DIAMOND, INDUSTRIAL

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Diamond is best known for its gem qualities, 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 chapter on gemstones. Diamond is the hardest known material and has the highest thermal conductivity of any material at room temperature (May, 1995). Diamond is more than twice as hard as cubic boron nitride or silicon nitride, which are the nearest competitors (Ravi, 1994, p. 537). Because it is the hardest substance known, diamond has been used for centuries as an abrasive in grinding, drilling, cutting, and polishing, and industrial-grade diamond continues to be used as an abrasive for many applications. Diamond that does not meet gem-quality standards for clarity, color, shape, or size is used as industrial-grade diamond. Even though it has higher unit cost, diamond has proven to be more cost-effective in many industrial processes because it cuts faster and lasts longer than its rival 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, and advanced technologies.

Both synthetic and natural diamonds have industrial uses, but synthetic industrial diamond is superior to its natural diamond counterpart because it can be produced in large quantities. In many cases, its properties can be tailored to specific applications (Boucher, 1996). It is for these reasons that manufactured diamond accounts for more than 90% of the industrial diamond used in the United States and the world.

Legislation and Government Programs

Congress has authorized the sale of all the diamonds in the National Defense Stockpile (NDS), which is managed by the U.S. Department of Defense (DOD). The NDS 2001 annual plan allowed for the sale of a portion of the stockpiled diamond stones. During 2001, the Defense National Stockpile Center (DNSC) sold 500,954 carats of diamond stone valued at $8.07 million. At yearend 2001, the DNSC reported an NDS remaining inventory of 1.007 million carats of industrial diamond stone (Tom Meeker, Market Analyst, Defense National Stockpile Center, oral commun., 2002). The DOD plans to conduct additional future sales until all NDS diamond stone stocks are exhausted. Further NDS information is available in the “Prices” section of this report.

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 2001 survey, a few significant firms withheld certain data that they deemed confidential. Thus, 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 308 million carats in 2001. Only two U.S. companies produced synthetic industrial diamond during the year—Mypodiamond, Inc., Gibbstown, NJ, and GE Superabrasives, Worthington, OH. General Electric Co., Fairfield, CT, which owns GE Superabrasives and other diamond manufacturing plants abroad, is one of the world’s largest producers of industrial diamond.

In 2001, nine firms also manufactured polycrystalline diamond (PCD) from synthetic diamond grit and powder. These companies were Dennis Tool Co., Houston, TX; GE Superabrasives, Worthington, OH; Novatek Inc., Provo, UT; Phoenix Crystal Corp., Ann Arbor, MI; Precorp Inc., Provo, UT; SII Megadiamond Industries Inc., Provo, UT; Tempo Technology Corp., Somerset, NJ; U.S. Synthetic Corp., Orem, UT; and Western Diamond Products, Salt Lake City, UT.

It is estimated that more than 10 million carats of used industrial diamond was recycled in the United States during 2001. Most of this material was recovered by recycling firms 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 for PCD 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 2001—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.

Consumption

The United States remained the world’s largest market for industrial diamond in 2001. Based on production estimates, trade data, and adjustments for Government stockpile sales, the apparent U.S. consumption of industrial diamond during the year increased to an estimated 504 million carats, which was a record high. The major consuming industries of industrial diamond in the United States during 2001 were construction, machinery manufacturing, mining services (drilling), 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. The manufacture of every automobile made in the United States consumes 1.5 carats 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, and polishing silicon wafers and disk drives in the computer industry (Bailey and Bex, 1995).

Diamond tools have a myriad 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 in various structures. The primary uses of point diamond tools are for dressing and truing grinding wheels and for cutting, machining, boring, and finishing applications; beveling glass for automobile windows is another application. Cutting dimension stone and cutting/grooving concrete in highway reconditioning are the major 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 microns) and diamond bort (smaller, fragmented material). Diamond stone is employed primarily 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 engraving points, glass cutters, bearings, and surgical instruments.

Synthetic diamond grit and powder are used in diamond grinding wheels, saws, impregnated bits and tools, and as loose abrasive compounds for polishing. Diamond grinding wheels can be as much as 1 meter (m) in diameter.

Loose powders and compounds made of synthetic diamond for polishing are used primarily to finish optical surfaces, jewel bearings, gemstones, wiredrawing dies, cutting tools, and silicon wafers for computer chips. Hundreds of other products made from metals, ceramics, plastics, and glass also are finished with diamond powders and compounds.

