2006 Minerals Yearbook

DIAMOND, INDUSTRIAL

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Diamond, Industrial

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In 2006, U.S. synthetic diamond production was estimated to be 258 million carats with an estimated value of $259 million. U.S. imports of all forms of industrial diamond totaled about 373 million carats valued at almost $108 million, while exports totaled more than 101 million carats valued at almost $85.6 million. The estimated U.S. apparent consumption of all forms of industrial diamond was 565 million carats with an estimated value of $302 million.

Diamond is best known as a gemstone, but some of its unique properties make it ideal for many industrial and research applications as well. Current information on gem-grade diamond can be found in the U.S. Geological Survey (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. Production and consumption quantities and values reported are estimated to avoid disclosing company proprietary data and still provide useful data on the overall market. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

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 (Ravi, 1994, p. 537). Because it is the hardest substance known, 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, diamond has proven to be more cost-effective in many industrial processes because it cuts faster and lasts longer than alternative abrasive materials (Boucher, 1997, p. 26.6). 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 synthetic and natural diamond 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 (Boucher, 1996). It is for these reasons that synthetic diamond accounts for nearly 99% of the industrial diamond used in the United States and about 88% of the industrial diamond used in the world.

Legislation and Government Programs

Congress has authorized the sale of all diamond in the National Defense Stockpile (NDS), which is managed by the Defense National Stockpile Center (DNSC). The entire remaining inventory of the stockpiled diamond stones was authorized for sale in the NDS's fiscal year 2006 annual plan. One sale was held in October in which 126,523 carats valued at approximately $3.4 million were sold (Deister, 2006). At yearend 2006, the DNSC reported an NDS remaining inventory of about 393,000 carats of industrial diamond stone with a market value of $4.37 million (Jenkins, 2006). The DNSC planned to conduct additional sales until all NDS diamond stone stocks are sold.

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 2006 survey, one of the two U.S. primary producers of industrial diamond and one of the four industrial diamond recycling firms withheld from reporting on the survey data that they deemed to be proprietary. To protect the proprietary data of other producers, only estimates of U.S. primary and secondary output are provided in this review.

As one of the world's leading producers of synthetic industrial diamond, the United States accounted for an estimated output of 258 million carats valued at more than $259 million in 2006. Only two U.S. companies produced synthetic industrial diamond during the year—Diamond Innovations, Inc., Worthington, OH, and Mypodiamond, Inc., Smithfield, PA.

In 2006, nine companies also manufactured polycrystalline diamond (PCD) from synthetic diamond grit and powder. These companies were Dennis Tool Co., Houston, TX; Diamond Innovations; Novatek Inc., Provo, UT; Phoenix Crystal Corp., Ann Arbor, MI; Precorp Inc., Provo; SII Megadiamond Industries Inc., Provo; Tempo Technology Corp., Somerset, NJ; U.S. Synthetics Corp., Orem, UT; and Western Diamond Products, Salt Lake City, UT.

It is estimated that about 34.8 million carats of used industrial diamond was recycled in the United States during 2006. 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; most of this material was recovered from within the production operations of the PCD-producing companies.

The recovery and sale of industrial diamond was the principal business of four U.S. companies in 2006—Industrial Diamond Laboratory Inc., Bronx, NY; Industrial Diamond Powders Co., Pittsburgh, PA; 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.

There have been no commercially operated diamond mines in the United States since 2002. Diamond was produced at the Kelsey Lake diamond mine, located close to the Colorado-Wyoming State line near Fort Collins, CO, for several years until April 2002. The Kelsey Lake property has now been fully reclaimed.

Studies by the Wyoming Geological Survey have shown that Wyoming has the potential for a $1 billion diamond mining business. Wyoming has many of the same geologic conditions that are found in the diamond-producing areas of Canada, and there is evidence of hundreds of kimberlite pipes in the State. There have been 20 diamondiferous kimberlite pipes and 1 diamondiferous mafic breccia pipe identified in southern Wyoming. The State Line and the Iron Mountain kimberlite fields of Wyoming are two of the largest kimberlite fields in the United States, and the Leucite Hills lamproite field in Wyoming is the largest lamproite field in the United States. Several diamond mining firms have shown interest in the northern Colorado and southern Wyoming area (Associated Press, 2002).

