent consumption are expected to continue increasing as manufacturing sectors that use industrial diamond continue experiencing economic growth. U.S. demand for industrial diamond is likely to continue in the construction sector as the United States continues building and repairing the Nation's highway system.

In the coming years, an increase in rough diamond production is expected, and three new mines are expected to begin operating in 2016. Mountain Province Diamonds Inc. is partnering with De Beers to open the Gahcho Kué Mine in the Northwest Territories of Canada, which is anticipated to produce 4.5 million carats per year when it is fully operational. Stornoway Diamond Corp. plans to open its Renard Mine in Quebec, Canada, where it expects to produce 1.6 million carats per year. Firestone Diamonds plc's main treatment plant was under construction at the Lihobong deposit in Lesotho, which is expected to produce 1 million carats per year (De Beers Group UK Ltd., 2016, p. 29).

Truing and dressing applications will remain a major domestic end use for natural industrial diamond stone. Stones for these applications have not yet been manufactured economically. No shortage of the stone is anticipated, however, because new mines and more producers selling in the rough diamond market will maintain ample supplies. More competition introduced by the additional sources also may temper price increases.

Demand for synthetic diamond bort, dust, grit, and powder is expected to remain greater than for natural diamond material. Constant-dollar prices of synthetic diamond products are likely to continue to decline as production technology becomes more cost effective. The decline is even more likely if competition from low-cost producers in China and Russia continues to increase.

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GENERAL SOURCES OF INFORMATION

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TABLE 1
SALIENT NATURAL AND SYNTHETIC INDUSTRIAL DIAMOND STATISTICS¹

(Thousand carats and thousand dollars)

	2011	2012	2013	2014	2015
United States:					
Natural:					
Secondary production: ^c					
Quantity	17,300	18,300	19,000	21,900	31,700
Value	8,470	8,920	9,240	10,600	1,710
Exports:					
Quantity	4,310 ^r	9,570 ^r	6,420	8,990	6,050
Value	3,060 ^r	7,340 ^r	5,010	5,670	4,710
Imports for consumption:					
Quantity	9,710 ^r	6,400 ^r	6,810	5,560	6,570
Value	51,100 ^r	37,000 ^r	30,400	32,500	24,800
Synthetic:					
Primary production: ^c					
Quantity	98,200	103,000	108,000	124,000	119,000
Value	67,100	70,600	73,200	84,200	117,000
Secondary production: ^c					
Quantity	17,700	18,600	19,400	22,400	31,900
Value	9,260	9,750	10,100	11,900	2,170
Exports:					
Quantity	164,000 ^r	165,000 ^r	143,000	154,000	133,000
Value	78,300 ^r	80,500 ^r	72,600	74,900	62,800
Imports for consumption:					
Quantity	721,000	591,000	724,000	679,000	270,000
Value	94,900 ^r	78,600 ^r	79,400	75,400	52,800
Apparent consumption, natural and synthetic: ^{c,2}					
Quantity	696,000 ^r	563,000 ^r	728,000	690,000	319,000
Value	149,000 ^r	117,000 ^r	125,000	134,000	131,000
World, production: ^c					
Natural	55,500 ^r	61,100 ^r	59,800 ^r	52,800 ^r	56,500
Synthetic	4,380,000	4,390,000	4,390,000	4,410,000	4,380,000
Natural and synthetic	4,440,000	4,450,000	4,450,000	4,460,000	4,430,000

^cEstimated. ^rRevised.

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

²Domestic primary and secondary production plus imports minus exports.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY¹

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones ²				Miners' diamond, natural and synthetic ³			
	2014		2015		2014		2015	
	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴
Australia	83	784	58	808	(5)	24	3	77
Austria	--	--	1	6	--	--	--	--
Belgium	(5)	2	--	--	--	--	--	--
Botswana	433	18,800	266	12,500	2	33	4	240
Brazil	(5)	13	(5)	12	--	--	--	--
Canada	(5)	23	(5)	1	(5)	2	--	--
China	(5)	4	--	--	--	--	--	--
Congo (Kinshasa)	20	556	56	355	--	--	--	--
Ghana	4	148	--	--	--	--	--	--
India	659	743	392	503	(5)	34	--	--
Ireland	--	--	--	--	(5)	3	--	--
Liberia	--	--	--	--	(5)	207	3	119
Namibia	79 ^r	517	26	122	--	--	--	--
Russia	6	278	79	106	--	--	--	--
Sierra Leone	(5)	(5)	1	48	(5)	7	--	--
South Africa	846	8,860	420	7,750	26 ^r	86 ^r	3	151
United Kingdom	(5)	7	1	66	(5)	14	--	--
Other	(5) ^r	15 ^r	(5)	15	(5) ^r	1 ^r	--	--
Total	2,130	30,800	1,300	22,300	30	409	13	586