The use of polycrystalline diamond shapes (PDSs) and polycrystalline diamond compacts (PDCs) continues to increase for many of the applications cited above, including some of those that employ natural diamond. The use of PDSs, PDCs, and matrix-set synthetic diamond grit for drilling bits and reaming shells has increased in recent years. PDSs and PDCs are used in the manufacture of single- and multiple-point tools, and PDCs are used in a majority of the diamond wire-drawing dies.

Prices

Natural and synthetic industrial diamonds differ significantly in price (Boucher, 1997, p. 26.6). Natural industrial diamond normally has a more limited range of values. Its price varies from about $0.30 per carat for bort-size material to about $7 to $10 per carat for most stone, with some larger stones selling for up to $200 per carat.

Synthetic industrial diamond has a much larger range of prices 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 $0.30 per carat to $1 per carat. Strong and blocky material for sawing and drilling sells for $1.50 to $4.75 per carat. Large synthetic crystals with excellent structure for specific applications sell for several hundred dollars per carat (Law-West, 2002, p. 23.8).

In 2001, the DNSC awarded bids that ranged from $4.00 to $91.58 per carat for NDS diamond stone sold, with the average awarded bid being $16.10 per carat (Tom Meeker, Market Analyst, Defense National Stockpile Center, oral commun., 2002).

Foreign Trade

The United States continued to lead the world in industrial diamond trade during 2001; imports came from 44 countries, exports went to 61 countries, and reexports went to 32 countries (tables 1-4). Although the United States has been a major producer of synthetic diamond for decades, its 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 domestic production of natural diamond was unable to meet demand.

During 2001, U.S. imports of industrial-quality diamond stones (natural and synthetic) decreased by 2.5% from 2000 imports to 2.46 million carats valued at $8.69 million (table 1). Imports of diamond powder, dust, and grit (natural and synthetic) decreased by 3.3% from 2000 imports to 281 million carats valued at $85 million (table 2).

During 2001, U.S. exports of industrial diamond stone decreased by approximately 31% from 2000 exports to 1.08 million carats valued at $9.53 million (table 3). U.S. reexports of industrial diamond stone decreased by approximately 39% from 2000 reexports to 1.26 million carats valued at $11.2 million (table 3). U.S. exports of industrial diamond powder, dust, and grit decreased by 10% from 2000 exports to 87.7 million carats valued at $63.8 million, and reexports of industrial diamond powder, dust, and grit increased by 268% from 2000 reexports to 7.36 million carats valued at $3.60 million (table 4). Reexports can 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.

World Review

Total 2001 industrial diamond output worldwide during the year was estimated to be in excess of 800 million carats; various reports estimated that global output was at least 600 million carats valued between $600 million and $1 billion (Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1999; Wilson Born, National Research Co., oral commun., 2001). World demand for industrial diamond in the 1990s had been growing at rates of more than 10% per year (Boucher, 1997, p. 26.6).

Industrial diamond was produced in 26 countries during 2001 (tables 5, 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 (Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1999). China may have produced much more than the output listed in the table (Owers, 2000; Wilson Born, National Research Co., oral commun., 2001).

In 2001, almost 70% of the total global natural and synthetic industrial diamond output was produced in Ireland, Russia, and the United States. The dominance of synthetic diamond was even more pronounced, accounting for more than 92% of global production and consumption.

The Ekati Diamond Mine, Canada's first and only operating commercial diamond mine, completed its third full year of production. In 2001, Ekati produced 3.7 million carats of diamonds from 3.3 million metric tons (Mt) of ore mined (Darren R. Dyck, senior project geoscientist, BHP Billiton Diamonds Inc., written commun., 2002). The mine, located in the Northwest Territories, was a joint venture between BHP Diamonds Inc. (BHP) and Dia Met Minerals Ltd. In June, BHP's parent company, BHP Ltd., merged with Billiton plc creating BHP Billiton Ltd., the world's largest mining company (BHP Billiton Ltd., 2001a; Diamond Registry Bulletin, 2001a). In July, BHP Billiton announced that it had agreed to purchase Dia Met Minerals Ltd. (BHP Billiton Ltd., 2001b). Buying out Dia Met gave BHP Billiton an 80% controlling ownership of the Ekati mine. Ekati has estimated reserves of 60.3 Mt of ore in kimberlite pipes, containing 54.3 million carats of diamonds, and the mine life is projected to be 25 years. Operating at full capacity, Ekati production is expected to range from 3.5 to 4.5 million carats per year. Ekati diamonds are sold by the BHP Billiton Diamonds Inc. sales office in Antwerp (65%) and by Diamond Trading Co. (35%) (Rombouts, 2001§[1]). Near the end of 2001, BHP Billiton Diamonds started producing from the Misery kimberlite pipe (BHP Billiton Ltd., 2001c). The Ekati mine already accounts for 4% of the world market by weight and 6% by value (Law-West, 2002). In 2002, BHP Billiton will begin using underground mining techniques to recover diamonds from deeper portions of two of the Ekati kimberlite pipes— Koala and Panda—which were first open pit mined (Diamond Registry Bulletin, 2002). 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).

