Graphite

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Graphite is a raw material with a unique blend of physical and chemical properties. There are quite a number of minerals similar in appearance to graphite; however, graphite's intrinsic properties make it easy to distinguish.

A useful classification of graphite depends on the mode of formation that leads to three physically distinct common varieties: amorphous (micro-crystalline) graphite, which has a carbon content of 70-85%; high crystalline graphite (lump, vein or crystalline vein), which has a carbon content of 90-99%; and flake graphite, which has a carbon range of 80-98%.

Flake graphite (i.e., flat plate-like grains from <1 mm to 2.5 cm in size) is divided into two particle size distributions: coarse flake (-20 to +100 mesh), and fine flake (-100 to +325 mesh). Crystalline graphite ranges from chip or dust to fine or amorphous lump, to coarse or crystalline lump.

The term "flake" is self-explanatory; flake forms occur disseminated in rock. Lump graphite occurs in fissure-filled veins in pegmatite dikes, also associated with chip and the rarer needle forms. Amorphous graphite occurs in beds that were once coal, but fine-grained, easily ground vein graphite is also classified as amorphous.

All graphite has crystal structure, but only certain kinds and sizes of natural graphite are commercially classified as crystalline, a term used for import duty purposes. Natural graphite, the mineral form of graphitic carbon, occurs worldwide. It differs from the carbon of coal and of diamond in its predominantly lamellar hexagonal crystal structure. The ore usually contains associated silicate minerals that vary in kind and amount with the source.

Synthetic graphite has a higher purity but lower crystallinity than natural graphite and is divided into primary or electrographite, with a carbon content of 99.9%, which is manufactured on a large scale in electric furnaces using calcined petroleum coke and coal tar pitch (used to produce electrodes and carbon brushes); secondary synthetic graphite in the form of powder or scrap, which is produced by heating calcined petroleum pitch (used in the refractories industry); and graphite fibres, which are produced from organic precursors such as rayon or polyacrylonitrile and tar pitch (used as reinforcing agents in polymer composites in aerospace and sporting goods). Artificially manufactured graphite is physically inferior to natural graphite because of its porosity, small flakes, and less desirable carbon.

Natural graphite is a lustrous black carbon mineral, crystallized in the hexagonal system with rhombohedral symmetry. Flake graphite is opaque, flexible and sectile, and exhibits perfect basal cleavage. Natural graphite is unctuous and relatively soft with a hardness of 1-2 on the Mohs scale. It has a black streak on glaze porcelain. Its specific gravity is 2.26 g/cm^3. Molybdenite, commonly confused with graphite, is heavier and not smudgy, and it is also metallic bluish silver in colour. Graphite is one of those "tip of the iceberg" materials. For example, large amounts of graphite are used to make "lead" pencils, so-called because graphite resembles lead in colour, but in reality it is not lead, but graphite mixed with clay.

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 many useful properties of graphite give rise to a wide variety of products (30 different applications with hundreds of formulations): unctuous – dry lubricant; marks readily – writing and drafting pencils; combination of lubricity and electrical conductivity – motor and generator brushes; excellent weathering properties and inertness – industrial paint pigment; solubility in molten iron – carbonraiser for steel; poorly wet by most metals and alloys – foundry mold facings; and burns slowly, conducts heat, and retains strength over a large temperature range – refractories such as crucibles, carbon-magnesite brick, continuously casting ware, and stopper heads for steel ladles. Some additional properties of interest include

hydrophobicity, forms water-in-oil emulsions, carries a negative charge, has low photo-electric sensitivity, is strongly diamagnetic, and is an infrared absorber. Therefore, graphite is an excellent conductor of heat and electricity and has a high melting temperature of 3500°C. It is extremely resistant to acid, chemically inert, and highly refractory.

GRAPHITE DEPOSITS IN CANADA

Graphite deposits of potentially commercial interest in Canada occur principally in rocks of the Grenville series of eastern Canada. The mineral is found in disseminated crystalline flake and vein forms. Most Canadian graphite deposits are associated with graphite gneiss and crystalline limestones that have been subjected to contact metamorphism associated with tectonic features such as folding, compression and fracturing, and with pegmatitic intrusions. The richest ore zones occur as a succession of veins or lenticular bodies that gradually merge into the adjacent non-graphitic host rock and that are bordered by lenses of lower-grade ore.

Fine-to-coarse flake graphite deposits have been reported mainly in Quebec and Ontario, but also in New Brunswick, Nova Scotia, Saskatchewan, Labrador, and British Columbia. The more important occurrences are those found in metasomatic-hydrothermal deposits and in sedimentary rocks that have been subjected to regional or thermal metamorphism. Marble, gneiss and schist are the more common rock types in which economic graphite deposits occur.

In Quebec, graphite deposits are located mainly along the Grenville series in several townships of western Quebec: Buckingham, Argenteuil, and Pontiac. The disseminated flake graphite variety is dominant in biotite gneiss and crystalline limestone associated with biotite quartzite, but the vein variety is also reported along the contact of intrusive rocks and crystalline limestone. Occurrences of graphite are associated with metasedimentary rocks that have been subjected to several deformations and where metamorphism has reached amphibolitic or granulitic phases.

