



2012 Minerals Yearbook

DIAMOND, INDUSTRIAL

DIAMOND, INDUSTRIAL

By Donald W. Olson

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the author. The world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2012, U.S. synthetic diamond production was estimated to be 103 million carats (Mct) with an estimated value of \$70.6 million (table 1). U.S. imports of natural and synthetic industrial diamond bort, dust, grit, powder, and stone totaled 1,180 Mct valued at \$194 million, and exports totaled 154 Mct valued at \$77.3 million (table 1). The estimated U.S. apparent consumption of industrial diamond bort, dust, grit, powder, and stone totaled 1,170 Mct with an estimated value of \$206 million (table 1). Total industrial diamond output worldwide was estimated by the U.S. Geological Survey (USGS) to be 4.52 billion carats (Gct) valued between \$1.65 and \$2.50 billion. This was the combination of more than 36.0 Mct of natural industrial diamond and about 4.48 Gct 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 computed using unrounded data. The USGS does not conduct surveys of domestic polycrystalline diamond (PCD) producers or domestic chemical vapor deposition (CVD) diamond producers for quantity or value of annual production. Also, trade and consumption quantity and value data are not available for PCD or for CVD diamond.

Production

The USGS conducts an annual survey of domestic industrial diamond producers and U.S. firms that recover diamond wastes. Although most of these companies responded to the 2012 survey, one of the two companies that are producers of synthetic industrial diamond and one of the three industrial diamond recycling firms did not. Production amounts 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.

As one of the world's leading producers of synthetic industrial diamond, the United States accounted for an estimated output of 103 Mct valued at more than \$70.6 million in 2012. Only two U.S. companies produced synthetic industrial diamond during the year—Diamond Innovations, Inc. (Worthington, OH) and Mypodiamond, Inc. (Smithfield, PA).

In 2012, at least eight U.S. companies also manufactured PCD from synthetic diamond grit and powder. These companies were Dennis Tool Co. (Houston, TX), Diamond Innovations, Novatek Inc. (Provo, UT), Precorp Inc. (Provo), Sii MegaDiamond Inc. (Provo), Tempo Technology Corp. (Somerset, NJ), US Synthetic Corp. (Orem, UT), and Western Diamond Products LLC (Salt Lake City, UT).

In the early 2000s, Apollo Diamond, Inc., near Boston, MA, developed and patented a method for growing single, extremely pure, gem-quality diamond crystals by chemical vapor deposition (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, Apollo Diamond discovered the temperature, gas composition, and pressure combination that resulted in the growth of a single diamond crystal. Apollo Diamond produced laboratory-created stones that ranged from 1 to 2 carats (ct). Apollo Diamond sold its large-stone diamonds at prices that averaged less than those of comparable quality natural diamonds. During 2011, Apollo Diamond ceased manufacture of single-crystal CVD diamond for gemstone and industrial use. During 2011 and 2012, SCIO Diamond Technology Corp. (Greenville, SC) acquired all Apollo's diamond growing equipment and machines, cultured diamond gemstone-related technology, inventory, and various intellectual property rights (SCIO Diamond Technology Corp., 2012). SCIO Diamond designed and built a new production facility in Greenville, SC, and relocated all production equipment from Massachusetts to South Carolina. Production began in July 2012, and over the next 9 months, SCIO Diamond produced more than 15,000 ct of laboratory-created single-crystal rough diamond. SCIO Diamond began shipping laboratory-created CVD rough diamonds in September 2012 (SCIO Diamond Technology Corp., 2013).

During 2012, an estimated 36.8 Mct of used industrial diamond worth about \$18.7 million (table 1) was recycled in the United States. 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 2012—Industrial Diamond Laboratory, Inc. (Bronx, NY), International Diamond Services Inc. (Houston, TX), and National Research Co. (Fraser, MI). In addition to these companies, other domestic firms may have recovered industrial diamond in smaller secondary operations.

No commercial diamond mines operated in the United States during 2012. 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.

Synthetic and natural 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 2012. Based on production estimates and trade data, U.S. apparent consumption of industrial diamond during the year increased by 64% to an estimated 1,170 Mct valued at \$206 million compared with 714 Mct valued at \$161 million in 2011 (table 1). This increase was owing to industrial sectors that consume industrial diamond beginning to recover from the economic recession and a decrease in the average cost of natural industrial diamond imports. Apparent consumption was the combination of 609 Mct of natural industrial diamond valued at \$120 million and 561 Mct of synthetic industrial diamond valued at \$85.5 million. By type, apparent consumption was the combination of 1,110 Mct of diamond bort, dust, grit, and powder valued at \$113 million and 62.3 Mct of diamond stone valued at \$92.6 million.