There are two other Canadian commercial diamond projects located in the Northwest Territories. They are the Diavik diamonds project and the Snap Lake diamond project. Diavik has estimated reserves of 25.6 Mt of ore in kimberlite pipes, containing 102 million carats of diamonds, and the mine life is projected to be 20 years. Diavik is expected to commence diamond production in the first half of 2003 and will produce about 102 million carats of diamond at a rate of 6 million carats per year worth about $63 per carat (Diavik Diamond Mines Inc., 2000, p. 10-12). De Beers Canada Mining Inc. acquired a 68% interest in the Snap Lake diamond project from Winspear Diamonds Inc. in 2000, and in early 2001 De Beers acquired the remaining 32% interest in the project from Aber Diamond Corp. Snap Lake will be De Beers' first mine outside of southern Africa and the first underground diamond mine in Canada. In August 2001, De Beers Canada announced that Snap Lake would begin production in 2006 (Law-West, 2002). Snap Lake has estimated reserves of 22.8 Mt of ore in a kimberlite dike, containing 38.8 million carats of diamonds, and the mine life is projected to be 20 years or more (De Beers Canada Mining Inc., 2000§).

Another Canadian commercial diamond project is the Jericho diamond project located in Nunavut. In 2000, Tahera Corp. completed a feasibility study that indicated that Jericho will produce 3 million carats over an 8-year mine life. Tahera has discovered five kimberlite pipes, of which three are land based. Geological models indicate a resource of approximately 17 Mt to a depth of 300 m, with grades ranging from 0.3 carats per metric ton to 1.0 carats per metric ton for the kimberlite pipes. In early 2001, Tahera filed a formal project proposal and a draft environmental impact statement for the Jericho project. These filings marked the beginning of the environmental assessment and regulatory approval process for the proposed Jericho diamond mine (Law-West, 2002; Tahera Corp., 2002§).

Diamond exploration is continuing in Canada, and many new deposits are being found. There have been additional discoveries in both the core and buffer zones of the Ekati lease as well as additional discoveries in the Northwest Territories and Nunavut. Many diamond-bearing deposits also have been discovered in Alberta, Ontario, Quebec, and Saskatchewan (Rombouts, 2001§). When the Diavik, Snap Lake, and Jericho mines begin production, Canada will be producing 15% to 20% of the total world diamond production. This means that Canada probably will eclipse South Africa's diamond production within a decade and will be a significant producer of natural industrial diamond as well as gem-quality diamond.

In May, De Beers Consolidated Mines Ltd. completed its privatization and was delisted from the Johannesburg Stock Exchange. The company was purchased by a consortium that included the Oppenheimer family, Anglo American plc, and Debswana Diamond Co. (Pty) Ltd. The company is now the world's largest private diamond mining company. The privatization left De Beers heavily in debt, made the company much less transparent, and had no effect on the company's antitrust issues (Diamond Registry Bulletin, 2001b).

Towards the end of 2001, De Beers quietly settled private civil class actions related to the industrial diamonds case in Ohio against De Beers Industrial Diamonds Division (Pty) Ltd. and General Electric Co. The settlement establishes a $20 million cash fund plus interest and also provides for payment of an in-kind rebate of industrial diamonds that "class members" purchase from the plaintiffs during the period from January 1, 2002 to December 31, 2003; such a settlement does not legally constitute a formal admission of guilt. The settlement covered an alleged illegal price fixing that took place during a period from November 1, 1987, through May 23, 1994. The timing of the settlement should be viewed in the context of the current policy of De Beers to conform with local laws of each jurisdiction in which the company conducts business (Tacy Diamond Intelligence, 2002§).

