



2005 Minerals Yearbook

GRAPHITE

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In 2005, there was no reported production of natural graphite, but U.S. production of synthetic graphite was estimated to be 209,000 metric tons (t) valued at about \$846 million. U.S. imports and exports of natural graphite were estimated to be 64,500 t and 22,100 t, respectively, while U.S. imports and exports of synthetic graphite were estimated to be 51,400 t and 34,100 t, respectively. U.S. apparent consumption of natural and synthetic graphite was estimated to be 42,400 t and 226,000 t, respectively.

This report includes information on U.S. trade and use of natural graphite and U.S. production, trade, and use of synthetic graphite. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using the unrounded data.

Graphite is one of four forms of crystalline carbon; the others are carbon nanotubes, diamonds, and fullerenes. Graphite occurs naturally in metamorphic rocks, such as gneiss, marble, and schist. It is a soft mineral also known by the names black lead, mineral carbon, and plumbago. The word graphite is derived from the Greek word “graphein,” to write. It has a Mohs hardness of 1 to 2 and exhibits perfect basal (one-plane) cleavage. Depending on purity, the specific gravity is 2.20 to 2.30. The specific gravity of pure graphite is 2.23. It is gray to black in color, opaque, and usually has a metallic luster; sometimes it exhibits a dull earthy luster. It is flexible but not elastic. It has a melting point of 3,927° C and is highly refractory. Graphite is the most electrically and thermally conductive of the nonmetals and is chemically inert. All these properties combined make graphite desirable for many industrial applications, and both natural and synthetic graphite have industrial uses.

Worldwide, natural graphite deposits occur as lenses or layers of disseminated or massive flakes. Naturally occurring organic carbon may be graphitized at temperatures from 300° C to 1,200° C. These temperatures could be associated with low-grade metamorphism or at the contact between an igneous intrusion and a carbonaceous body. The three principal types of natural graphite, which are amorphous, crystalline flake, and lump, are distinguished by physical characteristics that are the result of major differences in geologic occurrence. Amorphous graphite is formed by the thermal metamorphism of coal. The designation “amorphous” is a misnomer. Its relatively low degree of crystalline order and very fine particle size make it appear amorphous. It is usually less pure than the crystalline flake graphite and, therefore, commands a lower price than its more ordered counterpart. Crystalline flake graphite consists of isolated, flat, plate-like particles with angular, irregular, or rounded edges. It is usually found in layers or pockets in metamorphic rocks. In some deposits, the flake graphite occurs as massive accumulations in lenses, pods, or veins. Lump graphite occurs in veins and is believed to be hydrothermal in origin. It typically appears as massive platy intergrowths of fibrous or acicular crystalline aggregates with the long axis parallel to the enclosing wall rock; the particle size ranges from extremely fine to coarse (Kenan, 1984).

Natural graphite is mined from open pit and underground mine operations. Production from open pit operations is less expensive and is preferred where the overburden can be removed economically. Mines in Madagascar are mostly of this type. In Mexico, the Republic of Korea, and Sri Lanka, where the deposits are deep, underground mining techniques are required.

Beneficiation processes for graphite may vary from a complex four-stage flotation at European and United States mills to simple hand sorting and screening of high-grade ore at Sri Lankan operations. Certain soft graphite ores, such as those found in Madagascar, need no primary crushing and grinding. Typically, such ores contain the highest proportion of coarse flakes. Ore is sluiced to the field washing plant where it undergoes desliming to remove the clay fraction and is subjected to a rough flotation to produce a concentrate with 60% to 70% carbon. This concentrate is transported to the refining mill for further grinding and flotation to reach 85% carbon. It is then screened to produce a variety of products marketed as flake graphite that contain 75% to 90% carbon.

Legislation and Government Programs

As of December 31, 2005, the National Defense Stockpile (NDS), maintained by the U.S. Department of Defense, contained no graphite inventories. All stockpiled graphite inventories were sold during 2004 (Jenkins, 2005).

Production

The U.S. Geological Survey (USGS) obtained the production data in this report through a voluntary survey of U.S. synthetic graphite producers. The survey of U.S. synthetic graphite producers collected data from 21 of 22 canvassed producers. Data were estimated for the producer that did not respond to the survey based on responses received in previous years and on industry trends.