The major consuming industrial sectors of industrial diamond cutting and drilling tools and abrasives in the United States during 2012 were construction, machinery manufacturing, mining services (exploration drilling for minerals, natural gas, and oil), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Within these sectors, stone cutting and highway building/repair, combined, accounted for the majority of demand for 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 minerals, natural gas, and oil. Other applications of diamond bits and reaming shells include foundation testing, masonry drilling, and inspecting concrete. 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/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 (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 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 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.

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. The global market value of industrial diamond and diamond-like films and coatings was estimated to have been more than \$905 million in 2010, and was expected to increase to more than \$1.7 billion by 2015.

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 finding increasing use 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 offer a compelling case for the use of diamond as a base material because of its high Young's Modulus and 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 (HF) 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 market opportunities exceeding \$1 billion and high-volume technology applications in the next 2 to 5 years (SCIO Diamond Technology, Corp., 2012).

Prices

Although diamond prices remained at historically high levels during 2012, they decreased from the record levels of 2011. Diamond prices began to drop in September 2011, and prices of rough diamonds remained at a lower level throughout 2012. This was due to a combination of factors including declining marginal demand from the emerging consumer markets of China and India; the impact of the relatively weak U.S. economy and the financial crisis in the European Union; the devaluation of the Indian rupee; and the pricing policies of the main producers, De Beers' subsidiary Diamond Trading Co. (DTC) and ALROSA, refusing to drop prices despite their clients' struggle to retain profitability. By mid-2012, the clients began rejecting their rough diamond allocations, and DTC and ALROSA were forced to reduce prices (Botswana Diamonds PLC, 2013). Factors that affect the prices of natural gemstone diamond affect prices of natural industrial diamond as well (Roffman, 2011).

Natural and synthetic industrial diamonds differ significantly in price. Natural industrial diamond normally had a more limited

range of values, from about \$0.49 per carat for bort size material to about \$2.50 to \$10 per carat for most stones, with some larger stones having sold for \$200 per carat or more. 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 \$2.50 per carat. Strong and blocky material for sawing and drilling sold for \$2.50 to \$4.00 per carat. Large, synthetic crystals with excellent structure for specific applications sold for several hundred dollars per carat. During 2012, U.S. imports of all types of industrial diamond had an average value of \$0.16 per carat. These imports were a combination of imports of diamond bort, dust, grit, and powder (natural and synthetic) that had an average value of \$0.13 per carat and imports of diamond stone (natural and synthetic) that had an average value of \$15.30 per carat. These average unit values for imported diamond material were lower than and undercut 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 2012; imports were received from 30 countries and exports and reexports were sent to 31 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 2012, U.S. imports of industrial-quality diamond stones (natural and synthetic) decreased by 5% from those of 2011 to 2.33 Mct valued at \$35.7 million (table 2). Imports of diamond dust, grit, and powder (natural and synthetic) increased from those of 2011 to 1,180 Mct valued at \$158 million (table 3).

Reexports account 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 2012, the United States did not export industrial diamond stones, unchanged from 2011. U.S. reexports of industrial diamond stone decreased by 39% from those of 2011 to 0.77 Mct valued at \$33.3 million and an average value of \$43.00 per carat (table 4). U.S. exports of industrial diamond dust, grit, and powder (natural and synthetic) increased by 3% from those of 2011 to 154 Mct valued at \$77.3 million and an average value of \$0.50 per carat. Reexports of industrial diamond dust, grit, and powder (natural and synthetic) increased by 3% from those of 2011 to 19.0 Mct valued at \$10.5 million and an average value of \$0.55 per carat (table 5).

World Industry Structure

Global natural diamond production increased by 4% during 2012 to 128 Mct. The world's leading rough diamond producers, in decreasing order of quantity produced, were

as follows: Russia, producing 34.9 Mct or 27% of total world production; Congo (Kinshasa), with 21.5 Mct (17%); Botswana, with 20.6 Mct (16%); Zimbabwe, with 12.1 Mct (9%); Canada, with 10.5 Mct (8%); Australia, with 9.18 Mct (7%); Angola, with 8.33 Mct (7%); South Africa, with 7.08 Mct (6%); and other countries, with 3.86 Mct (3%) (table 6). Total natural and synthetic industrial diamond output worldwide was estimated by the USGS to be about 4.52 Gct (table 1) valued between \$1.65 and \$2.50 billion.