Graphite also occurs in Esmanville Township, south of Fermont. Several graphite-rich schist zones, measuring 1-25 m in thickness, are found interlayered with quartz-feldspar gneiss. Some graphite zones locally contain more than 15% graphite in the form of fine and well-crystallized flakes.

In Ontario, graphite deposits are found in several townships of eastern Ontario in rocks of the Grenville Geological Province. Flake graphite occurs disseminated in marble and gneiss. The occurrences of major interest are in semipelitic and pelitic gneiss units within paragneiss sequences. Graphite is present in amounts up to 10%. Accessory minerals consist of biotite, garnet and pyrite; trace elements in these graphitic rocks include nickel, cobalt, boron and vanadium.

In southeastern British Columbia, the Hoder Creek and Little Slocan River Valleys graphite deposits, located in the Regolith Zone, host rocks were metamorphosed primarily from limestone to marble of other limey metasediments. The granites within the batholith were metamorphosed to hybrid or mixed gneisses. This calc-silicate metasediment is regional (typical of crystal graphite deposits) with numerous occurrences of graphite. In the west-central coast Bentinck Arm area, the graphite showing occurs as small thin graphite flakes widely dispersed in a quartz-rich gneiss, an area that is underlain by metavolcanic rocks that have been intruded by a now foliated granodiorite.

CANADIAN PRODUCTION

Since there was, until recently, only one Canadian producer of natural graphite, production values and quantities cannot be released by Natural Resources Canada due to a confidentiality agreement with the Canadian producer.

With the additions in 2004, there are presently three graphite deposits being exploited in Canada and another is in its final analysis phase prior to production.

Quebec

Stratmin Graphite Inc., which recently changed its name to Timcal Canada Inc. (part of the graphite business unit "Timcal Graphite" of Imerys SA of France), operates the Lac-des-Îles graphite mine near Mont-Laurier, which has a nominal production capacity of 25 000 t/y. The company began exploiting a new pit in October 2002. In 2003, it reduced production by 25%. To diversify production, it invested US$10 million in a new processing plant in Terrebonne, near Montréal. Mechanical concentration of the graphite, which raises the carbon content to 98.8%, and packaging, mainly for refractory grades, will continue to be performed at Lac-des-Îles. The Terrebonne plant added value to natural graphite (expanded graphite) from its mining and processing operation in Lac des-Iles, Quebec, and from offshore sources.

In the developmental stage, Quinto Technology Inc. of Delta, British Columbia, is currently developing a graphite deposit in the province of Quebec called the Lac Gueret property. The graphite deposit project is a 50:50 joint venture between Quinto and SOQUEM Inc. (wholly owned subsidiary of Société générale de financement du Québec [SGF]). The property lies in southeastern Quebec, 300 km north-northwest of Baie-Comeau, along the southwest shore of Reservoir Manicouagan.

Ontario

In 2004, Industrial Minerals Inc. (IMI) of Mississauga started its graphite mill and processing plant in Bissett Creek, located in Maria Township northwest of Deep River (i.e., 240 km west of Ottawa and 100 km east of North Bay). The deposit has approximately 640 000 t of proven graphite resources. It contains coarse flakes ranging in size from -12 to 80 mesh. The Bissett Creek plant is designed to produce 20 000 t/y, employs a dry process, and offers two grades of 85% and 94% graphitic carbon.

British Columbia

In 2004, Crystal Graphite Corp. (CGC) of Vancouver also started its own graphite beneficiation plant for the mining of its high-purity graphite Black Crystal deposit near Slocan Lake, northwest of Nelson. The quarrying, transportation and some processing are contracted out. Currently, and for the first few years of production, the deposit will be mined by open-pit methods. In the long term, the company envisages eventually moving to a selective room and pillar mining method to reach the bulk of the resource. Long-term run-of-mine production is designed to be 300 000 t/y for a 20-year mine life, from which 8000 t/y of high-purity graphite would be produced. CGC has decided to focus primarily on value-added markets in the long term, notably the fuel cell market. The sold material has achieved prices of $2500/t (97.5-99% graphite carbon and +150 to -50 mesh). Ultimately, CGC estimates that 85% of its product will be fuel-cell grade with the remaining 15% being fine-grade graphite for other uses. CGC has also secured a source of graphite foil and expandable-grade graphite through an alliance with several producers in China to distribute along with the Black Crystal product in North America.

World production (source: USGS's 2003 review on graphite) of natural graphite decreased by about 3% in 2004 to an estimated 742 000 t from 763 000 t in 2003. China maintained its position as the world's leading graphite producer with 450 000 t (61% of world production). India was the second largest graphite producer with 110 000 t, followed by Brazil, Canada, North Korea, the Czech Republic, Mexico and Turkey, in decreasing order of tonnage produced. These eight countries accounted for more than 96% of world production. Sri Lanka continued to account for nearly all of the high-purity lump graphite produced with deposits estimated to average 95% graphite in situ.

MINING

Graphite deposits are usually located at or near the surface and are typically mined by open-pit methods. Underground mining methods are only employed when warranted by grade and structure. The present graphite producers operate open-pit deposits. Underground mining of graphite was relatively common in eastern Ontario and in the Buckingham area of Quebec during the early 1900s with shafts extending to depths of 80 m or more.

