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GRAPHITE

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Graphite

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In 2008, there was no reported production of natural graphite, but U.S. production of synthetic graphite was estimated to be 196,000 metric tons (t) valued at about $1.05 billion. U.S. imports and exports of natural graphite were estimated to be 58,300 t and 7,950 t, respectively, while U.S. imports and exports of synthetic graphite were estimated to be 61,900 t and 54,900 t, respectively. U.S. apparent consumption of natural and synthetic graphite was estimated to be 50,300 t and 203,000 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 is gray to black in color, opaque, and usually has a metallic luster; sometimes it exhibits a dull earthy luster. Graphite occurs naturally in metamorphic rocks. It is a soft mineral with a Mohs hardness of 1 to 2, and it exhibits perfect basal (one-plane) cleavage. Graphite is flexible but not elastic, has a melting point of 3,927° C, and is highly refractory. It has a low specific gravity. 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.

There are three types of natural graphite—amorphous, flake or crystalline flake, and vein or lump. Amorphous graphite is the lowest quality and most abundant. Amorphous refers to its very small crystal size and not to a lack of crystal structure. Amorphous is used for lower value graphite products and is the lowest priced graphite. Large amorphous graphite deposits are found in China, Europe, Mexico, and the United States. Flake or crystalline flake graphite is less common and higher quality than amorphous. Flake graphite occurs as separate flakes that crystallized in metamorphic rock. Flake graphite can be four times the price of amorphous. Good quality flakes can be processed into expandable graphite for many uses, such as flame retardants. The foremost deposits are found in Austria, Brazil, Canada, China, Germany, and Madagascar. Vein or lump graphite is the rarest, most valuable, and highest quality type of natural graphite. It occurs in veins along intrusive contacts in solid lumps, and it is only commercially mined in Sri Lanka (Moores, 2007).

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.

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 15 of 17 canvassed producers. Data were estimated for the producers 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 2008, but 196,000 t of synthetic graphite with an estimated value of $1.05 billion was 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 59 of 94 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. reported consumption of natural graphite increased by 27% to 49,800 t in 2008 from 39,200 t in 2007 (table 2). The natural graphite consumption data in table 2 include mixtures of natural and synthetic graphite in the amorphous graphite category, and this reported consumption data may include company stocks from previous years. Consequently, the table 2 consumption numbers are different from the computed apparent consumption numbers given in table 1. Consumption of crystalline grade increased in 2008 by 8% to 20,200 t from 18,600 t in 2007. Consumption of amorphous grade increased by 44% to 29,600 t in 2008 from 20,500 t in 2007, owing to a 75% increase over the previous year in the amount of natural graphite used in steelmaking. Brake linings, foundries, refractories, and

steelmaking were the four industries that dominated U.S. natural graphite use. Brake linings, foundries, lubricants, and refractories accounted for 42% of natural graphite consumption. The production of batteries and pencils together made up another 3% of consumption. The refractories industry was the leading consumer of crystalline flake graphite, accounting for almost 36% of crystalline flake graphite used in 2008.

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. Natural graphite is purified to 99.9% carbon content for use in battery applications.

Graphite is made up 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 acids to produce expanded graphite from which foils are formed that are used in seals, gaskets, and fuel cells (Hawley, 2001).

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 used in more applications in North America than 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, 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 most types during 2008. Prices for crystalline and crystalline flake graphite concentrates ranged from $550 to $1,000 per metric ton; prices for amorphous powder averaged $460 per ton (table 4). Ash and carbon content, crystal and flake size, and size distribution affect the price of graphite. The European port price of synthetic graphite in 2008 ranged from $5,550 to $17,900 per ton. The average unit value of synthetic graphite exports increased by 5% to $3,040 per ton in 2008 from $2,890 per ton in 2007 (table 5).

Foreign Trade

Total graphite exports increased by 5% in tonnage to 62,800 t valued at $182 million in 2008 from 59,800 t valued at $147 million in 2007 owing to a 49% decrease and a 24% increase in natural and synthetic graphite exports, respectively (table 5). Total natural graphite imports decreased slightly in tonnage to 58,300 t in 2008 from 58,600 t in 2007, and the value increased by 29% to $48.1 million in 2008 from $37.3 million in 2007 (table 6). Principal import sources of natural graphite were, in descending order of tonnage, China, Canada, Mexico, Brazil, Guyana, and Madagascar, which combined, accounted for 98% of the tonnage and 88% of the value of total imports. Mexico and Guyana were, in descending order of tonnage, the leading suppliers of amorphous graphite, and Sri Lanka provided all the lump and chippy dust variety. China and Canada were, in descending order of tonnage, 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 was Canada.

