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DIAMOND, INDUSTRIAL [ADVANCE RELEASE]

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Diamond, Industrial

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In 2017, U.S. synthetic diamond production was estimated to be 129 million carats with an estimated value of $129 million. No natural industrial diamond mining took place in the United States, but an estimated 11.6 million carats of used industrial diamond (natural and synthetic) worth about $2.72 million was recycled (secondary production). U.S. imports of natural and synthetic industrial diamond bort, dust and powder, grit, and stone totaled 400 million carats valued at $77.7 million, and exports totaled 161 million carats valued at $73.2 million. The estimated U.S. apparent consumption of industrial diamond bort, dust and powder, grit, and stone totaled 379 million carats with an estimated value of $136 million. Total industrial diamond output worldwide was estimated by the U.S. Geological Survey (USGS) to be 14.6 billion carats. This was the combination of more than 63.0 million carats of natural industrial diamond and about 14.6 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 Gemstones chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals. 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 on the basis of past and current reported data. Trade data in this chapter are from the U.S. Census Bureau. All percentages in the chapter were calculated using unrounded data.

Production

The USGS conducts an annual survey of domestic synthetic industrial diamond producers and a survey of the U.S. firms that recover diamond wastes. Of the two U.S. synthetic industrial diamond producers, one responded to the USGS survey, and of the three leading U.S. firms that recover diamond wastes, two responded to the USGS survey. Production quantities and values for the nonreporting companies were estimated on the basis of 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 2017, the United States was one of the world's leading producers of synthetic industrial diamond. The United States accounted for an estimated output of 129 million carats valued at $129 million. Only two U.S. companies produced synthetic industrial diamond during the year—Mypodiamond Inc. (Smithfield, PA) and Sandvik Hyperion (Worthington, OH). By type, primary production was entirely diamond bort, dust and powder, and grit.

In 2017, at least eight U.S. companies also manufactured PCD from synthetic diamond dust and powder and grit. 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 2017, an estimated 11.6 million carats of used industrial diamond (natural and synthetic) worth about $2.72 million (table 1) was recycled (secondary production) in the United States. By type, secondary production was made up of 11.2 million carats of bort, dust and powder, and grit valued at $1.86 million and 392,000 carats of diamond stone valued at $856,000. 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 2017—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.

In 1954, scientists at General Electric Co. manufactured the first synthetic bits of diamond grit using a high-pressure, high-temperature (HPHT) method. In 1956, the first commercially available synthetic diamond was produced by HPHT at General Electric. Diamonds of 1 carat or more are harder to manufacture because that size high-quality diamond is difficult to consistently produce, even in the controlled environment of a laboratory using the HPHT method. After more than 60 years of development, several synthetic diamond companies were able to produce relatively large high-quality industrial diamonds that equaled those produced from mines, and billions of carats of synthetic diamonds were manufactured annually by the HPHT process, mostly for industrial applications (Linares, 2013).

In 1954, a patent was issued for a CVD type of diamond growth technique. The CVD technique transforms carbon into plasma, which is then precipitated onto a substrate as diamond. Initially, the manufacture of gem-quality CVD synthetic diamond was not possible, but in the mid-1980s, scientists discovered how to reproducibly grow microscopic diamond crystals to cover surfaces using the CVD process (Linares, 2013). In the early 2000s, technology was further developed for a method for growing large single, extremely pure diamond crystals by CVD. 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.

No commercial diamond mines operated in the United States during 2017. The Arkansas Department of Parks and Tourism operated a dig-for-fee diamond mine for hobbyists at Crater of Diamonds State Park in Murfreesboro, AR.

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 one of the world's leading markets for industrial diamond in 2017. According to production estimates and trade data, U.S. apparent consumption of industrial diamond during the year increased by 38% in quantity to an estimated 379 million carats valued at $136 million compared with 275 million carats valued at $131 million in 2016 (table 1). Apparent consumption was the combination of 5.27 million carats of natural industrial diamond valued at $14.9 million and 374 million carats of synthetic industrial diamond valued at $121 million. By type, apparent consumption was the combination of 11.2 million carats of diamond bort, dust and powder, and grit valued at $1.86 million and 392,000 carats of diamond stone valued at $856,000.