No natural graphite was reported mined in the United States in 2005, but 209,000 t of synthetic graphite with an estimated value of \$846 million was reported produced and shipped (table 3).

Consumption

The USGS obtained the data in this report through a survey of natural graphite companies in the United States. The survey of natural graphite companies collected data from 82 of 98 canvassed companies and plants. Data were estimated for the companies that did not respond to the survey. This survey represented most of the graphite industry in the United States.

Graphite uses have changed dramatically in the past 20 years. U.S. consumption of natural graphite decreased slightly by about

3% to 43,200 t in 2005 from 44,300 t in 2004 (table 2). The natural graphite consumption data in table 2 include mixtures of natural and synthetic graphite with the amorphous graphite. Consequently, the table 2 consumption numbers are higher than the computed apparent consumption numbers given in table 1. Consumption of crystalline grade increased in 2005 by more than 4% to 22,400 t from 21,500 t in 2004, and consumption of amorphous grade decreased by almost 9% to 20,800 t in 2005 from 22,900 t in 2004. These changes in end use corresponded with a 3% decrease in total graphite value in 2005. Brake linings, refractories, and steelmaking were the three industries that dominated U.S. natural graphite use. Brake linings and refractories accounted for 42% of natural graphite consumption. Foundries and lubricants industries together made up another 5% of consumption. The refractories industry was the leading consumer of crystalline flake graphite, increasing its graphite use compared with 2004.

Graphite has properties of both metals and nonmetals, which makes it suitable for many industrial applications. The metallic properties include electrical and thermal conductivity. The nonmetallic properties include high thermal resistance, inertness, and lubricity. The combination of conductivity and high thermal stability allows graphite to be used in many applications, such as in batteries, fuel cells, and refractories. Graphite's lubricity and thermal conductivity make it an excellent material for high-temperature applications because it provides effective lubrication at a friction interface while furnishing a thermally conductive matrix to remove heat from the same interface. Electrical conductivity and lubricity allow its use as the primary material in the manufacture of brushes for electric motors. A graphite brush effectively transfers electric current to a rotating armature while the natural lubricity of the brush minimizes frictional wear. Today's advanced technology products, such as friction materials and battery and fuel cells, require high-purity graphite.

Refractory applications of graphite included carbon-bonded brick, castable ramming, and gunning mixtures. Carbon-magnesite brick has applications in high-temperature corrosive environments, such as iron blast furnaces, ladles, and steel furnaces. Carbon-alumina linings are principally used in continuous steel-casting operations. Alumina- and magnesite-carbon brick requires a particle size of 100 mesh and a purity of 95% to 99% graphite.

Crystalline flake graphite accounted for almost 53% of natural graphite usage in the United States. It was consumed mainly in batteries, brake linings, lubricants, other applications, and refractories. Amorphous graphite is mainly used in brake linings, refractories, steelmaking, and other applications where additions of graphite improve the process or the end product. Lump graphite finds appropriate uses in a number of areas, such as steelmaking, depending on purity and particle size.

Synthetic graphite is most often chosen in North America instead of natural graphite and accounts for a significant share of the graphite market. The main market for high-purity synthetic graphite is as a carbon-raiser additive in iron and steel. This market consumes a significant portion of the synthetic graphite. Other significant uses of all types of graphite are in the manufacture of catalyst supports; low-current, long-life batteries; porosity-enhancing inert fillers; powder metallurgy; rubber; solid carbon shapes; static and dynamic seals; steel; and valve and stem

packing. The use of graphite in low-current batteries is gradually giving way to carbon black, which is more economical.

Graphite is used to manufacture antistatic plastics, conductive plastics and rubbers, electromagnetic interference shielding, electrostatic paint and powder coatings, high-voltage power cable conductive shields, membrane switches and resistors, and semiconductive cable compounds, and electrostatic paint and powder coatings (George C. Hawley, President, George C. Hawley and Associates, written commun., January 16, 2004).