PROCESSING

Flake graphite in Canada is too finely disseminated for hand sorting and cobbing methods, which are used in some countries to recover massive flake graphite. Production of Canadian graphite is usually only possible by a combination of careful grinding and screening to recover coarse flakes, and flotation to recover fine graphite. Flotation concentrates are sometimes further beneficiated by tabling to remove associated gangue minerals such as quartz, mica, hornblende, feldspar, calcite and base-metal sulphides.

Impurities tend to float with graphite since, being soft, graphite tends to smear and coat impurity minerals during grinding so that they behave like graphite. This is especially true when processing finely divided ores that require extensive grinding.

Size reduction is usually accomplished by jaw, cone, or hammer mill-type crushers; screening to recover coarse flakes or to reject coarse hard impurities is accomplished by trommel or vibratory screens. The recovery of intermediate and fine flake graphite is possible by rolls crushing, ball, roller or jet milling followed by additional screening, air classification, wet tabling or flotation.

Graphite is naturally floatable and particles as coarse as 1 mm may be floated in a slightly alkaline pH medium. Pine oil and kerosene are the standard collectors and are usually employed together. The alcohol frother is the primary collector, and the function of kerosene or fuel oil is as a promoter to recover unliberated graphite middlings. Flotation is fairly fast, and multiple cleaning is necessary for recoveries of 80 to 85%; recovery can be improved by regrinding and reflotation, but careful regrinding is necessary to avoid smearing of gangue minerals and the production of slime graphite.

Modifiers and depressants to improve selectivity include sodium silicate, which acts as a quartz depressant and slime dispersant, and lactic acid, $C_3H_6O_3$, which is used to depress mica.

Graphite may be further purified to 99% carbon by chemical treatment, chloridization or fluoridization.

Synthetic graphite, mainly manufactured in the United States, is made from a mixture of petroleum coke or anthracite filler, coal tar or petroleum pitch binder, and various impregnating or additive materials. The coke or anthracite, which should contain 95% carbon and have a

low sulphur content, is calcined to remove volatiles, ground, mixed with binder and other materials, and molded to the required shape. The product, known in the trade as "green bar" or "green stock," is then baked at 800-1000°C to convert the pitch binder to coke and to solidify the shape. The resulting product is then "graphitized" by heating in an electric furnace at 2600-3000°C over an extended period. The product is then cooled and machined to final size specifications (e.g., production of electrodes = turned on lathes to the desired diameter for application as an additive in iron and steel manufacturing).

USE AND TRADE

NRCan's 2004 voluntary survey on the use of nonmetallic minerals by Canadian manufacturing plants indicated that the use of graphite in Canada for 2003 increased by 4% to 14 674 t from 14 137 t in 2002. Of these figures (Table 3), natural graphite represented 3681 t (25.1%) and synthetic graphite represented 10 993 t (74.9%). Natural graphite consumption was mainly in the foundry facing (65%) industry, while the balance (35%) reported was for other uses (i.e., brake linings, chemicals, abrasives, primary steel, and other uses).

As for Canadian trade (Table 2), Statistic Canada reported that the total value of Canadian exports of graphite increased by 31% to $33.5 million in 2004 from $25.5 million in 2003. Of these exports, $17.8 million (24 707 t) was natural graphite, the balance being refractory products and carbon/graphite brushes. The United States was the main destination of Canadian natural graphite, valued at $11.9 million (14 257 t). Imports into Canada totaled $49.5 million in 2004, an increase of 42.7% from $34.7 million in 2003. Of these imports, $4.3 million (4892 t) was natural graphite and the balance was refractory products and carbon/graphite brushes. The United States exported $1.8 million worth (3246 t) of natural graphite in 2004, a decrease from $2.3 million in 2003, even if the quantity of its exports into Canada increased from 2183 t in 2003. It was also the main supplier of other graphite products imported into Canada even though no natural graphite was reported mined in the United States in 2003 (Source: USGS 2003 review on graphite).

U.S. imports for the consumption of natural graphite increased by 16% to 52 300 t in 2003 from 45 100 t in 2002. The majority was imported from China (46%) and Mexico (20%). U.S. consumption of natural graphite, from USGS surveys, indicate a decrease of 3% to 38 200 t in 2003 from 39 400 t in 2002. The three major industries that continued to dominate in graphite usage, accounting for more than 55% of the graphite consumed by the U.S. industry, were brake linings, refractories, and steelmaking. Foundries and the lubricants industries together made up almost another 16% of U.S. graphite consumption.

As for U.S. synthetic graphite, reported production reached 236 000 t with an estimated value of US$625 million.

PRODUCTION AND MARKET CONSIDERATIONS

The major producing countries, by type of graphite and in decreasing order of importance, are as follows:

- Flakes: China, Ukraine, Brazil, Canada, Madagascar, Zimbawe and Norway;
- Microcrystalline (amorphous): China, South Korea, Mexico, the Czech Republic, Austria, North Korea, Russia, and Zimbawe; and
- Lump: Sri Lanka.

Refractories, foundries, friction products and lubricants are the highest-volume applications for graphite (Source: *Industrial Minerals* magazine, October 2003). New applications for graphite producers to keep tabs on include the use of natural graphite in heat sinks, which could be used for electronics cooling applications, e.g., in computers, servers and power devices. There is also an increasing new interest in graphite as a flame retardant and as an additive in polymers used in applications such as sealing and piping.