In 2012, natural industrial diamond was produced in 12 countries (tables 6). Natural industrial diamond production worldwide was estimated to be more than 36.0 Mct, a 3% increase compared with that of 2011. Russia was the leading producing country, followed by Australia, Botswana, and South Africa, in descending order of quantity. These four countries produced almost 94% of the world's natural industrial diamond (table 6). Synthetic industrial diamond production worldwide was estimated to be more than 4.48 Gct, a slight increase compared with that of 2011. 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 2012, 97% of the total global natural and synthetic industrial diamond output 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.

Global natural diamond production increased by 4% during 2012 to 128 Mct. The world's leading rough diamond producers, in decreasing order of quantity produced, were as follows: Russia, producing 34.9 Mct or 27% of total world production; Congo (Kinshasa), with 21.5 Mct (17%); Botswana, with 20.6 Mct (16%); Zimbabwe, with 12.1 Mct (9%); Canada, with 10.5 Mct (8%); Australia, with 9.18 Mct (7%); Angola, with 8.33 Mct (7%); South Africa, with 7.08 Mct (6%); and other countries, with 3.86 Mct (3%) (table 6).

Worldwide diamond exploration spending increased by 16% in 2012 with 65 companies allocating \$520 million, compared with 70 companies allocating \$449 million during 2011. The diamond share of overall worldwide mineral exploration spending was 2.5%. Africa was the leading diamond exploration location (SNL Metals Economics Group, 2012).

Worldwide in 2012, average diamond values decreased by 13.9% to \$100.00 per carat from the 2011 average value of \$116.19 per carat. This decrease was influenced during the first half of the year by fears of global recession stalling demand in the Far East and India. During the second half of the year, prices were influenced by slow economic growth in China and economic decline in India (SNL Metals Economics Group, 2013).

Two new diamond projects were commissioned in 2012. The Karowe Mine in Botswana began operation, and the expansion of the Koidu Mine in Sierra Leone was commissioned in early 2012 (SNL Metals Economics Group, 2013).

World Review

Botswana.—Commissioning of Lucara Diamond Corporation's Karowe Mine was completed in May 2012, and commercial production began in July 2012. During 2012, production was 303,060 ct, and when ramped up to full capacity in 2013, production was expected to be 400,000 carats per year (ct/yr) (SNL Metals Economics Group, 2013).

Canada.—Canada's diamond production was 10.5 Mct during 2012, a decrease of 3% compared with that of 2011. Diamond exploration continued in Canada, with several commercial diamond projects and additional discoveries in Alberta, British Columbia, the Northwest Territories, the Nunavut Territory, Ontario, and Quebec. In 2012, Canada produced 8% of the world's combined natural gemstone and industrial diamond output.

The Ekati Diamond Mine produced 1.45 Mct of diamond from 4.24 million metric tons (Mt) of ore. This was a 29% decrease compared with that of 2011. Approximately 21% of the Ekati 2011 diamond production was industrial-grade material (BHP Billiton Ltd., 2013, p. 10). During 2012, Harry Winston Diamond Corp. entered into an agreement with BHP Billiton Canada Inc. to purchase BHP Billiton's diamond assets, which included its 80% controlling interest in the Ekati Diamond Mine and its diamond sorting and sales facilities for \$500 million (DeMarco, 2012).

The Diavik Diamond Mine produces an average of 2 Mt of ore per year, grading an average of 3.1 carats per metric ton (ct/t). During 2012, Diavik produced 7.2 Mct of rough diamond. At yearend 2012, Diavik estimated the mine's remaining proven and probable reserves to be 18.3 Mt of ore in kimberlite pipes containing 2.9 ct/t of diamond and projected the total mine life to be 16 to 22 years. Diavik began developing an underground mine and substantially completed construction on the project during 2009. The first ore was produced from the underground mine during the first quarter of 2010, with full production expected in 2013. The mine is an unincorporated joint venture between Diavik Diamond Mine Inc. (60%) and Harry Winston Diamond Mines Ltd. (40%) (Diavik Diamond Mine Inc., 2013, p. 6).

The Snap Lake Mine, in the Northwest Territories, is wholly owned by De Beers Canada Inc. The Snap Lake deposit is a tabular-shaped kimberlite dyke rather than the typical kimberlite pipe. The dyke is 2.5 meters thick and dips at an angle of 12° to 15°. The mine's production for 2012 was 870,000 ct (De Beers Canada Inc., 2011; De Beers Group Inc., 2013, p. 23).