Prices

Natural graphite prices increased for all types during 2005. Prices for crystalline and crystalline flake graphite concentrates ranged from \$410 to \$795 per metric ton; prices for amorphous powder ranged from \$240 to \$260 per ton (table 4). Ash and carbon content, crystal and flake size, and size distribution affect the price of graphite. The Swiss border price of synthetic graphite in 2005 was \$2,007 per ton. The average unit value of synthetic graphite exports increased by 44% to \$2,729 per ton in 2005 from \$1,901 per ton in 2004 (table 5).

Foreign Trade

Total graphite exports decreased by about 41% in tonnage to 56,200 t valued at \$109 million in 2005 from 94,900 t valued at \$118 million in 2004 owing to a 52% and 30% decrease in natural and synthetic graphite exports, respectively (table 5). Total natural graphite imports increased slightly in tonnage to 64,500 t in 2005 from 63,700 t in 2004, and the value increased by 16% to \$34.7 million in 2005 from \$29.9 million in 2004 (table 6). Principal import sources of natural graphite, in descending order of tonnage, were China, Mexico, Canada, Brazil, and Madagascar, which accounted for about 98% of the tonnage and 88% of the value of total imports. Mexico and China, in descending order of tonnage, were the suppliers of amorphous graphite, and Sri Lanka provided the lump and chippy dust variety. China and Canada, in descending order of tonnage, were the major suppliers of crystalline flake and flake dust graphite. A number of other producing nations supplied several other natural types and grades of graphite to the United States; among the most notable were Canada and the United Kingdom.

World Review

World production of natural graphite increased by 3% in 2005 to an estimated 1.05 million metric tons (Mt) compared with 1.02 Mt in 2004. China maintained its position as the world's leading graphite producer with 720,000 t. India was the second ranked graphite producer with 130,000 t, followed by Brazil, North Korea, and Canada, in decreasing order of tonnage produced. These five countries accounted for 94% of world production, and China alone accounted for about 68% (table 8).

Research and Technology

New technology in processing and treatment expanded the use of natural graphite in battery applications. Graphite for these applications is purified to 99.9% carbon content. Most new uses for

graphite products are being developed through advances in graphite thermal technology. The ability to refine and modify graphite and other carbon products is expected to be the key to future growth in the graphite industry. Innovative refining techniques have enabled the use of improved graphite in electronics, foils, friction materials, and lubrication applications (Hand, 1997). One of the new application areas is in electrically conductive asphalt for heated runways at airports and roadway bridges. With its high corrosion resistance, high refractory property, and low specific gravity, graphite is critical for many industrial applications, such as dies for continuous casting, heat exchangers for the chemical industry, and rocket nozzles. The relatively poor wear and oxidation resistance of graphite, however, limit its use. A class of high-performance materials based on titanium-carbide-coated graphite makes the material suitable for some applications that require combined hardness, toughness, and thermal resistance (Webb, 2000). Because titanium carbide is a very hard and durable material, the resulting components are extremely resistant to corrosion, elevated temperatures, and wear. These composites can be engineered for many industrial uses through control of the coating composition, microstructure, surface finish, and thickness. In metal melting applications, titanium-carbide coatings have been shown to improve the service life of graphite components by as much as fivefold.

Graphite is formed of parallel sheets of carbon atoms in a hexagonal arrangement. It is possible to insert other atoms between the sheets, a process that is called intercalation. The insertion of other atoms makes dramatic changes in the properties of graphite. Lithium ions can be inserted to create graphite anodes for lithium ion batteries. Graphite can be intercalated with sulfuric and nitric acid to produce expanded graphite from which foils are formed that are used in seals and gaskets and are beginning to be used in fuel cells (Hawley, 2001).

Outlook

Refractory use trends for graphite closely follow events in the steel industry because graphite is used in the manufacture of refractory brick used in iron and steel furnace linings. Graphite-base refractories are also used as continuous casting ware usually in the form of nozzles to guide molten steel from ladle to mold. Brake linings and other friction materials are expected to steadily use more natural graphite as new automobile production continues to increase and more replacement parts are required for the growing number of vehicles. Natural graphite (amorphous and fine flake) is used as a substitute for asbestos in brake linings for vehicles heavier than cars and light trucks. Flexible graphite products, such as grafoil (a thin graphite cloth), are expected to be the fastest growing market but are expected to use small amounts of natural graphite compared with major end-use markets, such as brake linings and refractories. Products produced by advanced refining technology in the next few years, despite a weak refractory market and competitive pricing from Chinese material, could increase profitability in the U.S. graphite industry.