Currently, the market for large flake, high-carbon graphite is experiencing a cycle of high growth. This is due in large measure to the new demand created by the fuel cell industry and its need for electrodes and conductive separators being developed for the automotive industry sector. There is additional new growth in demand in magnesia and alumina refractories, and in the use of graphite in the lithium ion battery.

The ability to purify and modify graphite and carbon products is the key to future growth in the graphite industry. Along with consistency in specifications and source of supply, and just-in-time (JIT) service and joint cooperation/development programs with industry users, consistency is the number one request made in the market today.

PRICES

Prices for actual transactions vary according to geographic region and will take into account the quantity purchased, application, quality assurance, exact grade purchased, credit terms, and other parameters. Due to the unavailability of Canadian prices, the following price examples from other sources are provided to facilitate an understanding.

Natural graphite prices (Source: USGS 2003 review on graphite) remained unchanged during 2003. Prices for crystalline and crystalline flake graphite concentrates

ranged from US$230 to $750/t; prices for amorphous powder were not available. Ash and carbon content, crystal and flake size, and flake distribution affect the price of graphite. The prices of synthetic graphite were not available; however, the average unit value of synthetic graphite exports decreased to US$1118/t in 2003 from US$1339/t in 2002.

Flake graphite has the advantage of being sold into a wider range of markets and enjoys higher prices than amorphous from Mexico or lump from Sri Lanka. As a general rule, the larger flake sizes sell at the highest prices amongst the natural graphite products. There are several levels of quality of graphite used in determining its market value (source: Industrial Minerals Inc. corporate information report). Examples of recent pricing relative to the specifications are as follows:

C.I.F. U.K. Port Basis	US$/t
Crystalline, large flake, 94% C	570-780
Crystalline, large flake, 90% C	480-550
Crystalline, medium flake, 90% C	370-410
Crystalline, small flake, 80-95% C	270-500
Amorphous powder, 80-85% C	220-235
Synthetic, 99.5% C, Swiss Border	2 010

MAJOR USES

Graphite usage, stable for some years, appears to be about to undergo a renaissance. Advantage is being taken of the electrical conductivity of graphite and of its light weight. There is renewed interest in making plastics conductive. Graphite has advantages over the carbon blacks of producing lower-viscosity compounds and being cleaner to use. End uses that are beginning include fuel cell components, energy cell components, graphite reactor fuel elements, and intercalation compounds. Further off the horizon are uses in magnetic levitation and lower-cost synthesis of diamonds.

The largest consumers (i.e., the Russian Federation, Japan, the United States, China, Germany, the United Kingdom, Italy, France, and Brazil) of graphite are the biggest producers of steel, base metals and precious metals. Together it is estimated that they consume about 50% of all graphite and are the largest users of flake graphite.

Graphite crucibles are used in steel-making and in the production of nonferrous and precious metals. Here, flake graphite is preferred to microcrystalline graphite because it burns more slowly, has a high attrition resistance, and imparts structural strength through the orientation of the flakes. The average carbon content is 80-90% and the average flake size is 0.15 mm.

Although graphite is used in metallurgy, it is also consumed for the chemical, mechanical, glass, and ceramic industries. Its role is also important in a range of medical, environmental, transportation and energy management technologies.

Growing markets include: (a) exfoliated “expanded” flake graphite rolled into sheet (grafoil, also called flexible graphite foil) for the manufacture of gaskets and seals used in the automotive industry, heat exchangers, and other products; (b) high-alumina and magnesia-graphite bricks for the refractory industry; (c) zirconia-graphite coatings; (d) flake graphite-silicon carbide refractories; and (e) friction materials. Other growing markets are very high-purity graphite for specialty applications, metal powders, and motor brushes.

New and developing applications are providing demand growth for graphite. In particular, there is considerable potential for high-purity, high-carbon graphite in the batteries sector, and in the fuel cells, which could offer good longer-term growth. A research group associated with the University of New South Wales in Sydney has developed a new form of very-high-density graphite (VHD graphite) that has advantages over conventional graphite in four key areas: porosity, composition, and electrical and thermal conductivity. VHD graphite can be manufactured at lower temperatures than conventional graphite and the processing time is an order of magnitude shorter.

Nanocomposites: When intercalated and expanded, graphite nano-flakes are produced with a thickness to 20-50 nanometers. The potential end use of graphite nano-flakes would be in the aerospace, automobile, and conductive plastics sectors.

OUTLOOK

Refractory use trends (source: USGS 2003 review on graphite) for graphite closely follow events in the steel industry because graphite is mostly used in the manufacture of refractory brick, which is used in iron and steel furnace linings. Brake linings and other friction materials will steadily use more natural graphite as new automobile production continues to increase and more replacement parts are required for the growing number of vehicles. Flexible graphite products, such as grafoil (a thin graphite cloth), will probably be the fastest growing market but will use small amounts of natural graphite compared with major end-use markets, such as brake linings and refractories.

Canadian deposits are of the flake type and are relatively easy to upgrade to +90% carbon; many contain graphite that is expandable. Products made from expandable graphite command higher prices and the outlook for growth in these products is good.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 64. (2) Information in this review was current as of July 15, 2005. (3) This and other reviews, including previous editions, are available on the Internet at www.nrcan.gc.ca/mms/cmy/com_e.html.