The major consuming industrial sectors of industrial diamond cutting and drilling tools and abrasives in the United States during 2017 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 most 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 and powder, and grit (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 is 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 dust and powder and grit 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 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 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 using 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 synthetic diamond for use as gemstones, research and development projects by several companies that use single-crystal CVD diamond materials in high-voltage power switches, lasers, quantum communications and computing, and water treatment and purification have been ongoing for the past decade. These projects could translate into high-value market opportunities and high-volume technology applications (Scio Diamond Technology Corp., 2012; WD Lab Grown Diamonds, 2019).

Prices

Natural and synthetic industrial diamonds had prices with a range of values, depending on their crystallinity, purity, shape, size, and in the case of synthetic diamond, the absence or presence of metal coatings. During 2017, the average value for diamond bort, dust and powder, and grit material was $0.55 per carat, and the average value for diamond stone material was $1.22 per carat. During 2017, U.S. imports of all types of industrial diamond had an average unit value of $0.19 per carat. These imports were a combination of natural diamond that had an average unit value of $2.88 per carat and synthetic diamond that had an average unit value of $0.15 per carat. By type, diamond imports were the combination of diamond bort, dust and powder, and grit (natural and synthetic) that had an average unit value of $0.16 per carat and diamond stone (natural and synthetic) that had an average unit value of $12.87 per carat. These average unit values for imported diamond bort, dust and powder, grit, and stone (natural and synthetic) were higher 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 2017; imports were received from 31 countries or localities, and exports and reexports were sent to 25 countries or localities (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 industrial diamond has not been produced domestically.

During 2017, U.S. imports of industrial-quality diamond stones (natural and synthetic) decreased by 10% from those of 2016 to 1.23 million carats valued at $15.8 million (table 2). Imports of natural diamond bort, dust and powder, and grit increased by 44% from those of 2016 to 5.17 million carats valued at $3.08 million owing to a 40% increase of imports from India, and imports from China more than tripled. Imports of synthetic diamond bort, dust and powder, and grit increased by 85% from those of 2016 to 394 million carats valued at $59.3 million, owing to a doubling of imports from China, a 78% increase of imports from Russia, and an 8% increase of imports from the Republic of Korea (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 2017, the United States did not export industrial diamond stones, unchanged from that of 2016. U.S. reexports of industrial diamond stone increased by 86% from those of 2016 to 981,000 carats valued at $19.2 million and an average unit value of $19.60 per carat (table 4). U.S. exports of industrial diamond bort, dust and powder, and grit (natural and synthetic) increased by 20% from those of 2016 to 161 million carats valued at $73.2 million and an average unit value of $0.45 per carat. Reexports of industrial diamond bort, dust and powder, and grit (natural and synthetic) increased by 25% from those of 2016 to 22.1 million carats valued at $8.04 million with an average unit value of $0.36 per carat (table 5). Trade quantity and value data were not available for PCD or CVD diamond.

World Industry Structure

Global natural rough diamond production increased by 19% during 2017 to 151 million carats from 127 million carats in 2016. The world's leading rough diamond producers were as follows: Russia produced 42.6 million carats (28% of total world production); Canada, 23.2 million carats (15%); Botswana, 22.9 million carats (15%); Congo (Kinshasa), 18.9 million carats (13%); Australia, 17.1 million carats (11%); South Africa, 9.68 million carats (6.4%); Angola, 9.44 million carats (6.3%); and other countries produced 6.95 million carats (4.6%). Of the 151 million carats of total natural diamond production, 87.9 million carats (58% of total diamond production) was gemstone diamond, and 63.0 million carats (42% of total diamond production) was industrial diamond (table 6). During 2017, the value of worldwide rough diamond production increased by 15% to $14.1 billion from the 2016 value of $12.3 billion (Kimberley Process, The, 2017, 2018). Total combined natural and synthetic industrial diamond output worldwide was estimated by the USGS to be about 14.6 billion carats (table 1).