The success of Canadian diamond mines has also stimulated some interest in exploring for commercially feasible diamond deposits in the United States outside of Colorado and Wyoming, in Alaska, Minnesota, and Montana. Parts of Alaska have similar geologic terrain to the Northwest Territories; and some diamond indicator minerals, as well as some microscopic diamonds have been found near Anchorage, AK. This has lead to exploratory drilling by two Canadian companies. University of Minnesota geologists, teamed with an Australian mining company, have conducted a soil sampling program in Minnesota exploring for diamond and other mineral deposits. The samples are being analyzed by Australia's WMC Resources Ltd., and they think that there is good chance of success owing to similarities between the geology in Canada and Minnesota (Diamond Registry Bulletin, 2005). Diamond deposit exploration is also being conducted near Lewistown, MT; a diamond-bearing kimberlite was found in a 32.4-hectare site known as the Homestead property. Preliminary tests have shown the presence of microscopic diamonds. Diamonds have been found in the stream beds and glacial valleys of Montana for years (Associated Press, 2004).

Consumption

The United States remained the world's leading market for industrial diamond in 2006. Based on production estimates, trade data, and adjustments for Government stockpile sales, apparent U.S. consumption of industrial diamond during the year increased by about 28% to an estimated 565 million carats valued at $302 million. This apparent consumption was the combination of 564 million carats of diamond bort, grit, dust, and powder valued at $298 million and 1.30 million carats of diamond stone valued at $5.23 million.

The major consuming industries of industrial diamond in the United States during 2006 were construction, machinery manufacturing, mining services (exploration drilling for minerals, oil, and gas), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Within these sectors, stone cutting and highway building/repair together made up the largest 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 gas, mineral, and oil exploration. 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 drilling 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 drilling 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 much as 1 meter in diameter.

Loose powders made with synthetic diamond for polishing are used primarily to finish cutting tools, gemstones, jewel bearings, optical surfaces, 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.

The use of polycrystalline diamond compacts (PDCs) and polycrystalline diamond shapes (PDSs) continues to increase for many of the applications cited above, including some of those that employ natural diamond. The use of PDCs, PDSs, and matrix-set synthetic diamond grit for drilling bits and reaming shells has increased in recent years. 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.

Apollo Diamond, Inc., near Boston, MA, has developed and patented a method for growing extremely pure, gem-quality diamond with flawless crystal structure by chemical vapor deposition (CVD). The CVD technique transforms carbon into plasma, which then is precipitated onto a substrate as diamond. CVD has been used for more than a decade to cover large surfaces with microscopic diamond crystals, but until this process, no one had discovered the combination of temperature, gas composition, and pressure that resulted in the growth of a single diamond crystal. CVD diamond precipitates as nearly 100% pure, almost flawless diamond, and therefore may not be distinguishable from natural diamond by some tests (Davis, 2003).

CVD diamond's highest value besides its use as gemstones is as a material for high-tech uses. CVD diamond could be used to make extremely powerful lasers; to create cell phones that fit into a watch and storage devices for MP3 players that could store 10,000 movies, not just 10,000 songs; to create frictionless medical replacement joints; or as coatings for cars that would not scratch or wear out. The greatest potential use for CVD diamond is in computer technology (Maney, 2005). For diamond to be a practical material for use as a semiconductor, it must be affordably grown in large wafers. After Apollo's process and technology are fully developed, CVD diamond could possibly be grown for prices as low as $5 per carat. CVD growth is limited only by the size of the seed placed in the diamond growing chamber. At the moment, the company is producing 10-millimeter wafers but predicts it will reach about 10 times that in the near future (Davis, 2003). Scientists have said that diamond computer chips are more durable because they can work at temperatures up to 1,000° C, while silicon computer chips stop working at about 150° C. This means that diamond computer chips could work at a much higher frequency or faster speed and could be placed in a high-temperature environment (Diamond Registry Bulletin, 2003).