NOTE TO READERS

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TARIFFS

Item No.	Description	Canada			United States	EU	Japan
		MFN	GPT	USA	Canada	Conventional Rate (1)	WTO (2)
25.04	Natural graphite						
2504.10.10	In powder or in flakes, in powder	Free	Free	Free	Free	Free	Free
2504.10.20	In powder of in flakes, in flakes	Free	Free	Free	Free	Free	Free
2504.90	Other	Free	Free	Free	Free	Free	Free
38.01	Artifical graphite; colloidal or semi-colloidal graphite; preparations based on graphite or other carbon in the form of pastes, blocks, plates or other semi-manufactures						
3801.10	Artificial graphite	Free	Free	Free	Free	3.6%	2.5%
3801.20	Colloidal or semi-colloidal graphite	Free	Free	Free	Free	4.1-6.5%	2.5%
68.15	Articles of stone or of other mineral substances (including carbon fibres, articles of carbon fibres and articles of peat), not elsewhere specified or included						
6815.10	Non-electrical articles of graphite or other carbon						
6815.10.20	Graphite blocks, of a diameter exceeding 1 m and a thickness exceeding 38 cm, to be employed in the manufacture of moulds for casting wheels for railway vehicles	3%	3%	3%	Free	Free	Free
6815.10.90	Other	6%	3%	6%	Free	Free	Free
69.02	Refractory bricks, blocks, tiles and similar refractory ceramic constructional goods, other than those of siliceous fossil meals or similar						
6902.90.11	Other, containing by weight 85% or more of carbon or graphite: Stopper head fire bricks	Free	Free	Free	Free	2%	1.5%
6902.90.19	Other, containing by weight 85% or more of carbon or graphite: Other	Free	Free	Free	Free	2%	1.5%
6902.90.98	Other, containing by weight more than 50% but less than 85% of carbon or graphite	Free	Free	Free	Free	2%	1.5%
69.03	Other refractory ceramic goods (for example, retorts, crucibles, muffles, nozzles, plugs, supports, cupels, tubes, pipes, sheaths and reds), other than those of siliceous fossil meals or of similar siliceous earths						
6903.10	Containing by weight more then 50% of graphite or other carbon or of a mixture of these products	Free	Free	Free	Free	5%	3.5%
6903.10.10	Crucibles and covers therefor	Free	Free	Free	Free	5%	3.5%
6903.10.91	Other, containing by weight 85% of more of graphite or other forms of carbon	Free	Free	Free	Free	5%	3.5%
6903.10.99	Other; other	Free	Free	Free	Free	5%	3.5%
85.45	Carbon electrodes, carbon brushes, lamp carbons, battery carbons and other articles of graphite or other carbon, with or without metal, of a kind used for electrical purposes						

TARIFFS (cont'd)

Item No.	Description	Canada			United States	EU	Japan
		MFN	GPT	USA	Canada	Conventional Rate (1)	WTO (2)
8545.11.12	Electrodes, of a kind used for furnaces, not exceeding 88.9 cm in circum-ference or outside measurement: Of graphite	Free	Free	Free	Free	2.7%	3.3%
8545.11.22	Electrodes, of a kind used for furnaces, exceeding 88.9 cm in circum-ference or outside measurement: Of graphite	Free	Free	Free	Free	2.7%	3.3%
8545.19	Electrodes: Other						
8545.19.10.22	Not exceeding 88.9 cm in circumference or outside measurement, of graphite	Free	Free	Free	Free	2.7%	3.3%
8545.19.21	Exceeding 88.9 cm in circumference or outside measurement: Carbon anode blocks for use in the manufacture of aluminum; graphite electrodes, other than for use with furnaces; for use in the manufacture of magnesium; pre-baked carbon electrodes, for use in the manufacture of silicon metal	Free	Free	Free	Free	2.7%	3.3%
8545.19.22	Exceeding 88.9 cm in circumference or outside measurement: Cathode blocks for use in the manufacture of aluminum	Free	Free	Free	Free	2.7%	3.3%
8545.19.29	Exceeding 88.9 cm in circumference or outside measurement: Other, of graphite	6.5%	6.5%	6.5%	Free	2.7%	3.3%
8545.20.20	Brushes, of graphite	Free	Free	Free	Free	2.7%	3.3%
8545.90.92	Other, of graphite	Free	Free	Free	Free	2.7%	3.3%

Sources: Canadian *Customs Tariff*, effective January 2005, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States*, 2005; *Official Journal of the European Union* (October 30, 2004 Edition); *Customs Tariff Schedules of Japan, 2004.*
(1) The customs duties applicable to imported goods originating in countries that are Contracting Parties to the General Agreement on Tariffs and Trade or with which the European Community has concluded agreements containing the most-favoured-nation tariff clause shall be the conventional duties shown in column 3 of the Schedule of Duties. (2) WTO rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, GRPAHITE PRODUCTION, SHIPMENTS AND TRADE, 2002-04