Outlook

It is difficult to determine from the mixed indicators whether or not the 2002 U.S. economy is in recovery, but the United States will most likely continue to be the world's largest market for industrial diamond well into the next decade. The United States also will 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

[1]References that include a section twist (§) are found in the Internet References Cited section.

the life cycle cost effectiveness of diamond compares with competing materials that initially are less expensive. The many advantages that diamond offers for precision machining and longer tool life, which compensate for increases in other production line costs, seem certain to spur demand for diamond tools. In fact, even the use of wear-resistant diamond coatings to increase the life of materials that compete with diamond promises to be a rapidly growing application (May, 1995). Increased tool life not only leads to lower costs per unit of output but also means fewer tool changes and longer unattended 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 U.S. demand for industrial diamond is likely to occur in the construction sector as the Nation builds and repairs the U.S. highway system in its implementation of the Transportation Equity Act for the 21st Century (Public Law 105-178, enacted June 9, 1998). The act provides funding for the building and repair of the Nation's highway system through 2003. Demand for saw-grade diamond alone is expected to increase by more than $1 billion during the coming year to fulfill goals mandated by the act for the repair and replacement of roads, bridges, and other components in the transportation infrastructure of the country (Wilson Born, National Research Co., oral commun., 2001).

According to industry sources, 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, National Research Co., written commun., 1998).

Truing and dressing applications will remain a major domestic end use for natural industrial diamond stone. The stone cannot be manufactured commercially. 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 chemical-vapor-deposition 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/			
	2000		2001		2000		2001	
Country	Quantity	Value 4/	Quantity	Value 4/	Quantity	Value 4/	Quantity	Value 4/
Australia	9	105	6	72	15	18	1	22
Belgium	111	334	53	345	41	567	41	526
China	2	7	22	76	9	10	--	--
France	--	--	--	--	66	91	80	99
Guyana	--	--	3	18	--	--	22	1,250
India	33	46	3	18	(5/)	5	(5/)	4
Ireland	322	757	322	871	31	94	36	81
Namibia	21	126	28	142	9	55	3	18
Netherlands	1	4	--	--	4	124	53	916
Russia	--	--	261	290	--	--	587	485
Switzerland	5	76	17	100	691	940	787	1,100
United Kingdom	489	330	43	196	338	8,390	46	1,190
Other	162 r/	602 r/	37	533	163 r/	678 r/	7	333
Total	1,150	2,390	794	2,660	1,370	11,000	1,660	6,030

r/ Revised. -- 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 1/2 unit.

Source: U.S. Census Bureau.

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

(Thousand carats and thousand dollars)

	Synthetic 2/				Natural 2/			
	2000		2001		2000		2001	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Belgium	1,890	946	1,750	666	6,400	4,440	6,090	3,580
China	37,700	5,220	55,100	6,250	3,140	281	8,330	521
Germany	2,390	3,320	1,660	2,000	144	69	--	--
Hong Kong	1,550	161	616	163	--	--	--	--
India	2,240	585	2,660	588	1,150	394	2,080	906
Ireland	140,000	69,900	98,100	44,100	2,070	984	2,030	1,220
Italy	1,520	789	3,250	1,330	45	34	57	25
Japan	6,540	3,040	6,860	2,880	913	1,640	195	320
Korea, Republic of	11,000	6,640	12,800	5,700	--	--	2	4
Russia	6,230	1,330	16,400	2,520	62	16	2,240	484
Switzerland	3,300	1,780	6,050	3,640	1,840	1,250	460	699
Ukraine	52,700	4,900	47,500	4,460	--	--	--	--
United Kingdom	4,150	1,140	3,190	1,140	815	293	705	268
Other	2,770 r/	1,790 r/	2,670	1,470	414 r/	486 r/	301	389
Total	274,000	102,000	259,000	76,900	17,000	9,890	22,500	8,420

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 codes: synthetic, 7105.10.0020, 7105.10.0030, and 7105.10.0050; natural 7105.10.0011 and 7105.10.0045.
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)