In early 2004, scientists at the Carnegie Institution of Washington's Geophysical Laboratory published a study showing that researchers grew diamond crystals by a special CVD process at very high growth rates. They were able to grow gem-sized crystals in a day—a growth rate 100 times faster than other methods used before. This is a new way of producing diamond crystals for such new applications as diamond-based electronic devices and next generation cutting tools (Willis, 2004). By early 2005, the Carnegie Institution's Geophysical Laboratory and the University of Alabama had jointly developed and patented the CVD process and apparatus to produce 10-carat, ½-inch thick single diamond crystals at very rapid growth rates (100 micrometers per hour). This faster CVD method uses microwave plasma technology and allows multiple crystals to be grown simultaneously. This size is about five times that of commercially available lab-created diamonds produced by high pressures and high temperatures (HPHT) methods and other CVD techniques (Willis, 2004; Carnegie Institution of Washington, 2005; Science Blog, 2005).

Both Apollo Diamond and the Carnegie Institution have noted that their diamonds produced by the CVD method are harder than natural diamonds and diamonds produced by HPHT methods.

Prices

Natural and synthetic industrial diamonds differ significantly in price. Natural industrial diamond normally has a more limited range of values. Its price varies from an average of $0.94 per carat for bort size material to about $2 to $10 per carat for most stones, with some larger stones selling for up to $200 per carat.

Synthetic industrial diamond has a much larger price range than natural diamond. Prices of synthetic diamond vary according to particle strength, size, shape, crystallinity, and the absence or presence of metal coatings. In general, synthetic diamond prices for grinding and polishing range from as low as $0.37 to $1.67 per carat. Strong and blocky material for sawing and drilling sells for $1.50 to $3.50 per carat. Large synthetic crystals with excellent structure for specific applications sell for many hundreds of dollars per carat (Law-West, 2002, p. 23.8).

Foreign Trade

The United States continued to lead the world in industrial diamond trade in 2006; imports were received from 49 countries, exports were sent to 44 countries, and reexports were sent to 33 countries (tables 1-4). Although the United States has been a major producer of synthetic diamond for decades, growing domestic markets have become more reliant on foreign sources of industrial diamond in recent years. U.S. markets for natural industrial diamond always have been dependent on imports and secondary recovery operations because there has been no domestic production of natural diamond.

During 2006, U.S. imports of industrial-quality diamond stones (natural and synthetic) increased by 3% from those of 2005 to about 2.17 million carats valued at more than $27.4 million (table 1). Imports of diamond dust, grit, and powder (natural and synthetic) increased by 30% from those of 2005 to 371 million carats valued at almost $80.5 million (table 2).

Reexports may account for a significant portion of total exports/reexports; therefore, exports and reexports are listed separately in tables 3 and 4 so that U.S. trade and consumption can be calculated more accurately. During 2006, U.S. exports of industrial diamond stones increased from those of 2005 to 7,450 carats valued at $16,300, and U.S. reexports of industrial diamond stone increased by 9% from those of 2005 to 1.56 million carats valued at $26.8 million (table 3). U.S. exports of industrial diamond dust, grit, and powder (natural and synthetic) decreased by 2% from those of 2005 to 90.3 million carats valued at $49.7 million, and reexports of industrial diamond dust, grit, and powder (natural and synthetic) decreased by 19% from those of 2005 to 9.41 million carats valued at $9.09 million (table 4).

World Industry Structure

In 2006, industrial diamond was produced in 28 countries (tables 5-6). Total industrial diamond output worldwide was estimated by the USGS to be about 646 million carats valued between $646 million and $1 billion. Natural industrial diamond production worldwide was estimated to be more than 79.9 million carats, a 7% decrease compared with that of 2005. Congo (Kinshasa) was the leading producing country, followed by Australia and Russia, in descending order of quantity. These three countries produced more than 74% of the world's natural industrial diamond (table 5). Synthetic industrial diamond production worldwide was estimated to be more than 566 million carats, a slight increase compared with that of the previous year. The United States was the leading producing country, followed by Russia, Ireland, and South Africa, in descending order of quantity. These four countries produced about 81% of the world's synthetic industrial diamond (table 6).

In addition to the countries listed in table 6, Germany and the Republic of Korea produced synthetic diamond, but specific data on their output could not be confirmed. China may have produced more than the output listed in the table (Wilson Born, President, National Research Co., oral commun., March 17, 2004).

In 2006, 80% of the total global natural and synthetic industrial diamond output was produced in Ireland, Japan, Russia, South Africa, and the United States. Synthetic diamond accounted for more than 88% of global diamond production and consumption.