During 2017, OJSC ALROSA and De Beers Group remained the two leading diamond producers by quantity and value. ALROSA's production was about 24% of total global quantity and 24% of total global value; De Beers' production was about 20% of total global quantity and 33% of total global value. The third-ranked company was Rio Tinto Ltd., which produced about 13% of total global production quantity and approximately 12% of global production value (De Beers Group UK Ltd., 2018, p. 7).

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. Australia assumed the chair of KPCS from January 1 through December 31, 2017. As of December 31, 2017, 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). The participating nations in the KPCS account for approximately 99.8% of the global production and trade of rough diamonds (Kimberley Process, The, 2019).

In 2017, natural industrial diamond production was reported from 13 countries (table 6). Natural industrial diamond production worldwide was estimated to be about 63.0 million carats, a 14% increase compared with 55.1 million carats in 2016. Russia was the leading country in the production of natural industrial diamond with 18.8 million carats or 30% of total world production, followed by Australia with 16.8 million carats (27%), Congo (Kinshasa) with 15.1 million carats (24%), Botswana with 6.90 million carats (11%), Zimbabwe with 2.26 million carats (4%), and South Africa with 1.94 million carats (3%). These six countries produced 98% of the world's natural industrial diamond (table 6). Synthetic industrial diamond production worldwide was estimated to be more than 14.6 billion carats, a slight increase compared with that of 2016. 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 99% of the world's synthetic industrial diamond.

In 2017, 99% 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 28% during 2017 from that of 2016 and by 60% since 2012. In 2017, the global diamond exploration budget was approximately $208 million, which was less than 3% of the total spent on all mineral exploration. The three leading countries for diamond exploration were, in descending order of 2017 budget, Russia, Canada, and Botswana. Their combined budgets accounted for about 79% of the global diamond exploration budget (Wilburn and Karl, 2018, p. 34–35).

World Review

Botswana.—Rough diamond production in Botswana was 22.9 million carats during 2017, a 9% increase compared with that of 2016, accounting for 15% of total global production. This diamond production was valued at $3.33 billion, a 17% increase compared with that of 2016 (Kimberley Process, The, 2017, 2018).

The Jwaneng diamond mine in the Kalahari Desert of south-central Botswana was wholly owned by Debswana Diamond Co. (Pty.) Ltd. The company began the Cut 8 project at Jwaneng in 2016, and production began in 2017 (De Beers Group UK Ltd., 2017, p. 7).

Canada.—Rough diamond production in Canada was 23.2 million carats during 2017, a 78% increase compared with that of 2016, accounting for 15% of total global production. This diamond production was valued at $2.06 billion, a 47% increase compared with that of 2016 (Kimberley Process, The, 2017, 2018). Canada accounted for most of the increase in global rough diamond production, overtaking Botswana as the second-ranked diamond-producing country by volume.

An extension project of the A21 kimberlite pipe pit at the Diavik Diamond Mine in the Northwest Territories began in 2016 and continued during 2017 with production expected to begin in 2018. Diavik was jointly owned by Rio Tinto Group (60%) and Dominion Diamond Corp. (40%) (De Beers Group UK Ltd., 2017, p. 7; 2018, p. 7).

The Gahcho Kué Mine in the Northwest Territories entered full production late in 2016 and had its first full year of production in 2017. The mine was jointly owned by De Beers Canada, Inc. (51%) and Mountain Province Diamonds Inc. (49%). The mine owners anticipated average annual diamond production of 4.5 million carats (De Beers Group UK Ltd., 2017, p. 7; Diamond Loupe, The, 2018).

The Renard Mine in Quebec also entered full production late in 2016 and had its first full year of production in 2017. The mine was wholly owned by Stornoway Diamond Corp. Stornoway anticipated average annual diamond production of 1.6 million carats (De Beers Group UK Ltd., 2017, p. 7; Diamond Loupe, The, 2018).

Lesotho.—Rough diamond production in Lesotho was 1.13 million carats during 2017, more than triple that of 2016, but accounting for less than 1% of total global production. This diamond production had a value of $343 million, a 47% decrease compared with that of 2016 (Kimberley Process, The, 2017, 2018).