	Industrial unworked diamonds 2/			
	2000		2001	
Country	Quantity	Value 3/	Quantity	Value 3/
Exports:				
Australia	23	77	5	51
Belgium	320	3,940	167	1,590
Bulgaria	73	72	37	48
Canada	237	845	113	411
Germany	52	366	35	249
Hong Kong	50	504	83	825
Israel	42	419	13	133
Japan	446	4,220	360	3,600
Korea, Republic of	64	649	69	705
Malaysia	2	23	44	428
Netherlands	1	14	1	6
Poland	17	160	14	140
Other	233 r/	2,010 r/	138	1,350
Total	1,560	13,300	1,080	9,530
Reexports:				
Belgium	1,180	13,100	790	7,250
Canada	66	214	90	308
Germany	89	504	52	386
Hong Kong	10	48	(4/)	3
Ireland	33	237	36	237
Israel	190	2,020	83	971
Japan	124	1,270	80	833
Korea, Republic of	75	787	57	622
Netherlands	2	23	13	131
South Africa	11	113	--	--
Switzerland	256	2,700	19	112
United Kingdom	12	119	20	225
Other	15 r/	128 r/	14	147
Total	2,060	21,300	1,260	11,200
Grand total	3,620	34,600	2,330	20,800

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 1/2 unit.

Source: U.S. Census Bureau.

TABLE 4

U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND POWDER, DUST AND GRIT, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Synthetic 2/				Natural 2/			
	2000		2001		2000		2001	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Exports:								
Austria	2,150	1,420	2,760	2,200	426	315	59	61
Belgium	1,690	841	1,510	669	273	284	275	399
Brazil	2,050	1,070	1,370	651	--	--	13	15
Canada	1,470	1,950	1,590	2,180	163	248	263	227
France	586	135	338	115	183	57	73	175
Germany	4,460	2,720	3,280	2,070	384	144	263	698
Greece	148	149	132	141	9	10	--	--
Hong Kong	882	540	300	339	102	125	227	195
India	1,400	564	1,320	661	11	3	7	16
Ireland	28,700	26,300	26,000	19,300	68	52	153	144
Israel	819	318	364	204	157	52	150	40
Italy	1,450	546	1,920	934	200	219	44	25
Japan	23,300	13,200	17,400	10,200	905	1,990	1,010	2,140
Korea, Republic of	13,100	6,630	12,400	5,520	262	165	424	178
Luxembourg	20	7	--	--	117	92	93	38
Malaysia	653	481	529	501	2	6	13	9
Mexico	429	218	208	149	133	78	170	102
Netherlands	11	3	329	350	276	280	1,830	2,710
Philippines	39	82	225	317	7	18	33	4
Singapore	124	70	84	50	5	9	15	37
Spain	397	117	336	99	121	38	24	10
Switzerland	1,490	1,260	1,260	872	2,820	3,590	4,740	5,940
Taiwan	1,700	1,540	1,590	1,050	94	193	76	145
Thailand	133	96	373	356	2	4	3	7
United Kingdom	2,870	1,040	665	550	496	284	526	269
Other	464 r/	546 r/	781	583	152 r/	112 r/	147	125
Total	90,600	61,800	77,100	50,100	7,370	8,370	10,600	13,700
Reexports:								
Australia	--	--	60	11	--	--	--	--
Austria	156	29	489	100	55	11	123	28
Belgium	9	13	135	61	9	25	40	18
Brazil	--	--	120	25	--	--	--	--
Canada	539	755	640	638	41	50	90	69
France	--	--	203	64	7	5	266	42
Germany	31	20	421	208	1	3	55	66
Hong Kong	130	49	--	--	35	14	40	60
India	34	6	11	3	89	223	132	158
Ireland	125	99	18	32	44	32	26	38
Israel	10	3	--	--	--	--	33	6
Italy	19	5	956	397	--	--	66	51
Japan	130	53	113	48	16	40	60	42
Korea, Republic of	248 r/	70	1,430	465	--	--	245	114
Malaysia	38	9	9	3	--	--	46	11
Mexico	35	17	20	6	24	13	11	7
South Africa	--	--	39	7	--	--	--	--
Spain	--	--	22	6	--	--	31	32
Switzerland	--	--	404	153	--	--	132	45
Taiwan	19	14	141	116	7	5	93	69
Thailand	37	20	15	10	--	--	7	4
United Kingdom	21	27	237	84	71	18	179	117
Other	4 r/	3 r/	142	161	17 r/	21 r/	55	25
Total	1,590	1,190	5,620	2,600	416	459	1,730	1,000
Grand total	92,200	63,000	82,700	52,700	7,790	8,830	12,400	14,700

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 State codes: synthetic, 7105.10.0025; natural, 7105.10.0010.

3/ Customs value.

Source: U.S. Census Bureau.