World Review

Canada.—The Ekati Diamond Mine, Canada's first operating commercial diamond mine, completed its eighth full year of production in 2006. Ekati produced 2.52 million carats of diamond from 4.48 million metric tons (Mt) of ore (BHP Billiton Ltd., 2007). BHP Billiton Ltd. has an 80% controlling ownership in Ekati, which is in the Northwest Territories in Canada. Ekati has estimated reserves of 60.3 Mt of ore in kimberlite pipes that contain 54.3 million carats of diamond, and BHP Billiton projected the mine life to be 25 years. Approximately one-third of the Ekati diamond production is industrial-grade material (Darren Dyck, senior project geologist, BHP Diamonds, Inc., oral commun., May 27, 2001).

The Diavik Diamond Mine, also in the Northwest Territories, completed its fourth full year of production. In 2006, Diavik produced 9.8 million carats of diamond from two adjacent kimberlite pipes located within the same pit (Diavik Diamond Mines Inc., 2007). The mine will also be producing from a third kimberlite pipe by yearend 2007. Diavik has estimated the mine's remaining proven and probable reserves to be 24.5 Mt of ore in kimberlite pipes, containing 81.7 million carats of diamond, and projected the mine life to be 16 to 22 years (Diavik Diamond Mine Dialogue, 2007). The mine is an unincorporated joint venture between Diavik Diamond Mines Inc. (60%) and Aber Diamond Mines Ltd. (40%). The mine is expected to produce a total of about 110 million carats of diamond at a rate of 8 million carats per year (Diavik Diamond Mines Inc., 2000, p. 10-12; Diavik Diamond Mine Dialogue, 2007).

Canada's third diamond mine, the Jericho Diamond Mine wholly owned by Tahera Diamond Corp., began production of rough diamonds during the first quarter of 2006 and declared commercial production on July 1, 2006. The Jericho mine is located in Nunavut. Jericho experienced startup difficulties, which persisted throughout 2006, but 539,000 t of kimberlite ore was processed, resulting in production of 296,000 carats. Tahera estimated the Jericho Diamond Mine's reserves at 2.6 Mt of ore and 3.11 million carats of diamond.

Diamond exploration is continuing in Canada, with several other commercial diamond projects and additional discoveries located in Alberta, British Columbia, the Northwest Territories, the Nunavut Territory, Ontario, and Quebec. Canada produced about 7% of the world's combined natural gemstone and industrial diamond production in 2006.

Outlook

The United States will most likely continue to be the world's leading market for industrial diamond well into the next decade. The United States also is expected to remain a significant producer and exporter of industrial diamond. The strength of U.S. demand will depend on the vitality of the Nation's industrial base and on how well the diamond life cycle cost-effectiveness compares with competing materials that initially are less expensive. 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 (Advanced Materials & Processes, 1998). In view of the many advantages that come from increased tool life and reports that diamond film surfaces can increase durability by a factor of 50, much wider use of diamond as an engineering material is expected.

The most dramatic increase in domestic use of industrial diamond is likely to be in the construction sector as the Nation builds and repairs the U.S. highway system in its implementation of the Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2005 (Public Law 109-59), which was passed by the U.S. House of Representatives on March 10, 2005, and by the U.S. Senate on May 17, 2005. This Act authorized appropriations for fiscal years 2005 through 2009 for Federal-aid highway programs out of the Highway Trust Fund (U.S. House of Representatives, 2005). Demand for saw-grade diamond alone is expected to increase in 2007 if goals mandated by the Act for the repair and replacement of roads, bridges, and other components in the transportation infrastructure of the country are fulfilled.

PCD for abrasive tools and wear parts will 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 (Wilson Born, President, National Research Co., written commun., 1998).

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.

World demand for industrial diamond will continue to increase during the next few years. Constant dollar prices of synthetic diamond products, including CVD diamond films, will decline as production technologies become more cost effective and as competition increases from low-cost producers in China and Russia.