		2002		2003 (r)		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION (all forms)							
	Quebec	x	x	x	x	x	x
EXPORTS							
2504.10	Natural graphite in powder or flake						
	United States	8 342	6 865	7 977	6 840	14 219	11 705
	Turkey	920	517	1 841	851	3 710	1 637
	United Kingdom	160	133	22 128	1 447	2 192	1 416
	Italy	218	36	2 304	641	2 016	1 319
	Spain	100	78	12	17	1 558	896
	Switzerland	–	–	697	635	252	288
	Austria	–	–	40	21	500	262
	Netherlands	40	20	120	59	85	59
	Japan	–	–	40	43	40	41
	Czech Republic	–	–	–	–	60	19
	Cuba	–	–	–	–	1	2
	New Caledonia	–	–	–	–	1	1
	China	9	10	2	13	–	–
	Germany	40	53	40	52	–	–
	Belgium	–	–	44	82	–	–
	France	–	–	4	7	–	–
	Sweden	–	–	80	33	–	–
	Total	9 829	7 712	35 329	10 741	24 634	17 645
2504.90	Natural graphite, n.e.s.						
	United States	1	9	2	15	38	152
	Trinidad and Tobago	–	–	–	–	27	16
	Germany	–	–	–	–	8	4
	France	8	3	14	2	–	–
	Australia	–	–	9	4	–	–
	Chile	–	–	12	6	–	–
	Hong Kong	–	–	5	2	–	–
	Mexico	–	–	2	1	–	–
	Qatar	–	–	1	. . .	–	–
	South Africa	–	–	6	3	–	–
	Total	9	12	51	33	73	172

TABLE 1 (cont'd)

		2002		2003 (r)		2004 (p)	
		(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
EXPORTS (cont'd)							
6902.90	Refractory bricks, blocks, tiles; other						
	United States	2 906	3 622	2 815	3 160	3 953	4 368
	South Africa	–	–	–	–	759	693
	Kazakhstan	–	–	–	–	30	180
	Japan	118	65	263	150	158	171
	Australia	1	2	–	–	174	161
	China	–	–	160	60	35	28
	El Salvador	–	–	–	–	16	25
	New Zealand	30	44	139	56	49	23
	Qatar	–	–	–	–	15	22
	Belgium	–	–	102	140	11	20
	Chile	17	25	–	–	20	13
	United Kingdom	12	15	–	–	8	10
	Mali	–	–	–	–	7	10
	Croatia	–	–	–	–	3	5
	Colombia	13	15	–	–	–	–
	France	126	134	14	19	–	–
	Israel	44	97	–	–	–	–
	Saint Vincent and the Grenadines	4	12	–	–	–	–
	Sweden	43	88	–	–	–	–
	Cuba	–	–	3	4	–	–
	Trinidad and Tobago	–	–	7	10	–	–
	Total	3 314	4 119	3 503	3 599	5 238	5 729
6903.10	Other refractory ceramic goods, containing by weight more than 50% of graphite or other carbon or of a mixture of these products						
	Sweden	–	–	–	–	..	66
	United States	..	10	..	46	..	58
	Finland	–	–	–	–	..	21
	New Zealand	–	–	–	–	..	14
	Brazil	–	–	–	–	..	12
	Australia	–	–	–	–	..	10
	Austria	–	–	–	–	..	7
	Germany	–	–	–	–	..	7
	Netherlands	–	–	–	–	..	5
	Spain	–	–	–	–	..	3
	Saudi Arabia	–	–	..	...	–	–
	Total	..	10	..	46	..	203
8545.20	Carbon or graphite brushes						
	United States	70 920	10 856	79 624	10 030	73 869	8 651
	South Africa	2 729	13	5 798	19	17 115	152
	United Kingdom	2 541	13	1 212	33	21 791	133
	Chile	1 593	17	14 371	77	13 259	130
	China	32 354	147	42 826	184	25 163	118
	Netherlands	7 837	34	17 913	93	16 151	92
	Peru	4 040	10	19 706	122	11 801	69
	Spain	17 351	58	13 624	69	9 273	64
	Vietnam	–	–	640	15	10 346	47
	Colombia	400	3	3 151	20	6 864	43
	Hong Kong	80	...	10 978	55	3 256	36
	Germany	–	–	8 335	40	7 289	33
	Israel	–	–	8 947	39	4 000	32
	Australia	9 116	40	8 284	38	6 566	32
	France	6 929	78	18 772	121	5 724	27
	South Korea	6 820	26	50	...	290	18
	Denmark	4 596	21	2 124	12	2 676	13
	Iran	386	35	–	–	1 503	7
	Senegal	1 000	7	–	–	1 000	6
	Uruguay	–	–	–	–	850	6
	Guinea	–	–	–	–	870	5
	Sweden	–	–	64	...	806	4
	India	3 560	8	92	...	628	3
	New Zealand	66	...	1 250	5	481	2
	Saudi Arabia	2 597	4	1 213	6	512	2
	Cuba	150	1	9 256	62	365	2
	Japan	–	–	238	1	100	1
	Italy	7 000	28	3 231	15	87	...
	Kyrgyzstan	–	–	–	–	4	...
	Greece	186	1	268	1	7	...
	Finland	–	–	404	1	71	...
	Indonesia	–	–	62	...	104	...
	Oman (Muscat)	–	–	156	1	98	...
	Singapore	–	–	2 000	14	30	...
	Switzerland	–	–	17	...	26	...
	United Arab Emirates	–	–	2 736	13	78	...