World Review

World production of natural graphite increased slightly in 2008 to an estimated 1.12 million metric tons (Mt) compared with 1.10 Mt in 2007. China maintained its position as the world's leading graphite producer with 810,000 t. India was the second ranked graphite producer with 140,000 t, followed by Brazil, North Korea, and Canada, in decreasing order of tonnage produced. These five countries accounted for 97% of world production, and China alone accounted for about 72% (table 8).

During the last half of 2008, global demand for graphite started weakening as the global economy slipped into a recession. This was because of the recession's effects in the

refractory and metallurgical sectors in which graphite is widely used (Industrial Minerals, 2009).

Outlook

Worldwide demand for graphite is expected to increase slowly as the world's economy comes out of recession.

An increasing trend of collaboration between Far Eastern and Western graphite producers is taking place in the graphite industry. These collaborations combine superior management, processing, and packaging techniques of Western companies with China's production power located in and adjacent to the largest markets. China offers the optimum cost-location balance. China has serious logistics challenges though, such as freight issues and shipping problems, rising container rates, Chinese-Government-prioritized internal transportation, possible renewal of export taxes, and licensing law issues. Despite these challenges, the Chinese graphite industry is thriving and is expected to continue increasing (Moores, 2007).

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. The ability to refine and modify graphite is expected to be the key to future growth in the graphite industry. Refining techniques have enabled the use of improved graphite in electronics, foils, friction materials, and lubrication applications (Hand, l997). Graphite-based 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 expected increase in manufacture and sales of hybrid and electric vehicles is likely 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 forecast 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 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 toward 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 U.S. 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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TABLE 1

SALIENT NATURAL GRAPHITE STATISTICS[1]

		2004	2005	2006	2007	2008
United States:						
Apparent consumption[2]	metric tons	17,600	42,400	30,400	42,900	50,300
Exports:						
Quantity	do.	46,100	22,100	22,200	15,700	7,950
Value	thousands	$24,900	$15,900	$16,000	$19,100	$15,600
Imports for consumption:						
Quantity	metric tons	63,700	64,500	52,600	58,600	58,300
Value	thousands	$29,900	$34,700	$29,100	$37,300	$48,100
World, production	metric tons	1,010,000 r	1,030,000 r	1,020,000 r	1,100,000 r	1,120,000 e

eEstimated. rRevised. do. Ditto.

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

[2]Apparent consumption is imports minus exports.

TABLE 2

U.S. REPORTED CONSUMPTION OF NATURAL GRAPHITE, BY END USE[1]

	Crystalline		Amorphous[2]		Total	
End use	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2007:						
Batteries	W	W	--	--	W	W
Brake linings	489	929	4,050	3,100	4,540	4,030
Carbon products[3]	284	775	W	326	W	1,100
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries[4]	W	W	474	323	W	W
Lubricants[5]	624	774	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	258	433	W	W	W	W
Refractories	6,490	3,190	W	W	W	W
Rubber	W	W	W	W	W	W
Steelmaking	W	W	W	W	W	7,410
Other[6]	8,820	9,660	2,150	2,410	11,000	12,100
Total	18,600	18,200	20,500	17,900	39,200	36,100
2008:						
Batteries	W	W	--	--	W	W
Brake linings	515	2,260	3,070	W	3,590	W
Carbon products[3]	266	693	W	W	W	W
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries[4]	W	W	3,600	13,100	W	W
Lubricants[5]	844	2,910	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	561	1,770	4	8	565	1,780
Refractories	7,210	6,280	W	W	W	W
Rubber	24	W	W	W	W	W
Steelmaking	W	W	W	W	W	W
Other[6]	8,740	12,600	3,390	19,900	12,100	32,400
Total	20,200	30,900	29,600	125,000	49,800	156,000

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

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

[2]Includes mixtures of natural and manufactured graphite.

[3]Includes bearings and carbon brushes.

[4]Includes foundries (other) and foundry facings.

[5]Includes ammunition and packings.