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

(Thousand carats and thousand dollars)

	Natural industrial diamond stones[2]				Miners' diamond, natural and synthetic[3]			
	2005		2006		2005		2006	
Country	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]
Australia	69	456	36	366	5	108	1	56
Belgium	49	321	158	193	32	198	28	178
Bhutan	--	--	--	--	--	--	1	23
Botswana	794	14,100	797	14,700	(5)	5	32	761
Brazil	8	130	--	--	5	16	1	4
Canada	(5)	11	1	74	1	42	1	24
Central African Republic	--	--	1	2	--	--	--	--
Congo (Kinshasa)	87	403	113	530	4	169	2	86
Ghana	97	721	121	221	68	144	1	53
Guinea	--	--	3	29	--	--	3	63
Guyana	(5)	23	(5)	7	(5)	13	--	--
India	81	37	138	62	33	82	89	64
Ireland	--	--	1	3	--	--	--	--
Israel	--	--	(5)	76	--	--	--	--
Namibia	261	1,360	297	1,630	1	7	1	16
Russia	134	2,890	115	3,020	--	--	--	--
Saudi Arabia	--	--	3	15	--	--	1	3
South Africa	356	7,710	216	4,850	4	215	10	140
Switzerland	5	11	--	--	6	16	--	--
Tanzania	2	39	2	35	--	--	--	--
United Kingdom	4	121	--	--	14	118	1	147
Total	1,950	28,300	2,000	25,800	172	1,130	171	1,620

-- Zero.

[1]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.

[3]HTS codes 7102.21.1010 and 7102.21.1020.

[4]Customs value.

[5]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Synthetic[2]				Natural[2]			
	2005		2006		2005		2006	
Country	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Australia	55	64	27	19	32	12	14	8
Austria	32	22	--	--	--	--	--	--
Belgium	8,650	3,630	4,400	1,660	962	512	1,130	574
Botswana	48	34	4	3	--	--	2	3
Brazil	138	117	89	56	21	25	40	46
Canada	15	11	8	5	430	14	4	2
China	119,000	14,600	210,000	19,400	506	252	867	458
Congo (Brazzaville)	--	--	--	--	--	--	5	3
Czech Republic	10	7	9	6	--	--	--	--
France	--	--	16	9	17	29	36	61
Germany	107	37	256	117	155	41	--	--
Ghana	130	57	54	27	--	--	--	--
Guinea	--	--	--	--	--	--	7	4
Hong Kong	4,460	1,050	2,280	1,460	--	--	--	--
India	1,460	547	1,220	534	275	114	448	203
Ireland	83,900	38,200	89,000	38,500	1,570	897	1,970	1,230
Israel	--	--	167	37	--	--	29	21
Italy	1,370	660	513	216	84	74	112	46
Japan	8,470	5,530	5,270	3,870	14	24	10	5
Korea, Republic of	10,500	4,020	16,400	4,660	45	22	41	34
Macau	--	--	110	46	2	3	--	--
Mexico	229	100	111	50	115	25	139	70
Namibia	13	46	--	--	118	322	57	81
Portugal	--	--	--	--	--	--	40	10
Romania	1,290	196	786	204	--	--	--	--
Russia	19,300	1,780	24,100	2,280	44	20	443	247
South Africa	--	--	96	95	61	67	16	64
Spain	616	49	30	8	1	2	6	10
Switzerland	1,070	1,210	746	1,040	319	425	232	279
Taiwan	277	83	180	31	27	5	--	--
Ukraine	14,600	889	4,410	367	24	10	10	5
United Arab Emirates	128	56	478	214	--	--	--	--
United Kingdom	2,760	1,180	3,700	1,440	697	294	1,160	584
Uruguay	--	--	14	6	--	--	--	--
Vanuatu	--	--	20	3	--	--	--	--
Total	278,000	74,200	364,000	76,400	5,520	3,190	6,810	4,050

-- Zero.

[1]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 7105.10.0020, 7105.10.0030, and 7105.10.0050 for synthetic and 7105.10.0011 and 7105.10.0015 for natural.

[3]Customs value.

Source: U.S. Census Bureau.