TABLE 1 (cont'd)

		2002		2003 (r)		2004 (p)	
		(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
EXPORTS (cont'd)							
	Poland	–	–	9	. . .	31	. . .
	Turkey	–	–	–	–	4	. . .
	Turks and Caicos Islands	–	–	–	–	12	. . .
	Botswana	–	–	1 400	9	–	–
	Belgium	–	–	2	. . .	–	–
	Jordan	–	–	86	. . .	–	–
	Philippines	–	–	400	1	–	–
	Jamaica	60	1	–	–	–	–
	Thailand	–	–	57	. . .	–	–
	Tunisia	–	–	173	1	–	–
	Bahrain	–	–	4	. . .	–	–
	Argentina	–	–	1 130	5	–	–
	Bahamas	–	–	1	. . .	–	–
	Total	182 311	11 401	280 604	11 102	243 100	9 728
	Total exports	. .	23 254	. .	25 521	. .	33 477
		(tonnes)	**($000)**	**(tonnes)**	**($000)**	**(tonnes)**	**($000)**
IMPORTS							
2504.10	Natural graphite in powder or flake						
	United States	2 679	3 110	1 782	1 885	2 863	1 426
	China	252	212	382	245	458	366
	Mexico	302	186	317	186	226	128
	Japan	175	324	116	172	103	114
	Switzerland	1 904	3 488	833	1 629	16	35
	Belgium	. . .	. . .	4	12	5	13
	Germany	5	5	7	7	5	7
	Canada	–	–	–	–	2	3
	Spain	–	–	. . .	. . .	1	1
	Austria	1	. . .	–	–	12	. . .
	Taiwan	5	. . .	–	–	1	. . .
	Italy	-	-	–	–	. . .	. . .
	Swaziland	-	-	–	–	. . .	. . .
	Australia	. . .	. . .	–	–	–	–
	Brazil	1	3	2	4	–	–
	Czech Republic	1	2	-	-	–	–
	Sweden	1	. . .	-	-	–	–
	India	–	–	1	2	–	–
	South Korea	–	–	. . .	. . .	–	–
	Total	5 326	7 330	3 444	4 142	3 692	2 093
2504.90	Natural graphite, n.e.s.						
	China	8	25	384	894	746	1 800
	United States	1 051	533	401	413	383	378
	Germany	17	21	192	121	46	75
	United Kingdom	1	. . .	–	–	12	26
	Dominican Republic	–	–	3	. . .	3	1
	Finland	–	–	–	–	7	1
	Japan	–	–	–	–	. .	1
	Guyana	2	1	4	1	2	. . .
	Belgium	–	–	–	–	1	. . .
	Tanzania	–	–	–	–	. . .	. . .
	Austria	1	. . .	. . .	1	–	–
	Brazil	1	. . .	–	–	–	–
	Ivory Coast	2	. . .	–	–	–	–
	Denmark	. . .	. . .	. . .	. . .	–	–
	Greenland	2	. . .	–	–	–	–
	Hong Kong	29	1	–	–	–	–
	Iran	. . .	. . .	–	–	–	–
	Mexico	19	11	–	–	–	–
	Russia	22	7	222	48	–	–
	Spain	2	1	–	–	–	–
	Switzerland	30	82	–	–	–	–
	Taiwan	1	. . .	2	. . .	–	–
	France	–	–	6	. . .	–	–
	Mongolia	–	–	. . .	. . .	–	–
	South Africa	–	–	1	. . .	–	–
	Total	1 188	682	1 215	1 478	1 200	2 282

TABLE 1 (cont'd)