[6]Includes 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 USE[1]

End use	Quantity (metric tons)	Value (thousands)
2007:		
Anodes	W	W
Cloth and fibers (low modulus)	W	189,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	849	W
Electrodes	137,000	595,000
High-modulus fibers	W	W
Unmachined graphite shapes	8,930	96,700
Synthetic graphite powder and scrap[2]	W	W
Other	W	9,170
Total	198,000	1,180,000
2008:		
Anodes	W	W
Cloth and fibers (low modulus)	W	211,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	134,000	W
High-modulus fibers	5,720	168,000
Unmachined graphite shapes	10,800	118,000
Synthetic graphite powder and scrap[2]	W	W
Other	W	W
Total	196,000	1,050,000

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

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

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

TABLE 4

REPRESENTATIVE YEAREND GRAPHITE PRICES[1]

(Dollars per metric ton)

Type	2007	2008
Crystalline large, 94% to 97% carbon, +80 mesh	880–990	900–1,000
Crystalline large, 90% carbon, +80 mesh	570–655	100–800
Crystalline medium, 94% to 97% carbon, +100-80 mesh	800–900	800–900
Crystalline medium, 90% carbon, +100-80 mesh	440–495	680–780
Crystalline medium, 85% to 87% carbon, +100-80 mesh	420–475	670–770
Crystalline fine, 94% to 97% carbon, +100 mesh	650–800	600–700
Crystalline fine, 90% carbon, -100 mesh	410–475	550–650
Amorphous powder, 80% to 85% carbon	240–260	460
Synthetic 99.95% carbon[2]	3,500–12,500	5,550–17,900

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

[2]Swiss border for 2007 and European port for 2008.

Sources: Industrial Minerals, no. 483, December 2007, p. 76; no. 495, December 2008, p. 88.

TABLE 5

U.S. EXPORTS OF NATURAL AND ARTIFICIAL GRAPHITE, BY COUNTRY[1, 2]

Country	Natural[3]		Artificial[4]		Total	
	Quantity (metric tons)	Value[5] (thousands)	Quantity (metric tons)	Value[5] (thousands)	Quantity (metric tons)	Value[5] (thousands)
2007:						
Canada	1,210	$1,140	7,780	$11,800	8,990	$13,000
China	533	687	5,600	19,200	6,130	19,900
France	10	27	4,220	23,000	4,230	23,000
Germany	193	401	1,250	3,890	1,450	4,290
Italy	269	395	1,100	4,020	1,370	4,410
Japan	3,840	2,780	3,030	13,100	6,870	15,900
Korea, Republic of	1,470	1,800	2,700	8,550	4,170	10,300
Mexico	1,280	1,400	4,990	6,250	6,270	7,650
Netherlands	276	224	936	2,430	1,210	2,660
Taiwan	181	261	1,840	4,760	2,020	5,020
United Kingdom	3,090	3,840	1,260	3,870	4,350	7,710
Other	3,310	6,190	9,420	26,700	12,700	32,900
Total	15,700	19,100	44,100	128,000	59,800	147,000
2008:						
Canada	1,500	1,130	8,330	13,500	9,830	14,600
China	259	323	6,100	22,500	6,360	22,700
France	20	189	5,130	31,900	5,150	32,100
Germany	125	441	2,010	5,030	2,140	5,470
Hong Kong	3	13	156	486	159	498
Italy	269	447	1,220	4,770	1,490	5,220
Japan	727	1,360	3,290	16,100	4,020	17,500
Korea, Republic of	149	1,330	2,830	10,500	2,980	11,800
Mexico	1,120	1,130	6,040	6,630	7,160	7,760
Netherlands	47	72	596	2,180	642	2,250
Taiwan	305	478	2,170	6,280	2,470	6,760
United Kingdom	379	2,100	1,480	3,410	1,860	5,510
Other	3,060	6,570	15,500	43,100	18,600	49,900
Total	7,950	15,600	54,900	166,000	62,800	182,000

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

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

[3]Amorphous, 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.

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

[5]Values are free alongside ship.