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes glazers' and engravers' diamond unset, Harmonized Tariff Schedule of the United States (HTS) codes 7102.21.3000 and 7102.21.4000 for natural industrial diamond stone.

³HTS codes 7102.21.1010 and 7102.21.1020 for miners' diamond, natural and synthetic.

⁴Customs value.

⁵Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND BORT, DUST, GRIT, AND POWDER, BY COUNTRY¹

(Thousand carats and thousand dollars)

Country	Natural ²				Synthetic ³			
	2014		2015		2014		2015	
	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴
Australia	51	39	8	3	439	391	273	194
Austria	--	--	--	--	480	39	37	36
Belgium	12	7	10	6	906	237	449	158
Brazil	3	5	--	--	--	--	--	--
China	605	300	1,450	455	549,000	43,900	185,000	25,500
France	--	--	--	--	--	--	65	54
Germany	192	114	130	39	130	85	32	22
Hong Kong	--	--	--	--	210	18	127	89
India	1,820	715	2,940	1,500	2,010	396	71	43
Indonesia	--	--	--	--	11	7	--	--
Ireland	285	167	130	60	38,900	14,700	29,300	12,800
Israel	--	--	--	--	128	59	170	75
Italy	--	--	--	--	10	7	--	--
Japan	10	15	2	3	1,150	1,420	957	1,230
Korea, Republic of	--	--	--	--	19,000	5,670	21,900	6,690
Luxembourg	--	--	--	--	62	118	139	109
Romania	3	5	37	63	45,300	2,660	10,600	938
Russia	3	5	50	11	16,900	3,410	15,600	2,470
South Africa	--	--	87	64	75	37	5	6
Switzerland	134	122	64	38	1,970	1,410	2,730	1,440
Taiwan	--	--	20	5	44	42	68	18
Thailand	--	--	--	--	--	--	369	39
Ukraine	--	--	--	--	4	3	--	--
United Kingdom	303	182	337	162	1,840	371	1,320	252
Vietnam	--	--	--	--	--	--	280	26
Other	12 ^r	8 ^r	5	16	86 ^r	43 ^r	21	12
Total	3,430	1,680	5,270	2,430	679,000	75,000	270,000	52,200

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States codes 7105.10.0011 and 7105.10.0015 for natural diamond.

³Harmonized Tariff Schedule of the United States codes 7105.10.0020, 7105.10.0030, and 7105.10.0050 for synthetic diamond.

⁴Customs value.

Source: U.S. Census Bureau.

TABLE 4
U.S. REEXPORTS OF INDUSTRIAL DIAMOND STONES, BY COUNTRY¹

(Thousand carats and thousand dollars)

Country	Industrial unworked diamonds ²			
	2014		2015	
	Quantity	Value ³	Quantity	Value ³
Australia	5	10	--	--
Austria	--	--	(4)	9
Belgium	330	7,510	200	6,770
Brazil	17 ^r	134	2	32
Canada	57	706	54	650
China	16	141	5	5
Germany	7	285	4	213
Hong Kong	14	624	15	818
India	35	1,110	10	192
Israel	78 ^r	514	30	40
Japan	102 ^r	8,330 ^r	98	7,330
Korea, Republic of	64	996	23	1,360
Mexico	11	361	14	594
Taiwan	5	84	16	167
Thailand	1	48	1	59
United Kingdom	84	2,490	96	3,250
Other	3 ^r	37 ^r	2	18
Total	827 ^r	23,400 ^r	569	21,500

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States code 7102.21.0000.

³Values are free alongside ship.