The predicted increase in manufacture and sales of hybrid and electric vehicles is expected to increase demand for high-purity graphite in fuel-cell and battery applications. Fuel cells are a potential high-growth, large-volume graphite (natural and synthetic) end use, but are currently a very small part of

consumption. High volumes of graphite are not expected to be consumed in this end use for many years, but may be used in the longer term (Taylor, 2006, p. 517). One prediction is that the demand for high-quality, high-carbon graphite could increase to more than 100,000 metric tons per year (t/yr) for fuel-cell and battery applications alone (Crossley, 2000).

Global demand for graphite used in batteries may increase to more than 25,000 t/yr in the next 4 to 5 years. This demand is expected to be spread between two main consuming sectors—alkaline batteries and lithium-ion batteries. Synthetic and natural graphite are used in these batteries. In alkaline batteries, graphite is the conductive material in the cathode. Until recently, synthetic graphite was predominantly used in these batteries. With the advent of new purification techniques and more efficient processing methods, it has become possible to improve the conductivity of most natural graphite to the point where it can be used in batteries. The decision whether to use synthetic or natural graphite will be based on performance and price. The growth of the lithium-ion battery market could have a more dramatic effect on the graphite market as the demand for mobile energy storage systems rises.

There is a common industry trend towards higher purity and consistency in specifications for some specialized and high-tech applications. The trend to produce higher purity graphite using thermal processing and acid leaching techniques continues. High-purity graphite has applications in advanced carbon-graphite composites.

The markets for graphite used in rubber and plastics (including Styrofoam coatings) are growing, and continued growth is expected. The market for graphite in pencils has almost disappeared; pencil “leads” now are imported directly from China (Taylor, 2006, p. 517). These markets, however, use little graphite and are not expected to have a significant impact on future consumption.

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GENERAL SOURCES OF INFORMATION

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TABLE 1
SALIENT NATURAL GRAPHITE STATISTICS¹

		2001	2002	2003	2004	2005
United States:						
Apparent consumption ²	metric tons	28,200	23,600	30,000	17,600	42,400
Exports:						
Quantity	do.	23,900	21,600	22,200	46,100	22,100
Value	thousands	\$16,900	\$19,200	\$19,500	\$24,900	\$15,900
Imports for consumption:						
Quantity	metric tons	52,100	45,100	52,300	63,700	64,500
Value	thousands	\$23,300	\$22,300	\$24,400	\$29,900	\$34,700
World, production	metric tons	816,000 ^r	932,000 ^r	999,000 ^r	1,020,000 ^r	1,050,000 ^c

^cEstimated. ^rRevised.

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

²Domestic production plus imports minus exports.

TABLE 2
U.S. CONSUMPTION OF NATURAL GRAPHITE, BY END USE¹

End use	Crystalline		Amorphous ²		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2004:						
Batteries	W	W	W	W	W	W
Brake linings	W	\$1,370	3,960	\$2,930	W	\$4,300
Carbon products ³	251	486	212	248	463	733
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries ⁴	W	457	W	631 ^r	W	1,090
Lubricants ⁵	2,040 ^r	2,380	W	W	W	W
Pencils	W	W	W	39	W	W
Powdered metals	367	500	W	W	W	W
Refractories	6,900 ^r	3,420 ^r	4,330	3,180	11,200 ^r	6,600 ^r
Rubber	W	W	377	W	W	360
Steelmaking	W	W	W	8,130 ^r	W	W
Other ⁶	W	7,460 ^r	W	W	9,310	W
Total	21,500	20,100 ^r	22,900 ^r	19,200 ^r	44,300 ^r	39,300 ^r
2005:						
Batteries	W	W	--	--	W	W
Brake linings	2,570	1,900	3,930	3,150	6,510	5,050
Carbon products ³	286	784	W	W	W	W
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	225
Foundries ⁴	178	137	W	634	W	771
Lubricants ⁵	768	808	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	283	463	18	44	300	507
Refractories	7,980	4,280	3,830	2,770	11,800	7,040
Rubber	54	85	W	434	W	520
Steelmaking	W	W	W	W	W	8,970
Other ⁶	8,170	8,600	1,120	894	9,290	9,490
Total	22,400	20,400	20,800	17,700	43,200	38,100

^rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

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

²Includes mixtures of natural and manufactured graphite.