TABLE 3

U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND STONES, BY COUNTRY[1]

(Thousand carats and thousand dollars)

Country	Industrial unworked diamonds[2]			
	2005		2006	
	Quantity	Value[3]	Quantity	Value[3]
Exports:				
Canada	--	--	7	16
United Kingdom	(4)	18	--	--
Total	(4)	18	7	16
Reexports:				
Australia	(4)	28	(4)	8
Belgium	469	7,830	380	8,500
Brazil	4	57	14	164
Bulgaria	--	--	1	52
Canada	149	923	108	924
China	11	86	--	--
Germany	10	385	15	579
Hong Kong	153	1,090	651	2,510
India	9	628	4	12
Ireland	10	32	2	35
Israel	6	1,320	61	97
Japan	162	7,810	145	8,160
Korea, Republic of	28	1,410	22	1,470
Mexico	(4)	(4)	--	--
Russia	--	--	(4)	300
South Africa	15	41	17	41
Switzerland	140	180	--	--
Taiwan	8	218	2	61
Thailand	--	--	(4)	10
United Arab Emirates	152	1,690	13	1,590
United Kingdom	94	2,190	117	2,320
Venezuela	1	3	5	12
Other	19 r	170 r	--	--
Total	1,430	26,100	1,560	26,800
Grand total	1,430	26,100	1,560	26,900

[r]Revised. -- Zero.

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

[2]Harmonized Tariff Schedule of the United States code 7102.21.0000.

[3]Customs value.

[4]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Synthetic[2]				Natural[2]			
	2005		2006		2005		2006	
Country	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Exports:								
Austria	144	47	113	57	--	--	121	31
Belgium	624	197	402	169	168	78	1	3
Brazil	3,390	1,810	3,330	1,470	--	--	291	48
Canada	3,760	3,000	5,020	3,760	229	431	270	580
France	--	--	2	4	19	36	--	--
Germany	1,320	455	1,120	441	102	99	208	98
Greece	720	215	611	144	--	--	--	--
Hong Kong	500	187	125	66	17	30	14	34
India	1,570	745	2,340	854	6	15	55	14
Ireland	23,500	11,600	21,300	11,200	318	417	296	406
Israel	384	134	135	66	104	33	--	--
Italy	4,170	1,860	4,050	1,640	37	20	20	14
Japan	21,400	9,830	23,300	13,000	493	501	119	79
Korea, Republic of	10,100	4,560	8,210	4,140	374	131	219	63
Macau	207	172	91	61	--	--	--	--
Malaysia	112	169	92	395	60	126	6	15
Mexico	459	163	166	59	294	258	80	54
Philippines	134	103	31	18	57	14	7	5
Singapore	1,460	1,450	552	1,050	64	128	53	61
Spain	319	87	276	73	124	29	21	10
Switzerland	3,850	3,760	5,330	4,540	825	1,180	285	166
Taiwan	1,440	1,440	4,220	1,860	36	30	7	3
Thailand	2,650	1,020	4,060	1,210	10	15	22	13
United Kingdom	1,460	896	589	228	283	114	57	76
Other	4,420	1,800	2,550	1,060	791	1,710	157	324
Total	88,000	45,700	88,000	47,600	4,410	5,400	2,310	2,090
Reexports:								
Austria	377	117	139	45	181	36	106	28
Belgium	258	213	248	195	412	299	195	307
Brazil	59	25	99	32	123	29	--	--
Canada	965	861	1,290	1,410	110	167	153	137
Germany	705	265	596	210	456	158	294	189
India	106	31	68	24	31	13	7	14
Ireland	136	169	310	315	241	67	18	15
Italy	450	114	142	64	147	38	39	15
Japan	2,330	1,310	1,580	594	77	10	0	0
Korea, Republic of	1,710	705	1,260	861	805	189	18	4
Macau	186	194	431	131	135	21	--	--
Mexico	116	72	114	47	18	16	2	10
United Arab Emirates	--	--	--	--	600	2,540	1,590	3,970
United Kingdom	157	101	79	70	252	129	79	86
Other	318	199	232	200	185	55	327	121
Total	7,870	4,370	6,590	4,200	3,770	3,770	2,820	4,890
Grand total	95,900	50,100	94,600	51,800	8,180	9,170	5,130	6,990

-- Zero.

[1]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 7105.10.0025 for synthetic and 7105.10.0010 for natural.

[3]Customs value.

Source: U.S. Census Bureau.