The Liqhobong Diamond Mine in the Maluti Mountains of northern Lesotho began ramping up production in 2016 and reached full commercial production in 2017. The 2017 reported production was 366,000 carats (Mining Data Online, 2020). The mine was owned by Firestone Diamonds plc (75%) and the Government of Lesotho (25%). The mine owners anticipated average annual diamond production of 1.0 million carats (De Beers Group UK Ltd., 2017, p. 7).

Russia.—Rough diamond production in Russia was 42.6 million carats during 2017, a 6% increase compared with that of 2016, accounting for 28% of total global production. This diamond production was valued at $4.11 billion, a 15% increase compared with that of 2016 (Kimberley Process, The, 2017, 2018).

ALROSA started construction of the Verkhne-Munskoe project in Yakutia during 2016. Project completion and mine startup were expected in 2018 (De Beers Group UK Ltd., 2017, p. 7; 2018, p. 7).

Outlook

China is expected to remain the world's leading producer of synthetic industrial diamond, with annual production exceeding 14 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.

Diamond offers many advantages for precision machining and longer tool life. In fact, even the use of wear-resistant diamond coatings to increase the life of materials that compete with diamond is a rapidly growing application. Increased tool life not only leads to lower costs per unit of output but also means fewer tool changes and longer production runs. In view of the many advantages that come from increased tool life and reports that diamond film surfaces can increase durability, much wider use of diamond as an engineering material is expected.

PCD for abrasive tools and wear parts is likely to continue to replace competing materials in many industrial applications by providing closer tolerances as well as extending tool life. For example, PDCs and PDSs will continue to displace natural diamond stone and tungsten carbide products used in the drilling and tooling industries.

CVD technology can produce extremely pure diamond crystals that have great potential in computer technology in the production of diamond computer chips when their cost becomes competitive. These diamond computer chips work at a much higher frequency or faster speed and can be placed in higher temperature environments than the silicon chips currently used in computers. Eventually, they may replace silicon chips in computers. CVD diamonds annealed using the low-pressure, high-temperature microwave plasma process may have applications in high-pressure research, optical uses that take advantage of the outstanding transparency of diamond, and in quantum computing to store quantum information in vacancy centers in the diamond's crystal lattice.

CVD diamond is likely to be used to provide a more efficient alternative process to existing water purification processes. This technology will use single-crystal diamond electrodes for electrochemical water purification.

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 and powder, and grit is expected to remain greater than that 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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TABLE 1

SALIENT NATURAL AND SYNTHETIC INDUSTRIAL DIAMOND STATISTICS[1]

(Thousand carats and thousand dollars)

	2013	2014	2015	2016	2017
United States:					
Natural:					
Secondary production:[e]					
Quantity	19,000	21,900	31,700	33,000	5,600
Value	9,240	10,600	1,710	1,770	932
Exports:					
Quantity	6,420	8,990	6,050	4,710	6,710
Value	5,010	5,670	4,710	3,790	4,410
Imports for consumption:					
Quantity	6,830 r	5,580 r	6,580 r	4,930 r	6,370
Value	31,300 r	32,700 r	25,100 r	20,400 r	18,400
Synthetic:					
Primary production:[e]					
Quantity	108,000	124,000	119,000	125,000	129,000
Value	73,200	84,200	117,000	123,000	129,000
Secondary production:[e]					
Quantity	19,400	22,400	31,900	33,400	6,000
Value	10,100	11,900	2,170	2,310	1,790
Exports:					
Quantity	143,000	154,000	133,000	129,000	155,000
Value	72,600	75,000 r	62,800	60,000	68,700
Imports for consumption:					
Quantity	724,000	679,000	270,000	213,000	394,000
Value	78,600 r	75,200 r	52,300 r	47,200 r	59,300
Apparent consumption, natural and synthetic:[e, 2]					
Quantity	728,000	690,000	319,000	275,000	379,000
Value	125,000	134,000	131,000	131,000	136,000
World, production:[e]					
Natural	60,800 r	52,300 r	56,100 r	55,100 r	63,000
Synthetic	17,400,000 r	17,400,000 r	15,500,000 r	14,300,000 r	14,600,000
Total, natural and synthetic	17,500,000 r	17,500,000 r	15,500,000 r	14,300,000 r	14,600,000

[e]Estimated. [r]Revised.