³Includes bearings and carbon brushes.

⁴Includes foundries (other) and foundry facings.

⁵Includes ammunition and packings.

⁶Includes antiknock and other compounds, drilling mud, electrical/electronic devices, industrial diamonds, magnetic tape, mechanical products, paints and polishes, small packages, soldering/welding, and other end-use categories.

TABLE 3
SHIPMENTS OF SYNTHETIC GRAPHITE BY U.S. COMPANIES, BY END USE¹

End use	Quantity (metric tons)	Value (thousands)
2004:		
Anodes	W	W
Cloth and fibers (low modulus)	W	\$130,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	168,000	363,000
High-modulus fibers	W	72,400
Unmachined graphite shapes	8,120	81,000
Synthetic graphite powder and scrap ²	W	W
Other	W	W
Total	249,000	774,000
2005:		
Anodes	W	W
Cloth and fibers (low modulus)	W	162,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	146,000	391,000
High-modulus fibers	7,020	134,000
Unmachined graphite shapes	9,090	85,300
Synthetic graphite powder and scrap ²	W	W
Other	W	W
Total	209,000	846,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

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

²Includes lubricants (alone/in greases), steelmaking carbon raisers, additives in metallurgy, and other powder data.

TABLE 4
REPRESENTATIVE YEAREND GRAPHITE PRICES¹

(Dollars per metric ton)

Type	2004	2005
Crystalline large, 94% to 97% carbon, +80 mesh	570-750	660-795
Crystalline large, 90% carbon, +80 mesh	480-550	570-655
Crystalline medium, 94% to 97% carbon, +100-80 mesh	560-640	630-710
Crystalline medium, 90% carbon, +100-80 mesh	370-410	440-495
Crystalline medium, 85% to 87% carbon, +100-80 mesh	230-350	450-555
Crystalline fine, 94% to 97% carbon, +100 mesh	450-600	525-640
Crystalline fine, 90% carbon, -100 mesh	350-400	410-475
Amorphous powder, 80%/85% carbon	NA	240-260
Synthetic 99.95% carbon, Swiss border	NA	2,007

NA Not available.

¹Prices are normally cost, insurance, and freight main European port.

Sources: Industrial Minerals, no. 447, December 2004, p. 72; no. 459, December 2005, p. 70

TABLE 5
U.S. EXPORTS OF NATURAL AND SYNTHETIC GRAPHITE, BY COUNTRY^{1,2}

Country	Natural ³		Synthetic ⁵		Total	
	Quantity (metric tons)	Value ⁴ (thousands)	Quantity (metric tons)	Value ⁴ (thousands)	Quantity (metric tons)	Value ⁴ (thousands)
2004:						
Australia	303	\$468	917	\$2,010	1,220	\$2,470
Belgium	192	157	1,850	2,510	2,040	2,670
Brazil	239	155	1,440	4,550	1,680	4,710
Canada	1,810	1,410	10,900	16,400	12,700	17,800
China	1,080	783	4,030	5,860	5,120	6,650
France	684	889	2,810	14,700	3,490	15,600
Hong Kong	18,700	4,080	222	1,650	19,000	5,730
Italy	801	1,520	677	1,400	1,480	2,910
Japan	3,510	1,660	6,720	9,810	10,200	11,500
Korea, Republic of	606	457	2,070	5,650	2,680	6,100
Mexico	9,590	4,280	5,590	6,400	15,200	10,700
Netherlands	226	169	3,570	3,890	3,790	4,060
Taiwan	414	308	823	1,550	1,240	1,860
United Kingdom	2,900	1,780	3,380	7,480	6,280	9,260
Other	5,030	6,790	3,720	8,830 ^r	8,750	15,600 ^r
Total	46,100	24,900	48,700	92,700 ^r	94,900	118,000 ^r
2005:						
Brazil	1,310	464	1,110	5,060	2,420	5,530
Canada	1,680	1,510	11,700	17,600	13,300	19,100
China	296	310	1,660	6,150	1,960	6,460
France	54	58	3,240	19,300	3,290	19,400
Hong Kong	1,670	1,820	327	2,030	1,990	3,850
Japan	4,650	1,940	2,330	8,240	6,990	10,200
Korea, Republic of	1,030	654	2,520	7,350	3,550	8,000
Mexico	822	701	3,360	5,600	4,180	6,300
Netherlands	425	375	1,030	2,960	1,460	3,340
Taiwan	960	565	678	2,070	1,640	2,630
United Kingdom	5,170	3,270	1,710	4,740	6,880	8,010
Other	4,000	4,280	4,500	12,000	8,500	16,300
Total	22,100	15,900	34,100	93,200	56,200	109,000