⁴Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND BORT, DUST, GRIT, AND POWDER, BY COUNTRY^{1,2}

(Thousand carats and thousand dollars)

Country	Natural				Synthetic			
	2014		2015		2014		2015	
	Quantity	Value ³	Quantity	Value ³	Quantity	Value ³	Quantity	Value ³
Exports:								
Australia	9	33	4	3	536	418	41	36
Austria	22	13	157	49	4,170	1,170	4,100	1,120
Belgium	181	336	183	309	241	72	189	47
Brazil	--	--	60	65	2,680	889	2,010	617
Canada	3,420	2,660	3,290	2,630	3,450	2,350	3,650	2,200
Chile	--	--	--	--	156	40	145	36
China	2	4	26	7	19,500	7,580	17,300	7,670
France	2	7	2	7	478	162	109	63
Germany	21	23	218	104	1,110	385	1,900	873
Hong Kong	112	202	30	94	162	139	90	101
India	--	--	3	7	3,690	1,130	3,090	1,080
Indonesia	2	6	4	9	762	436	145	76
Ireland	14	20	1	5	11	6	--	--
Israel	191	65	145	40	3,560	1,330	3,240	1,150
Italy	--	--	11	28	4,000	868	1,160	316
Japan	177	301	163	257	32,900	14,900	35,100	14,600
Korea, Republic of	2,270	490	464	151	20,200	9,950	19,700	9,030
Mexico	627	589	586	460	1,470	652	1,450	475
Netherlands	12	29	--	--	18,900	6,560	17,600	6,200
Singapore	2	6	--	--	2,080	3,640	1,080	2,450
South Africa	2	5	--	--	579	250	76	32
Spain	--	--	42	18	64	12	13	3
Switzerland	402	267	317	192	12,700	11,800	7,780	6,930
Taiwan	--	--	--	--	6,080	3,850	5,150	3,540
Thailand	53	58	--	--	6,000	1,910	1,930	917
Turkey	--	--	--	--	2,500	1,180	2,820	1,200
United Kingdom	1,450	527	329	257	3,090	1,100	1,340	531
Other	23 ^r	40 ^r	9	16	2,520 ^r	2,030 ^r	2,380	1,480
Total	8,990	5,670	6,050	4,710	154,000	74,900	133,000	62,800
Reexports:								
Australia	--	--	--	--	4	3	--	--
Austria	2	3	157	49	--	--	--	--
Belgium	97	160	93	134	86	39	44	19
Brazil	--	--	31	8	294	177	82	46
Canada	2,380	1,900	2,420	1,940	929	477	1,370	628
Chile	--	--	--	--	156	40	98	23
China	--	--	18	4	787	283	857	220
Germany	2	12	170	60	39	14	101	31
Hong Kong	12	30	7	9	--	--	8	10
India	--	--	--	--	25	16	--	--
Ireland	6	11	1	5	--	--	--	--
Italy	--	--	4	11	--	--	--	--
Japan	177	301	163	257	5,780	1,270	9,120	2,160
Korea, Republic of	16	22	--	--	800	293	946	416
Mexico	15	41	58	78	556	176	443	138
Netherlands	--	--	--	--	18	4	237	87
Singapore	--	--	--	--	29	153	4	19
South Africa	2	5	--	--	--	--	--	--
Spain	--	--	42	18	--	--	--	--
Switzerland	--	--	9	3	11	17	125	150
Taiwan	--	--	--	--	--	--	11	3
Thailand	20	39	--	--	124	177	131	232
United Kingdom	51	57	6	20	87	39	47	22
Other	2 ^r	10 ^r	6	8	379 ^r	217 ^r	510	218
Total	2,780	2,590	3,180	2,600	10,100	3,400	14,100	4,420
Grand total	11,800	8,270	9,230	7,310	164,000	78,300	148,000	67,200

See footnotes at end of table.

TABLE 5—Continued
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND BORT, DUST, GRIT, AND POWDER, BY COUNTRY^{1,2}

(Thousand carats and thousand dollars)

¹Revised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States codes 7105.10.0010 for natural and 7105.10.0025 for synthetic.

³Values are free alongside ship.

Source: U.S. Census Bureau.