The Victor Mine, in northern Ontario on the James Bay coast, also is wholly owned by De Beers Canada. The Victor kimberlite consists of two pipes with surface area of 15 hectares. The Victor reportedly has 27.4 Mt of ore with average ore grade of 0.23 ct/t estimated minable reserves. At full capacity, the open pit mine was expected to produce 600,000 ct/yr, and the mine life was expected to be about 12 years. In 2012, the mine's

production was 690,000 carats (De Beers Group Inc., 2013, p.23; De Beers Canada Inc., undated).

Sierra Leone.—An expansion of the Koidu Mine, wholly owned by Koidu Holdings SA, involved the redevelopment of the K1 kimberlite pipe and commissioning of a new plant to increase capacity to 500,000 ct/yr from 120,000 ct/yr. The plant was commissioned in September 2012 (SNL Metals Economics Group, 2013, p. 26).

Outlook

China is expected to remain the world's leading producer of synthetic industrial diamond, with annual production exceeding 4 Gct. 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 to increase as manufacturing sectors that use industrial diamond recover from the negative effects of the economic recession that started in mid-2008. 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 will work at a much higher frequency or faster speed and can be placed in a higher temperature environment 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 applications 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 better and 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, grit, and powder is expected to remain greater than for natural diamond material. Constant-dollar prices of synthetic diamond products probably will 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)

	2008	2009	2010	2011	2012
United States:					
Natural:					
Secondary production:					
Quantity ^c	17,000 ²	16,700 ²	16,700	17,300	18,300
Value ^c	8,320	8,150	8,190	8,470	8,920
Exports:					
Quantity	5,580	1,510	2,330	3,710	6,500
Value	4,250	2,280	1,780	1,790	4,100
Imports for consumption:					
Quantity	9,130	4,230	6,440	9,750	598,000
Value	42,600	20,400	34,600	51,900	115,000
Synthetic:					
Primary production:					
Quantity ^c	131,000 ²	91,000 ²	93,000	98,200	103,000
Value ^c	132,000	65,100	66,400	67,100	70,600
Secondary production:					
Quantity ^c	17,300 ²	17,200 ²	17,100	17,700	18,600
Value ^c	9,360	9,080	9,120	9,260	9,750
Exports:					
Quantity	112,000	65,500	110,000	145,000	147,000
Value	52,400	31,100	51,000	68,600	73,200
Imports for consumption:					
Quantity	486,000	243,000	591,000	719,000	586,000
Value	74,300	39,300	84,200	94,200	78,300
Apparent consumption, natural and synthetic:³					
Quantity	542,000	305,000	612,000	714,000	1,170,000
Value	210,000	109,000	150,000	161,000	206,000
World:					
Production, natural ^c	49,100 ^r	40,000 ^r	38,200 ^r	35,100 ^r	36,000
Production, synthetic ^c	4,420,000	4,370,000	4,380,000	4,380,000	4,480,000
Production, natural and synthetic ^c	4,470,000 ^r	4,410,000 ^r	4,410,000 ^r	4,420,000 ^r	4,520,000

^cEstimated. ^rRevised.

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

²Reported figure.

³Domestic 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			
	2011		2012		2011		2012	
	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴
Australia	45	845	44	976	3	190	2	20
Belgium	127	749	175	1,120	--	--	5	28
Botswana	842	32,600	505	21,600	15	20	--	--
Congo (Kinshasa)	6	156	5	157	2	17	--	--
Ghana	(5)	3	2	82	--	--	--	--
India	540	617	862	933	15	681	22	416
Namibia	218	1,230	219	1,270	--	--	--	--
Russia	29	190	7	101	--	--	--	--
South Africa	580	10,200	482	8,680	15	243	1	36
Other	22	601	3	157	(5)	11	(5)	128
Total	2,410	47,200	2,300	35,100	50	1,160	30	628

-- 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.

³HTS codes 7102.21.1010 and 7102.21.1020.

⁴Customs value.

⁵Less than ½ unit.

Source: U.S. Census Bureau.