^rRevised.

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

²Numerous countries for which data were reported have been combined in "Other."

³Amorphous, crystalline flake, lump and chip, and natural, not elsewhere classified. The applicable Harmonized Tariff Schedule of the United States (HTS) nomenclatures are "Natural graphite in powder or in flakes" and "Other," codes 2504.10.0000 and 2504.90.0000.

⁴Values are free alongside ship.

⁵Includes data from the applicable HTS nomenclatures "Artificial graphite" and "Colloidal or semicolloidal graphite," codes 3801.10.0000 and 3801.20.0000.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF NATURAL GRAPHITE, BY COUNTRY^{1,2}

Country	Crystalline flake and flake dust			Lump and chippy dust			Other natural crude; high-purity; expandable			Amorphous			Total		
	Quantity (metric tons)	Value ³ (thousands)		Quantity (metric tons)	Value ³ (thousands)		Quantity (metric tons)	Value ³ (thousands)		Quantity (metric tons)	Value ³ (thousands)		Quantity (metric tons)	Value ³ (thousands)	
2004:															
Brazil	2,650	\$3,250	--	--	--	--	122	\$235	--	--	--	--	2,770	\$3,480	
Canada	13,900	6,710	--	--	--	386	2,220	--	--	--	--	--	14,300	8,940	
China	15,100	5,200	--	--	--	511	1,010	12,400	\$3,210	--	--	--	28,000	9,420	
Germany	66	54	--	--	--	49	167	--	--	--	--	--	115	224	
India	76	52	--	--	--	(4)	45	--	--	--	--	--	76	97	
Japan	--	--	--	--	--	497	2,440	2,780	156	--	--	--	3,280	2,600	
Madagascar	1,210	734	--	--	--	--	--	--	--	--	--	--	1,210	734	
Mexico	--	--	620	\$1,500	--	--	--	--	--	12,800	1,590	--	12,800	1,590	
Sri Lanka	--	--	--	--	--	--	--	--	--	--	--	--	620	1,500	
United Kingdom	31	27	--	--	--	342	1,030	--	--	--	--	--	374	1,060	
Zimbabwe	20	10	--	--	--	--	--	--	--	--	--	--	20	10	
Other ⁵	34	46	--	--	--	33	199	--	--	--	--	--	66	246	
Total	33,100	16,100	620	1,500	1,940	1,940	7,360	28,000	4,960	28,000	4,960	63,700	29,900		
2005:															
Brazil	3,110	4,000	--	--	--	32	81	--	--	--	--	--	3,140	4,070	
Canada	9,430	6,440	--	--	--	527	3,440	--	--	--	--	--	9,960	9,890	
China	31,700	12,000	--	--	--	116	448	1,690	461	--	--	--	33,500	12,900	
Germany	22	14	--	--	--	85	329	--	--	--	--	--	107	343	
India	18	21	--	--	--	--	--	--	--	--	--	--	18	21	
Japan	--	--	--	--	--	139	1,300	--	--	--	--	--	139	1,300	
Madagascar	1,620	1,060	--	--	--	--	--	--	--	--	--	--	1,620	1,060	
Mexico	289	90	--	--	--	--	--	14,800	2,350	--	--	--	15,100	2,440	
Sri Lanka	--	--	598	1,530	--	--	--	--	--	--	--	--	598	1,530	
United Kingdom	--	--	--	--	--	261	874	--	--	--	--	--	261	874	
Other ⁵	22	31	--	--	--	58	206	--	--	--	--	--	80	237	
Total	46,200	23,700	598	1,530	1,220	1,220	6,680	16,500	2,810	16,500	2,810	64,500	34,700		

-- Zero.

