GRAPHITE

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Graphite, a soft crystalline form of carbon, is also known by the names of black lead, plumbago, and mineral carbon. The word "graphite" is derived from the Greek word "graphein," to write. Graphite is a soft mineral with a Mohs hardness of 1 to 2, and it exhibits perfect basal cleavage. Depending upon the purity, the specific gravity is 2.20 to 2.30. The theoretical density is 2.26 grams per cubic centimeter (g/cc). It is gray to black in color, opaque, and has a metallic luster. It is flexible but not elastic. It has high thermal and electrical conductivities, is highly refractory, and is chemically inert. Graphite is one of three forms of crystalline carbon; the other two are diamond and fullerenes. It occurs naturally in metamorphic rocks such as marble, schist, and gneiss. Various silicate minerals are generally associated with graphite in ore.

There are two general types of graphite, natural and synthetic. Graphitization of naturally occurring organic carbon may occur at temperatures as low as 300° C-500° C or as high as 800° C-1,200° C, such as when an igneous intrusion contacts a body of carbonaceous rock.

The three principal types of natural graphite—lump, crystalline flake, and amorphous—are distinguished by physical characteristics that are the result of major differences in geologic origin and occurrence. Lump graphite occurs in veins and is believed to be hydrothermal in origin. It is typically massive, ranging in particle size from extremely fine to coarse, platy intergrowths of fibrous or acicular crystalline aggregates with the long axis parallel to the enclosing wall rock (Kenan, 1984). Crystalline flake graphite consists of isolated, flat, plate-like particles with angular, rounded, or irregular edges. It is usually found in layers or pockets in metamorphic rocks. In some deposits, the flake graphite occurs as massive accumulations in veins, lenses, or pods. 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 of lower purity than the crystalline flake graphite and, therefore, commands a lower price than its more ordered counterpart.

Legislation and Government Programs

Total National Defense Stockpile graphite inventories, excluding nonstock grade, were 9,000 metric tons (t) with a value of about $1.75 million. Madagascar natural graphite inventories in the United States were 4,200 t with a value of $0.7 million; there were 4,830 t of Sri Lanka amorphous lump with a value of $1.07 million (table 2). No acquisition of graphite for the strategic and critical materials stockpile took place in 1999. Graphite no longer has a Government stockpile goal and all graphite in the Government stockpile has been authorized for sale.

Production

No graphite was mined in the United States in 1999. Owing to insufficient response by its producers, synthetic graphite data were not compiled from 1995 to 1998. With renewed cooperation of the major manufacturers, however, synthetic graphite production figures for 1999 were successfully gathered. The U.S. production of synthetic graphite reached 267,000 t with a value of $817 million (table 4).

Graphite is mined from open pit and underground mine operations. Open pit operations are more economical and, thus, are preferred where the overburden is thin enough. Most mines in Madagascar are of this type. In the Republic of Korea, Mexico, and Sri Lanka, where the deposits are deep, underground mining techniques are required.

Consumption

The use of graphite has changed dramatically. Graphite exhibits the properties of a metal and a nonmetal, which make it suitable for many industrial applications. The metallic properties include thermal and electrical conductivity. The nonmetallic properties include inertness, high thermal resistance, and lubricity. The combination of conductivity and high thermal stability allows graphite to be used in many applications. Lubricity and thermal conductivity make it an excellent material for high-temperature applications, because it results in a material that provides effective lubrication at a friction interface while furnishing a thermally conductive matrix to remove heat from the same interface. Lubricity and electrical conductivity 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 high-technology products, such as friction materials and battery and fuel cells demand higher purity graphite.

U.S. consumption of natural graphite increased to 34,600 t, in 1999 from 27,400 t in 1998 (table 3). The crystalline grade increased by 19%, to 17,300 t, in 1999 from 14,500 t in 1998, whereas amorphous grade increased by an impressive 34%, to 17,300 t, in 1999 13,000 t in 1998. This translated into 20% increase in value in 1999 for natural graphite.

The four major industries— refractories, brake linings,

lubricants, and foundries—for which natural graphite is used, continued to lead the way in graphite usage, accounting for one-half of the graphite consumed by U.S. industry in l999 (table 3). The refractories industry was again the major consumer of crystalline flake graphite followed by the manufacture of brake linings and metal powders. Refractory applications of graphite included castable ramming, gunning mixtures, and carbon-bonded brick. Carbon-magnesite brick has applications in high-temperature corrosive environments such as steel furnaces, ladles, and iron blast furnaces. Carbon-alumina linings are principally used in continuous steel casting operations. Magnesite- and alumina-carbon brick require a particle size of 100 mesh and a purity of 95% to 99% graphite.

Crystalline flake graphite accounted for nearly 50% of graphite usage in the United States. It was mainly used in refractories, batteries, and other thermal and electrical conductivity applications. Amorphous graphite is mainly used as lubricant additives as pigment in paints, plastic refractories, and other applications where additions of graphite improve the process or the end product. Lump graphite finds appropriate uses in a number of areas depending on the purity and particle size.