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

(Thousand carats and thousand dollars)

Country	Natural ²				Synthetic ³			
	2011		2012		2011		2012	
	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴	Quantity	Value ⁴
Belgium	273	210	1,230	357	1,720	483	1,100	283
China	1,940	1,170	447,000	33,300	575,000	44,600	446,000	33,200
Germany	40	42	45	35	20	21	11	8
Hong Kong	--	--	204	78	28	18	204	79
India	1,880	1,210	1,980	1,210	1,420	939	506	316
Ireland	490	353	59,300	25,200	62,700	26,800	58,900	24,900
Israel	--	--	143	77	--	--	143	77
Italy	--	--	9	9	6	4	7	5
Japan	--	--	1,290	1,750	1,380	1,850	1,290	1,750
Korea, Republic of	1	3	26,300	9,350	33,300	11,400	26,300	9,350
Mexico	10	8	211	37	65	42	--	--
Romania	--	--	25,000	2,110	16,600	1,590	25,000	2,110
Russia	1,930	467	14,300	2,170	13,700	2,410	14,200	2,100
Switzerland	314	183	8,670	2,670	7,550	2,320	8,200	2,430
Taiwan	--	--	1,550	144	276	28	1,520	136
Ukraine	--	--	65	14	20	14	65	14
United Arab Emirates	84	122	--	--	--	--	--	--
United Kingdom	234	175	2,650	944	3,210	780	2,510	836
Other	134	129	5,210	600	1,970	341	--	470
Total	7,320	4,070	595,000	80,000	719,000	93,600	586,000	78,000

-- 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 graphite.

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

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			
	2011		2012	
	Quantity	Value ³	Quantity	Value ³
Reexports:				
Belgium	492	10,500	240	8,440
Brazil	31	187	8	81
Canada	183	1,070	203	8,720
Germany	11	539	8	472
Hong Kong	45	810	26	684
Israel	32	77	3	64
Japan	136	10,700	104	8,720
Korea, Republic of	28	1,860	29	1,250
South Africa	30	79	8	36
United Kingdom	178	3,740	105	3,680
Other	96	2,530	40	1,170
Total	1,260	32,100	774	33,300

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.

³Customs value.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY¹

(Thousand carats and thousand dollars)

Country	Natural ²				Synthetic ²			
	2011		2012		2011		2012	
	Quantity	Value ³	Quantity	Value ³	Quantity	Value ³	Quantity	Value ³
Exports:								
Austria	13	4	--	--	2,960	1,010	1,490	1,230
Belgium	--	--	35	38	448	106	440	111
Brazil	--	--	15	4	4,170	1,140	3,800	1,010
Canada	195	534	1,990	1,950	5,930	4,120	3,470	2,420
Germany	86	38	60	33	3,660	1,340	2,610	843
Hong Kong	72	37	101	43	166	92	212	110
India	31	6	9	13	3,200	1,060	2,910	1,080
Ireland	42	53	40	66	39,900	14,700	40,100	15,500
Israel	--	--	431	95	56	36	25	26
Italy	7	4	--	3	3,530	835	4,320	899
Japan	7	6	47	69	35,100	17,400	39,100	18,800
Korea, Republic of	1,800	348	1,840	429	12,700	8,960	14,700	10,500
Mexico	427	217	546	295	891	231	862	383
Singapore	--	--	--	--	640	1,250	1,350	1,940
Spain	--	--	--	--	77	28	86	23
Switzerland	393	212	486	453	8,550	7,410	12,200	10,800
Taiwan	5	12	--	--	5,820	2,360	5,130	2,520
Thailand	--	--	--	--	5,140	1,430	4,600	1,420
United Kingdom	521	196	797	482	3,050	825	2,300	656
Other	113	119	96	126	8,740	4,240	7,280	2,900
Total	3,710	1,790	6,500	4,100	145,000	68,600	147,000	73,200
Reexports:								
Belgium	51	150	44	86	158	80	143	30
Brazil	--	--	--	--	733	285	437	217
Canada	128	528	2,610	2,630	9,240	6,500	5,660	3,510
Germany	5	15	--	--	31	8	54	12
Ireland	18	16	7	18	258	102	675	389
Italy	--	--	--	--	--	--	18	4
Japan	126	223	144	244	5,360	1,220	5,880	1,800
Korea, Republic of	53	75	38	53	891	351	972	272
Mexico	50	86	37	95	59	33	410	122
United Kingdom	33	46	143	82	55	59	45	11
Other	132	499	40	39	1,090	767	1,600	888
Total	596	1,640	3,070	3,250	17,900	9,400	15,900	7,260
Grand total	4,310	3,420	9,560	7,350	163,000	78,000	163,000	80,400

-- 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 7105.10.0025 for synthetic and 7105.10.0010 for natural.

³Customs value.

Source: U.S. Census Bureau.