TABLE 6
NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE¹

(Thousand carats)

Country and type ²	2011	2012	2013	2014	2015
Gemstones:					
Angola ³	7,500	7,500	7,740 ^r	7,910	8,120
Australia ⁴	157	184	235	186	271
Botswana ⁵	16,000	14,400	16,200	17,300	14,500
Brazil, unspecified ⁶	46	49 ^r	49	57	32
Cameroon, unspecified ⁷	--	1 ^r	3	4	2
Canada, unspecified	10,795	10,451	10,600 ^r	12,012	11,677 ^p
Central African Republic ⁸	259	293	65 ^{r,9}	-- ⁹	-- ⁹
China, unspecified	(10)	2	1	--	--
Congo (Brazzaville), unspecified	77	52	56	53	40
Congo (Kinshasa) ¹¹	3,850	4,300	3,140	3,130	3,200
Côte d'Ivoire, unspecified	-- ¹²	-- ¹²	-- ¹²	1	15
Ghana, unspecified	302	233	169	242	174
Guinea ⁸	243	213	162	131	134
Guyana, unspecified	51	44	60	100	118
India ¹³	3	7	10	10	9
Lesotho, unspecified	224	479	414	346	304
Liberia ¹⁴	25	25	32	39	41
Namibia, unspecified	1,256	1,629	1,689	1,918	2,053
Russia ¹⁵	19,700	19,600	21,200	21,500	23,500
Sierra Leone ⁸	286 ^r	433 ^r	487 ^r	496 ^r	400
South Africa ⁸	5,640	5,660	6,520	5,950	5,780
Tanzania ¹⁶	35 ^r	108 ^r	153 ^r	215 ^r	184
Togo, unspecified	(10)	(10)	(10)	(10)	(10)
Zimbabwe ¹⁷	850	1,210	1,040	477	349
Total	67,300^r	66,800	70,000^r	72,000	70,900
Industrial:					
Angola ³	833	833	860 ^r	879	902
Australia ⁴	7,670	9,000	11,500	9,100	13,300
Botswana ⁵	6,870	6,170	6,960	7,400	6,230
Central African Republic ⁸	65	73	16 ^{r,9}	-- ⁹	-- ⁹
Congo (Kinshasa) ¹¹	15,400	17,200	12,500	12,500	12,800
Guinea ⁸	61	53	40	33	33
India ¹³	9	20	27	27	24
Liberia ¹⁴	17	17	21	26	27
Russia ¹⁵	15,500	15,400	16,700	16,900	18,400
Sierra Leone ⁸	71 ^r	108	122	124	100
South Africa ⁸	1,410	1,420	1,630	1,490	1,440
Tanzania ¹⁶	6 ^r	19 ^r	27 ^r	38 ^r	33
Zimbabwe ¹⁷	7,650	10,900	9,370	4,290	3,140
Total	55,500^r	61,100^r	59,800^r	52,800	56,500
Grand total, unrounded	122,829	127,966^r	129,844^r	124,778	127,399

^pPreliminary. ^rRevised. -- Zero.

¹Gem and industrial diamond quantities except "unspecified" are estimated from reported country totals using percentages noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown. Reported values for countries for which proportions of gem and industrial qualities were not known are listed as "unspecified" under "Gemstones." Includes data available through January 17, 2018.

²In addition to the countries listed, Nigeria produced natural diamond, but information was inadequate to make reliable estimates of output.

³About 90% gem quality and 10% industrial quality.

⁴About 2% gem quality and 98% industrial quality.

⁵About 70% gem and near-gem quality and 30% industrial quality.

⁶Private sector and artisanal mining. Includes near-gem and cheap-gem qualities.

⁷From artisanal mining.

⁸About 80% gem quality and 20% industrial quality.

⁹From May 2013 through 2015, the Central African Republic was under a temporary suspension from the Kimberley Process Certification Scheme and was not trading in rough diamond.

¹⁰Less than 1/2 unit.

¹¹About 20% gem quality and 80% industrial quality; the majority of production was from artisanal mining.

TABLE 6—Continued
NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE¹

(Thousand carats)

¹²In 2011–13, Côte d’Ivoire was under United Nations sanctions and was not trading in rough diamond.

¹³About 27% gem quality and 73% industrial quality.

¹⁴About 60% gem quality and 40% industrial quality.

¹⁵About 56% gem quality and 44% industrial quality.

¹⁶About 85% gem quality and 15% industrial quality.

¹⁷About 10% gem quality and 90% industrial quality.

Source: Kimberley Process Certification Scheme.