[1]Table includes data available through September 11, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Domestic primary and secondary production plus imports minus exports.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY OR LOCALITY[1]

(Thousand carats and thousand dollars)

	Natural industrial diamond stones[2]				Miners' diamond, natural and synthetic[3]			
	2016		2017		2016		2017	
Country or locality	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]
Angola	(5)	18	(5)	8	--	--	--	--
Australia	181	1,140	118	910	9	73	22	135
Belgium	1	21	2	19	--	--	--	--
Botswana	304	11,500	250	7,430	1	101	2	224
Brazil	--	--	15	18	--	--	--	--
Canada	(5)	2	3	179	--	--	--	--
Congo (Kinshasa)	58	478	17	203	(5)	1	(5)	1
Guyana	--	--	--	--	--	--	1	96
India	461	359	314	307	45	71	20	220
Liberia	--	--	--	--	--	--	(5)	(5)
Namibia	20	70	20	76	--	--	--	--
Russia	4	14	53	43	--	--	(5)	14
Sierra Leone	--	--	(5)	4	2	48	(5)	7
South Africa	277	4,470	386	5,500	4	186	2	187
United Kingdom	(5)	53	1	128	(5)	7	(5)	28
Other	1	35	(5)	30	--	--	(5)	2
Total	1,310	18,200	1,180	14,800	60	487	47	913

-- Zero.

[1]Table includes data available through September 11, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes 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.

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

[4]Customs value.

[5]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND BORT, DUST AND POWDER, AND GRIT, BY COUNTRY OR LOCALITY[1]

(Thousand carats and thousand dollars)

	Natural[2]				Synthetic[3]			
	2016		2017		2016		2017	
Country or locality	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]
Australia	30	21	55	36	192	138	26	25
Austria	1	4	15	7	--	--	60	32
Belgium	60	38	4	3	331	154	609	251
Canada	--	--	--	--	--	--	268	14
China	207	135	635	477	146,000	23,700	316,000	33,700
Finland	--	--	--	--	--	--	147	94
Germany	275	77	170	42	76	20	363	84
Hong Kong	--	--	--	--	119	28	774	127
India	2,180	1,310	3,040	1,660	221	134	496	258
Ireland	85	25	96	38	28,700	11,200	28,800	11,400
Israel	--	--	--	--	14	10	288	121
Italy	--	--	8	6	13	9	120	50
Japan	38	21	37	14	582	650	542	637
Korea, Republic of	--	--	112	45	22,200	6,650	23,900	6,760
Romania	7	12	--	--	3,010	1,280	2,200	1,370
Russia	--	--	40	23	9,180	1,630	16,300	2,220
Singapore	--	--	--	--	74	42	173	69
South Africa	101	70	100	64	7	5	87	23
Switzerland	203	92	345	316	1,440	1,330	2,090	1,840
United Arab Emirates	--	--	--	--	--	--	100	27
United Kingdom	308	137	481	327	592	130	595	190
Vietnam	23	38	--	--	--	--	--	--
Other	78 r	43 r	35	19	70 r	41 r	34	12
Total	3,590	2,020	5,170	3,080	213,000	47,200	394,000	59,300

[r]Revised. -- Zero.
[1]Table includes data available through September 11, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Harmonized Tariff Schedule of the United States (HTS) codes 7105.10.0011 and 7105.10.0015 for natural diamond.
[3]HTS codes 7105.10.0020, 7105.10.0030, and 7105.10.0050 for synthetic diamond.
[4]Customs value.

Source: U.S. Census Bureau.