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

²The information framework from which data for this material were derived originated from Harmonized Tariff Schedule of the United States base data.

³Customs values.

⁴Less than 1/2 unit.

⁵Includes Austria, Belgium, Finland (2004), France (2004), Italy, the Netherlands, Sweden, and Switzerland.

Source: U.S. Census Bureau, adjusted by the U.S. Geological Survey.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF GRAPHITE
ELECTRODES, BY COUNTRY^{1,2}

Country	Quantity (metric tons)	Value ³ (thousands)
2004:		
Brazil	4,170	\$5,040
Canada	5,770	14,400
China	12,600	17,700
France	1,320	2,260
Germany	1,200	6,040
Italy	1,310	3,180
Japan	11,300	28,100
Mexico	42,100	59,700
Russia	2,550	2,810
South Africa	1,470	2,340
Venezuela	1,500	547
Other ⁴	1,000	2,020
Total	86,400	144,000
2005:		
Brazil	2,690	5,320
Canada	7,820	20,500
China	14,700	23,000
Germany	1,860	9,900
Japan	12,600	37,000
Mexico	39,400	58,100
Other ⁴	2,180	3,380
Total	81,200	157,000

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

²The applicable Harmonized Tariff Schedule of the United States nomenclature is "Electric furnace electrodes," code 8545.11.0000.

³Customs values.

⁴Includes data for countries that ship less than 1,000 metric tons per year to the United States.

Source: U.S. Census Bureau.

TABLE 8
GRAPHITE: WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country	2001	2002	2003	2004	2005
Austria	116	100	100	-- ^r	--
Brazil, marketable	70,091	60,922	70,739 ^r	76,332 ^r	76,500 ^e
Canada ^e	35,000 ^r	25,000	25,000	28,000 ^r	30,000 ^e
China ^e	450,000	629,000	710,000	700,000	720,000
Czech Republic ^e	17,000	16,000	9,000	10,000	10,000
Germany, marketable	3,190 ^r	3,312 ^r	2,840 ^r	3,155 ^r	3,200
India, run-of-mine ^{e,3}	140,000	130,000	110,000	120,000	130,000
Korea, North ^e	25,000	25,000	25,000	30,000	32,000
Korea, Republic of	238 ^r	94	58 ^r	247 ^r	250
Madagascar ^e	2,013 ⁴	2,000 ^r	15,000 ^r	15,000 ^r	15,000
Mexico, amorphous	21,442	14,065	8,730	14,769 ^r	11,143
Norway ^e	2,500	2,400	2,400	2,300	2,300
Romania	1,176	1,001	--	500 ^e	500 ^e
Russia ^e	6,000	--	--	--	--
Sri Lanka	6,585	3,619	3,387	3,400 ^e	3,000
Sweden ^e	963 ⁴	900	850	800	800
Turkey, run-of-mine ⁵	15,000 ^e	1,393	942	1,000 ^e	6,000 ^e
Ukraine ^e	7,500	7,500	7,500	7,500	7,500
Uzbekistan ^e	60	60	60	60	60
Zimbabwe	11,836	9,912	7,675	10,267	6,000 ^e
Total	816,000 ^r	932,000 ^r	999,000 ^r	1,020,000 ^r	1,050,000

^eEstimated. ^rRevised. -- Zero.

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

²Table includes data available through May 8, 2006.

³Indian marketable production is 10% to 20% of run-of-mine production.

⁴Reported figure.

⁵Turkish marketable production averages approximately 5% of run-of-mine production. Almost all is for domestic consumption.