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)
2007:										
Brazil	2,470	$2,870	--	--	349	$564	--	--	2,820	$3,440
Canada	12,000	7,030	--	--	948	5,760	--	--	12,900	12,800
China	24,200	9,740	--	--	517	1,900	3,280	$629	28,000	12,300
Germany	12	12	--	--	124	734	--	--	136	746
Japan	5	5	--	--	186	1,330	--	--	190	1,340
Madagascar	572	371	--	--	--	--	--	--	572	371
Mexico	2,530	766	--	--	--	--	9,900	1,350	12,400	2,120
Sri Lanka	--	--	1,090	$2,430	--	--	--	--	1,090	2,430
United Kingdom	36	30	--	--	340	1,250	--	--	376	1,280
Other[4]	--	--	--	--	92	497	--	--	92	497
Total	41,800	20,800	1,090	2,430	2,560	12,000	13,200	1,980	58,600	37,300
2008:										
Brazil	2,800	3,600	--	--	26	46	--	--	2,820	3,640
Canada	10,900	8,890	--	--	1,770	7,570	--	--	12,700	16,500
China	27,900	18,800	--	--	--	--	--	--	27,900	18,800
Germany	--	--	--	--	127	1,000	--	--	127	1,000
Guyana	--	--	--	--	--	--	1,380	92	1,380	92
Japan	--	--	--	--	140	1,500	--	--	140	1,500
Madagascar	799	653	--	--	--	--	--	--	799	653
Mexico	--	--	--	--	--	--	11,500	2,510	11,500	2,510
Sri Lanka	--	--	523	1,330	--	--	--	--	523	1,330
United Kingdom	--	--	--	--	211	914	--	--	211	914
Other[4]	18	17	--	--	107	1,110	43	8	168	1,140
Total	42,500	32,000	523	1,330	2,380	12,100	12,900	2,610	58,300	48,100

-- Zero.

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

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

[3]Customs values.

[4]Includes Austria, Belgium, the Czech Republic (2008), India, Italy, the Republic of Korea (2008), Russia (2008), the Netherlands, Sweden, Switzerland, and Ukraine (2008).

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)
2007:		
Canada	12,500	$51,100
China	26,500	44,600
Germany	1,900	11,700
India	1,360	3,390
Italy	1,230	2,050
Japan	18,000	81,400
Mexico	22,600	46,000
Poland	1,650	2,830
Russia	9,670	11,000
Ukraine	1,520	489
Other[4]	800	2,230
Total	97,600	257,000
2008:		
Canada	9,640	45,100
China	29,000	61,200
Germany	2,020	13,600
India	1,010	2,870
Italy	129	265
Japan	18,100	87,200
Mexico	23,800	62,400
Poland	4,410	10,900
Russia	7,350	12,400
Ukraine	961	2,570
Other[4]	1,650	4,630
Total	98,100	303,000

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

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

[3]Customs values.

[4]Includes 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	2004	2005	2006	2007	2008[e]
Brazil, marketable	76,332	75,515 [r]	76,194	77,163 [r]	77,200 [p]
Canada[e]	28,000	28,000	28,000	28,000	27,000
China[e]	700,000	720,000	720,000	800,000	810,000
Czech Republic[e]	5,000	3,000	5,000 [r]	3,000	3,000
Germany, marketable	3,155	2,638	--	--	--
India, run-of-mine[e, 3]	120,000	130,000	120,000	130,000	140,000
Korea, North[e]	30,000	32,000	30,000	30,000	30,000
Korea, Republic of	247	39	68	52 [r]	55
Madagascar[e]	7,770 [r]	6,400 [r]	4,857 [r]	5,000 [r, e]	5,000
Mexico, amorphous	14,769	12,357	12,500 [e]	12,500 [e]	9,900
Norway[e]	2,300	2,300	2,300	2,000	2,000
Romania	500 [e]	500 [e]	--	--	--
Sri Lanka[e]	3,400	3,000	3,200	3,300	3,400
Sweden[e]	800	800	800	800	800
Turkey, run-of-mine[4]	1,000	100 [r]	300 [r]	400 [r]	400
Ukraine[e]	7,500	7,500	7,500	7,500	7,500
Uzbekistan[e]	60	60	60	60	60
Zimbabwe[e]	10,267 [5]	4,298 [r, 5]	6,588 [r, 5]	5,000	2,000
Total	1,010,000 [r]	1,030,000 [r]	1,020,000 [r]	1,100,000 [r]	1,120,000

[e]Estimated. [p]Preliminary. [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 16, 2009.

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

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

[5]Reported figure.