TABLE 4

U.S. REEXPORTS OF INDUSTRIAL DIAMOND STONES, BY COUNTRY OR LOCALITY[1]

(Thousand carats and thousand dollars)

	Industrial unworked diamonds[2]			
	2016		2017	
Country or locality	Quantity	Value[3]	Quantity	Value[3]
Belgium	173	3,460	71	3,390
Brazil	(4)	11	--	--
Canada	90 r	717 r	114	950
Germany	4	168	6	275
Hong Kong	34	1,360	17	4,760
India	(4)	8	1	4
Ireland	20	80	19	52
Israel	--	--	545	277
Japan	81	5,150	100	5,850
Korea, Republic of	17	954	14	990
Mexico	8	334	8	207
Taiwan	13	119	9	295
Thailand	6	52	1	44
United Arab Emirates	6	48	--	91
United Kingdom	74	2,930	67	2,030
Other	2	7	7	38
Total	527 r	15,400 r	981	19,200

rRevised. -- Zero.

1Table includes data available through September 11, 2018. Data 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 AND POWDER, AND GRIT, BY COUNTRY OR LOCALITY[1, 2]

(Thousand carats and thousand dollars)

	Natural				Synthetic			
	2016		2017		2016		2017	
Country or locality	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Exports:								
Austria	--	--	13	33	3,330	783	2,870	807
Belgium	149	279	677	338	125	36	845	194
Brazil	45	74	--	--	1,300	462	824	408
Canada	3,130	2,420	3,870	2,670	4,650	2,630	8,250	4,120
China	7	3	--	--	9,820	3,870	19,900	10,900
Germany	97	28	78	36	3,640	849	9,330	1,850
Hong Kong	7	19	26	66	167	122	111	100
India	--	--	72	25	2,760	889	2,640	964
Indonesia	--	--	9	3	147	53	594	134
Israel	384	50	526	200	1,770	677	2,470	938
Italy	--	--	--	--	1,110	249	1,430	362
Japan	153	203	168	302	33,200	14,100	40,600	17,700
Korea, Republic of	124	40	49	13	21,000	9,370	19,700	7,460
Mexico	164	157	414	229	1,150	337	1,610	512
Netherlands	1	3	308	128	22,500	8,250	20,700	7,550
Philippines	--	--	--	--	516	399	299	142
Portugal	--	--	--	--	11	17	18	17
Singapore	--	--	--	--	2,530	4,050	1,680	3,260
Switzerland	20	11	124	74	6,830	6,290	5,010	4,480
Taiwan	9	5	--	--	5,100	3,380	5,220	2,680
Thailand	2	4	13	33	2,170	868	3,520	1,290
Turkey	--	--	--	--	2,490	1,010	2,590	841
United Kingdom	354	449	208	180	1,150	336	1,850	623
Other	70 r	47 r	154 r	85	1,710 r	952 r	2,470	1,400
Total	4,710	3,790	6,710	4,410	129,000	60,000	155,000	68,700
Reexports:								
Brazil	--	--	--	--	16	21	24	14
Canada	2,290	1,810 r	2,700	1,740	2,470	981	5,070	2,150
China	7	3	--	--	1,270	286	1,760	438
Germany	68	20	57	13	249	60	515	116
Hong Kong	2	6	2	7	--	--	--	--
Japan	100	188	168	302	8,320	2,310	8,680	1,950
Korea, Republic of	--	--	--	--	1,140	527	1,050	443
Mexico	79	102	63	45	446	126	482	142
Netherlands	--	--	--	--	252	165	--	--
Portugal	--	--	--	--	11	17	18	17
Singapore	--	--	--	--	7	32	5	18
Switzerland	--	--	--	--	166	280	7	3
Thailand	--	--	--	--	111	189	80	109
United Kingdom	143	311	71	32	33	9	65	16
Other	49	71	679	261	488	231	650	220
Total	2,740	2,510 r	3,740 r	2,400	15,000	5,230	18,400	5,640
Grand total	7,450	6,300	10,500	6,820	144,000	65,200 r	173,000	74,400

rRevised. -- Zero.

[1]Table includes data available through September 11, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

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

[3]Values are free alongside ship.

Source: U.S. Census Bureau.