TABLE 6
NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE^{1, 2, 3}

(Thousand carats)

Country and type	2008	2009	2010	2011	2012
Gemstones:					
Angola ^c	8,020 ^r	8,310 ^r	7,530 ^r	7,500 ^r	7,500
Australia ^c	149 ^r	156 ^r	100	78 ^r	92
Botswana ^c	22,600 ^r	12,400 ^r	15,400 ^r	16,000 ^r	14,400
Brazil, unspecified ^{4, 5}	80 ^r	21	25	46 ^r	46
Canada, unspecified ^{4, 5}	14,803	10,946	11,804 ^r	10,795	10,451
Central African Republic ^c	302	249	241 ^r	259 ^r	293
China, unspecified ^{4, 5}	69 ^r	46 ^r	17 ^r	(6) ^r	2
Congo (Brazzaville) ^{4, 5}	22 ^r	14 ^r	76 ^r	15 ^r	10
Congo (Kinshasa) ^c	33,402	21,298	20,166	19,249	21,524
Ghana, unspecified ^{4, 5}	643 ^r	376 ^r	334 ^r	302 ^r	233
Guinea ^c	2,480 ^r	557	299 ^r	243 ^r	213
Guyana, unspecified ^{4, 5}	193 ^r	97 ^r	46 ^r	51 ^r	44
India ^c	--	2	5	3	7
Indonesia ^c	24	9	--	--	--
Lesotho, unspecified ^{4, 5}	253 ^r	92 ^r	109 ^r	224 ^r	479
Liberia, unspecified ^{4, 5}	47	28	27	42	42
Namibia, unspecified ^{4, 5}	2,435	1,192	1,693	1,256 ^r	1,629
Russia ^c	21,900 ^r	20,600 ^r	20,700 ^r	20,900 ^r	20,700
Sierra Leone ⁷	223	241	263 ^r	214 ^r	406
South Africa ^c	5,160 ^r	2,460 ^r	3,550 ^r	2,820 ^r	2,830
Tanzania ^c	202	155	60 ^r	35 ^r	108
Togo, unspecified ^{4, 5}	9	(6)	(6)	(6)	(6)
Venezuela ^c	4 ^r	3 ^r	1 ^r	-- ^r	--
Zimbabwe ^c	725 ^r	876 ^r	7,670 ^r	7,730 ^r	11,000
Total	114,000^r	80,200^r	90,100^r	87,800^r	92,000
Industrial:^c					
Angola	891 ^r	924 ^r	836 ^r	833 ^r	833
Australia	14,800 ^r	15,400 ^r	9,880 ^r	7,750 ^r	9,090
Botswana	9,680 ^r	5,320 ^r	6,610 ^r	6,870 ^r	6,170
Central African Republic	75 ^r	62	60 ^r	65 ^r	73
Congo (Kinshasa)	88 ^r	54 ^r	305 ^r	61 ^r	41
Guinea	620 ^r	139	75 ^r	61 ^r	53
India	--	7	13	9	20
Indonesia	6	2	--	--	--
Russia	15,000	14,100 ^r	14,200 ^r	14,300 ^r	14,200
Sierra Leone ⁸	149	160	175 ^r	143 ^r	135
South Africa	7,740 ^r	3,680 ^r	5,320 ^r	4,230 ^r	4,246
Tanzania	36	27	11 ^r	6 ^r	19
Venezuela	6	5	1	-- ^r	--
Zimbabwe	73 ^r	88 ^r	768 ^r	774 ^r	1,100
Total	49,100^r	40,000^r	38,200^r	35,100^r	36,000
Grand total	163,000^r	120,000^r	128,000^r	123,000^r	128,000

See footnotes at end of table.

TABLE 6—Continued
NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE^{1, 2, 3}

⁶Estimated. ⁵Revised. -- Zero.

¹Estimated data and subtotals are rounded to no more than three significant digits; may not add to unrounded, reported grand totals shown.

²Subcategory estimates are based on reported country totals, in carats. Includes data available through June 19, 2014.

³In addition to the countries listed, Belarus, Germany, Ireland, Nigeria, the Republic of Korea, and Sweden produced natural diamond, but information is inadequate to formulate reliable estimates of output levels.

⁴Includes near-gem and cheap-gem qualities.

⁵Reported figure.

⁶Less than ½ unit.

⁷From 2008 to 2011, production was estimated to be about 60% gem quality. In 2012, production is estimated to be about 75% gem quality.

⁸From 2008 to 2011, production was estimated to be about 40% industrial quality. In 2012, production is estimated to be about 25% industrial quality.

Source: Kimberley Process Certification Scheme