TABLE 5

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE[1, 2, 3]

(Thousand carats)

Country and type[4]	2002	2003	2004	2005	2006
Gemstones:					
Angola[e]	4,520	5,130	5,490	6,300 r	7,000
Australia	15,136	13,981	6,058	8,577 r	7,305
Botswana[e]	21,297	22,800	23,300	23,900	24,000
Brazil[e]	500 [5]	400	300 [5]	300	300
Canada	4,937	10,756	12,618	12,300 e	12,350
Central African Republic[e]	312	250	263	285 r	315
China[e]	100	100	100	100	100
Congo (Kinshasa)	4,223	5,381	6,180	6,100 r, e	5,600
Côte d'Ivoire	205	154	201 e	201 e	200
Ghana	770	724 r	725 r	850 r	780
Guinea	368	500 r	555 r	413 r	355
Guyana	248	413	445 r	340 r, e	300
Liberia[e]	52 r	26 r	7 r	7 r	7
Namibia	1,562	1,481	2,004	1,902 r	2,200
Russia[e]	17,400	20,000	21,400	23,000	23,400
Sierra Leone[e]	162 [5]	233	318	395	360
South Africa	4,351	5,144	5,800 r, e	6,400 r, e	6,240 e
Tanzania[e]	204 [5]	201	258	185 r	195
Venezuela	46	11	40 e	46 e	45 e
Other[6]	42	131 r	186 r	241 r	236
Total	76,400	87,800 r	86,200 r	91,800 r	91,300
Industrial:					
Angola[e]	502	570	610	700 r	800
Australia	18,500	17,087	18,172 r	25,730 r	21,915
Botswana[e]	7,100	7,600	7,800	8,000	8,000
Brazil[e]	600	600	600	600	600
Central African Republic[e]	104	83	88	95 r	105
China[e]	955	955	960	960	965
Congo (Kinshasa)	17,456	21,600	24,700	24,200 r, e	22,400 e
Côte d'Ivoire	101	76	99 e	99 e	99 e
Ghana[e]	193	180 r	180 r	213 r	190
Guinea[e]	123	167 r	185 r	138 r	118
Liberia[e]	28	14 r	4 r	4 r	4
Russia[e]	11,600	13,000	14,200	15,000	15,000
Sierra Leone	190	274 e	374 e	274 r	252
South Africa	6,526	7,540	8,500 e	9,400 r, e	9,130
Tanzania[e]	36	36	46	35 r	35
Venezuela	61	24	60 e	69 e	70 e
Other[7]	81	82	121	190	189
Total	64,200	69,900	76,700 r	85,700 r	79,900
Grand total	141,000	158,000	163,000 r	178,000 r	171,000

[e]Estimated. [r]Revised.

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

[2]Table includes data available through June 5, 2007.

[3]In addition to the countries listed, Nigeria and the Republic of Korea produce natural diamond and synthetic diamond, respectively, but information is inadequate to formulate reliable estimates of output levels.

[4]Includes near-gem and cheap-gem qualities.

[5]Reported figure.

[6]Includes Cameroon, Congo (Brazzaville), Gabon (unspecified), India, Indonesia, Togo (unspecified), and Zimbabwe.

[7]Includes Congo (Brazzaville), India, Indonesia, and Zimbabwe.

TABLE 6

SYNTHETIC DIAMOND: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand carats)

Country	2002	2003	2004	2005	2006
Belarus	25,000	25,000	25,000	25,000	25,000
China	17,000	17,000	17,000	17,000	18,000
Czech Republic	5	5	5	5	5
France	3,000	3,000	3,000	3,000	3,000
Ireland	60,000	60,000	60,000	60,000	60,000
Japan	34,000	34,000	34,000	34,000	34,000
Russia	80,000	80,000	80,000	80,000	80,000
South Africa	60,000	60,000	60,000	60,000	60,000
Sweden	20,000	20,000	20,000	20,000	20,000
Ukraine	8,000	8,000	8,000	8,000	8,000
United States	222,000	236,000	252,000	256,000	258,000
Total	529,000	543,000	559,000	563,000	566,000

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

[2]Table includes data available through June 5, 2007.

[3]In addition to the countries listed, Germany and the Republic of Korea also produces significant amounts of synthetic diamond, but output is not officially reported, and available information is inadequate to formulate reliable estimates of output levels.