TABLE 6

DIAMONDS (NATURAL): WORLD PRODUCTION, BY COUNTRY OR LOCALITY AND TYPE[1]

(Thousand carats)

Country or locality[2]	2013	2014	2015	2016	2017
Gemstones:					
Angola[e, 3]	7,740	7,910	8,120	8,100 [r]	8,500
Australia[e, 4]	235	186	271	279	343
Botswana[e, 5]	16,200	17,300	14,500	14,500 [r]	16,000
Brazil, unspecified[6]	49	71 [r]	32	184	255
Cameroon, unspecified[7]	3	4	2	1 [r]	2
Canada, unspecified	10,600	12,012	11,677	13,036	23,234
Central African Republic[e, 8]	65	--	--	9	38
China, unspecified	105 [r, e]	150 [r, e]	150 [r, e]	127 [r, e]	--
Congo (Brazzaville)	56	53	40	12	47
Congo (Kinshasa)[e, 9]	3,400 [r]	2,900 [r]	3,300 [r]	3,100 [r]	3,780
Côte d'Ivoire, unspecified	--	1	15	20	7
Ghana, unspecified	169	242	174	142	82
Guinea[e, 8]	162	131	134	90	145
Guyana, unspecified	64 [r]	100	118	140	52
India[e, 10]	10	10	9	9	11
Lesotho, unspecified	414	346	304	342	1,126
Liberia[e, 11]	32	39	41	38 [r]	38
Namibia, unspecified	1,689	1,918	2,053	1,718	1,948
Russia[e, 12]	21,200	21,500	23,500	22,600	23,800
Sierra Leone[e, 9]	487	496	400	439	231
South Africa[e, 8, 13]	6,520	5,950	5,780	6,650	7,750
Tanzania[e, 14]	145 [r]	215	185 [r]	205	260
Togo, unspecified	(15)	(15)	-- [r]	-- [r]	(15)
Zimbabwe[e, 16]	1,040	477	349	210	251
Total	70,400 [r]	72,000	71,200 [r]	72,000 [r]	87,900
Industrial:					
Angola[e, 3]	860	879	902	902	940
Australia[e, 4]	11,500	9,100	13,300	13,700	16,800
Botswana[e, 5]	6,960	7,400	6,230	6,500 [r]	6,900
Central African Republic[e, 8]	16	--	--	2	10
Congo (Kinshasa)[e, 9]	13,500 [r]	12,000 [r]	12,500 [r]	12,500 [r]	15,100
Guinea[e, 8]	40	33	33	23	36
India[e, 10]	27	27	24	24	30
Indonesia	7	7	--	--	--
Liberia[e, 11]	21	26	27	25 [r]	25
Russia[e, 12]	16,700	16,900	18,400	17,700	18,800
Sierra Leone[e, 9]	122	124	100	110	58
South Africa[e, 8, 13]	1,630	1,490	1,440	1,660	1,940
Tanzania[e, 14]	26 [r]	38	31 [r]	35 [r]	44
Zimbabwe[e, 16]	9,370	4,290	3,140	1,890 [r]	2,260
Total	60,800 [r]	52,300 [r]	56,100 [r]	55,100 [r]	63,000
Grand total	131,000 [r]	124,000 [r]	127,000	127,000 [r]	151,000

[e]Estimated. [r]Revised. -- Zero.

[1]Table includes data available through October 24, 2018. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]In addition to the countries and (or) localities listed, Belarus, Germany, Ireland, Nigeria, the Republic of Korea, and Sweden may have produced natural diamond, but available information was inadequate to make reliable estimates of output.

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

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

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

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

[7]From artisanal mining.

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

[9]About 20% gem quality and 80% industrial quality; the majority of production is from artisanal mining.

[10]About 27% gem quality and 73% industrial quality.

[11]About 60% gem quality and 40% industrial quality.

[12]About 56% gem quality and 44% industrial quality.

[13]Includes artisanal mining.
[14]About 85% gem quality and 15% industrial quality.
[15]Less than ½ unit.
[16]About 10% gem quality and 90% industrial quality.