		2002		2003 (r)		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
6902.90	Refractory bricks, etc., n.e.s. (containing by weight more than 50% carbon or graphite)						
	United States	12 188	11 697	9 162	8 877	15 067	10 172
	France	95	194	370	553	7 639	6 699
	Germany	855	1 050	1 190	2 561	7 071	5 918
	China	1 022	2 453	998	1 818	1 542	3 296
	United Kingdom	754	1 785	712	1 460	1 512	2 921
	Denmark	570	563	251	247	1 979	1 890
	Netherlands	234	296	360	408	1 176	959
	Switzerland	2	7	–	–	380	219
	Italy	54	37	21	29	2 268	133
	Belgium	20	89	58	136	31	124
	Mexico	88	186	66	146	182	113
	Japan	2 253	1 594	89	429	55	98
	Thailand	–	–	12	46	5	44
	Brazil	91	128	171	235	576	37
	Spain	–	–	149	105	37	30
	Norway	21	24	–	–	4	21
	Zimbabwe	–	–	1	2	2	6
	India	–	–	–	–	3	3
	Poland	43	43	–	–	1	2
	Argentina	-	-	–	–	..	1
	Australia	10	28	3	8	2	1
	Taiwan	1	...	–	–	...	...
	Turkey	–	–	–	–	..	...
	Canada	2	1	4	3	2	...
	Czech Republic	–	–	–	–	...	...
	Austria	300	187	–	–	...	...
	Ukraine	–	–	–	–	...	...
	American Samoa	–	–	2	3	–	–
	Hong Kong	–	–	64	62	–	–
	South Korea	–	–	12	14	–	–
	Sweden	–	–	1	...	–	–
	Kazakhstan	1	...	–	–	–	–
	Hungary	9	42	–	–	–	–
	Portugal	–	–	22	8	–	–
	Total	18 613	20 404	13 718	17 150	39 534	32 687
		(kilograms)	**($000)**	**(kilograms)**	**($000)**	**(kilograms)**	**($000)**
6903.10	Refractory ceramic goods, n.e.s., containing more than 50% or graphite or other forms of carbon, etc. (including crucibles)						
	United States	3 426	1 271	4 405	1 019	67 767	1 467
	United Kingdom	108	239	57	72	16 020	468
	Germany	44	87	727	183	452	223
	China	–	–	11	...	1 753	46
	France	241	94	167	55	239	44
	Sweden	–	–	–	–	14	10
	Brazil	–	–	55	14	1	8
	Australia	–	–	3	...	3	4
6903.1 (cont'd)							
	Italy	3	2	2	1	36	3
	Taiwan	–	–	1	...	27	3
	India	7	18	–	–	2	2
	South Korea	–	–	10	...	5	2
	Finland	1	1	6	3	3	1
	Netherlands	–	–	1	...	1	...
	Ghana	–	–	–	–	1	...
	Mexico	2	...	–	–	–	–
	Poland	3	...	–	–	–	–
	South Africa	1	2	–	–	–	–
	Spain	1	...	–	–	–	–
	Austria	–	–	1	...	–	–
	Canada	–	–	3	4	–	–
	Japan	–	–	2	1	–	–
	Switzerland	–	–	6	1	–	–
	Total	3 837	1 714	5 457	1 353	86 324	2 281
8545.20	Carbon or graphite brushes						
	United States	194 314	7 428	177 776	7 603	377 214	7 263
	Germany	9 715	503	9 098	470	18 815	549
	United Kingdom	4 883	275	4 231	312	20 762	535
	France	5 217	344	4 565	267	6 911	452
	Japan	21 776	471	22 686	468	37 804	432
	China	4 190	327	6 070	736	3 616	280
	Netherlands	173	5	2 002	105	2 828	179
	Brazil	9 066	584	4 462	239	3 622	127

TABLE 1 (cont'd)

		2002		2003 (r)		2004 (p)	
		(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
IMPORTS (cont'd)							
8545.2 (cont'd)	Canada	1 053	43	551	47	3 350	54
	Sweden	262	51	200	87	801	54
	Austria	1 107	45	1 064	40	2 602	35
	Taiwan	3 364	52	503	42	9 801	33
	Italy	381	17	576	26	671	23
	Thailand	4	4	18	10	1 316	22
	Mexico	18 469	325	754	14	667	21
	South Korea	122	12	232	20	642	18
	Switzerland	204	51	307	30	511	15
	Slovakia	1	...	121	4	271	13
	India	15	1	23	3	124	7
	Slovenia	17	...	106	2	61	7
	Australia	97	10	34	1	737	4
	Ireland	-	-	20	...	33	1
	Czech Republic	20	...	3	...	101	1
	Belgium	2	...	22	1	59	1
	Spain	31	1	58	2	180	1
	Denmark	25	1	188	6	28	1
	Norway	53	2	23	...	38	1
	Hungary	1	...	69	1	97	1
	Poland	82	3	202	2	15	...
	Romania	13	...	1	...	4	...
	South Africa	–	–	–	–	2	...
	Hong Kong	..	...	..	...	6	...
	Vietnam	–	–	3	...	..	...
	Argentina	–	–	–	–	1	...
	Indonesia	–	–	–	–	..	...
	Sierra Leone	–	–	–	–	7	...
	Russia	1	...	1	...	–	–
	Singapore	..	...	1	...	–	–
	Macedonia	1	...	–	–	–	–
	Costa Rica	2	...	–	–	–	–
	Finland	23	1	6	...	–	–
	Belize	216	11	5	...	–	–
	Greece	1	...	–	–	–	–
	Dominican Republic	–	–	1	...	–	–
	Israel	...	...	–	–	–	–
	Malaysia	–	–	1	...	–	–
	Peru	–	–	1	...	–	–
	Turkey	–	–	...	...	–	–
	Antigua and Barbuda	4	...	–	–	–	–
	Total	274 905	10 567	235 984	10 538	493 697	10 130
	Total imports	..	40 697	..	34 661	..	49 473

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; (p) Preliminary; (r) Revised; x Confidential.
Note: Numbers may not add to totals due to rounding.

TABLE 2. REPORTED USE (1) **OF GRAPHITE IN CANADA, 1998-2003**

	1998	1999	2000	2001	2002	2003 (p)
			(tonnes)			
Natural graphite						
Foundry facing	4 873	4 807	2 496	2 170	2 217	2 387
Refractories	x	x	x	x	x	–
Other uses (2)	x	x	x	x	x	1 294
Synthetic graphite						
Foundry facing	2 241	2 296	2 597	1 992	1 943	1 650
Other uses (3)	4 260	6 896	7 152	7 331	8 515	9 343
Total	16 119	16 459	14 955	13 297	14 137	14 674

Source: Natural Resources Canada.
– Nil; (p) Preliminary; x Confidential.
Notes: (1) Reported from NRCan survey on the use of nonmetallic minerals by Canadian manufacturing plants. (2) Includes brake linings, chemicals, abrasives, primary steel and other end uses. (3) Includes abrasives, batteries, bearings and brake linings, cement, chemicals, primary steel, and other uses.
Note: Numbers may not add to totals due to rounding.