TABLE 5
ESTIMATED WORLD PRODUCTION OF NATURAL DIAMOND, BY TYPE AND COUNTRY 1/ 2/ 3/

(Thousand carats)

Country	1997	1998	1999	2000	2001
Gemstones: 4/					
Angola	1,110	2,400	3,360 r/	3,914 r/ 5/	4,653 5/
Australia	18,100	18,400	13,403 5/	11,992 r/ 5/	10,700
Botswana	15,111 5/	14,772 5/	16,000	19,368 r/ 5/	20,100
Brazil	100 r/	100 r/	900 r/	1,000 r/	1,000
Canada	--	203 r/ 5/	2,429 r/ 5/	2,558 r/ 5/	2,600
Central African Republic	400	330	311 r/	346 r/	360
China	230	230	230	230	235
Congo (Kinshasa)	3,300	5,080	4,120	3,500	9,100
Cote d' Ivoire	207	210	270 r/	210 r/	210
Ghana	664	649	282 r/	178	700
Guinea	165	294 r/	410	278 r/	270
Liberia	80	150	120	100 r/	100
Namibia	1,350	1,390	1,550	1,520	1,490
Russia	11,200	11,500	11,500	11,600	11,600
Sierra Leone	300	200	450	450	450
South Africa	4,500	4,300	4,000	4,300	4,470
Tanzania	82	83	200	301	302
Venezuela	-- r/ 5/	80 5/	59 5/	80 r/ 5/	85
Zimbabwe	321	10	15	7	5
Other	33 r/	32 r/	29 r/	44 r/	70
Total	57,200 r/	60,400 r/	59,600 r/	62,000 r/	68,500
Industrial:					
Angola	124	364	373 r/	435 r/	517
Australia	22,100	22,500	16,381 5/	14,700 r/	13,100
Botswana	5,000	5,000	5,350	5,850 r/	5,060
Brazil	-- r/	-- r/	-- r/	-- r/	--
Central African Republic	100	200	120 r/	115 r/	120
China	900	900	920	920	950
Congo (Kinshasa)	18,677 5/	21,000	16,000	14,200	9,100
Cote d' Ivoire	100	100	128 r/	110 r/	110
Ghana	166	160	101 r/	712	170
Guinea	40	98 r/	140	91 r/	90
Liberia	120	150	80	70 r/	70
Namibia	71	73	89	80	--
Russia	11,200	11,600	11,500	11,600	11,600
Sierra Leone	100	50	150	150	150
South Africa	5,540	6,460	6,020	6,480	6,700
Tanzania	35	15	35	55	53
Venezuela	85 r/ 5/	17 5/	36 5/	29 r/ 5/	40
Zimbabwe	100	19	30	13	10
Other	79 r/	80 r/	87 r/	126 r/	200
Total	64,500 r/	68,700 r/	57,500 r/	55,700 r/	48,000
Grand total	122,000 r/	129,000 r/	117,000	118,000	117,000

r/ Revised. -- Zero.
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 May 27, 2002.
3/ In addition to the countries listed, natural diamond is produced in Nigeria, but information is inadequate to estimate output.
4/ Includes near- and cheap-gem qualities.
5/ Reported figure.

TABLE 6
ESTIMATED WORLD PRODUCTION OF SYNTHETIC DIAMOND, BY COUNTRY 1/ 2/ 3/

(Thousand carats)

Country	1997	1998	1999	2000	2001
Belarus	25,000	25,000	25,000	25,000	25,000
China	16,000	16,500	16,500	16,800	17,000
Czech Republic	5,000	5,000	3,000	--	--
France	3,000 r/	3,000	3,000	3,000	3,000
Greece	750	750	750	750	--
Ireland	60,000	60,000	60,000	60,000	60,000
Japan	32,000	32,000	32,000	33,000	33,000
Poland	260	210	200	--	--
Romania	5,000	3,000	3,000	--	--
Russia	80,000	80,000	80,000	80,000	80,000
Slovakia	5,000	5,000	3,000	--	--
South Africa	60,000	60,000	--	--	60,000
Sweden	25,000	25,000	25,000	20,000	20,000
Ukraine	8,000	8,000	8,000	8,000	8,000
United States	125,000	140,000	208,000	248,000	308,000
Total	450,000 r/	463,000	467,000	495,000	614,000

r/ Revised. -- Zero.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through May 27, 2002.

3/ In addition to the countries listed, 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.