Synthetic graphites remain the choice in North America, accounting for more than one-half of the market. The main market for high-purity synthetic graphites is iron and steel. This market consumes more than 50% of the synthetic graphite, as a carbon-raiser additive (table 4).

Other significant uses of all types of graphites are the manufacture of low-current, long-life batteries, steelmaking, solid carbon shapes, static and dynamic seals, valve and stem packing, catalyst supports, porosity enhancing inert fillers, manufacture of rubber, and powder metallurgy. The use of graphite in low-current batteries is gradually giving way to carbon black, which is more economical.

Prices

The range of graphite prices has remained steady and unchanged during 1999. Prices for crystalline flake graphite concentrates ranged from $480 to $550 per ton, and commanded higher prices than the amorphous, priced at $220 to $235 per ton. Carbon content, flake and crystal size, size distribution, and ash content affect the price of graphite. Customary negotiations between the buyer and the seller lead to wide short-term price fluctuations (table 5).

Foreign Trade

Total imports of natural graphite declined slightly in tonnage to 55,800 t in 1999 from 61,600 t in 1998, but the values remained essentially unchanged, $34.7 million in 1999 compared to $34.8 million in 1998 (table 7). Principal import sources of natural graphite, in order of tonnage, were China, Mexico, Canada, and Brazil which accounted for 80% of the dollar value of total imports. Mexico continued to be the major supplier of amorphous graphite; Sri Lanka provided the lump variety. A number of other producers supplied various types and grades of graphite to the United States, among the more notable being Germany, India, Japan, and Madagascar. In spite of showing a noticeable decrease in tonnage, total exports recorded an 8% increase in total revenue to $82,800 million in 1999, compared with $76,700 million in 1998 (table 6).

World Review

World production of graphite in 1999 was estimated to be 685,000 t, compared with 683,000 t in 1998. China maintained its position as the world's leading graphite producer, at 280,000 t, with India in second place with 145,000 t, followed by Brazil, Mexico, and Czech Republic. These five countries accounted for 80% of the world production (table 9).

For the past several years, Sri Lanka has accounted for nearly all the high-purity lump graphite produced. Sri Lankan deposits were estimated to average 95% graphite in situ.

The combination of a decrease in world demand in the early 1990's and competition from cheap Chinese material forced many non-Chinese producers to reduce production or even to leave the market altogether. China accounted for 40% of world production.

Current Research and Technology

In recent years, new technology in processing and treatment has expanded the use of natural graphites in battery applications. Graphite for these applications has been purified to 99.9% carbon. Most new uses for graphite products are being developed through advances in graphite thermal technology. The ability to refine and modify graphite and carbon products will be the key to future growth in the graphite industry. Innovative refining techniques have enabled the use of improved graphite in friction materials, electronics, foil, and lubrication applications (Hand, l997). Some of the new application areas include electrically conductive asphalt for heated runways at airports and roadway bridges.

With its low specific gravity, refractoriness, and corrosion resistance, graphite is critical for many industrial applications, such as dies for continuous casting, rocket nozzles, and heat exchangers for the chemical industry. However, relatively poor wear and oxidation resistance of graphite limit its use. A class of high-performance materials based on titanium carbide-coated graphite, makes the material suitable for some of the most demanding applications (Webb, 2000). Because titanium carbide is one of the hardest and most durable materials, the resulting components are extremely resistant to wear, corrosion, and elevated temperatures. These composites can be engineered to fit many industrial uses through control of the coating composition, thickness, microstructure, and surface finish. In metal melting applications, titanium carbide coatings have shown to improve the service life of the graphite components by as much as fivefold.

Enigmatic clusters of carbon atoms, called fullerenes, found as large carbon-cage molecules, have been puzzling scientists since 1985 when they were first discovered among the byproducts of laser-vaporized graphite (Pierson, 1993). Their hollow spherical structure, reminiscent of geodesic domes of architect Buckminster Fuller, earned them the names

"buckyballs" and "fullerenes." Mistakenly called a "new form of carbon," fullerenes have been found to exist in interstellar dust as well as in geologic formations on earth. Fullerenes are fascinating because they exhibit unusual properties for carbon materials. For example, adding three alkali atoms per fullerene unit (C_{60}) results in a material that exhibits superconductivity at quite high temperatures (10^{o} K-40^{o} K). These materials also exhibit lubricity superior to that of graphite. To date, no product based on fullerenes has been offered in the market. The full potential of fullerenes in practical applications remains to be explored.

Outlook

The main areas of natural graphite consumption in the near future will be in high-temperature applications for the iron and steel industry as the industry modernizes its production facilities. Brake linings and other friction materials will steadily consume more natural graphite as new automobile production continues to increase and more replacement parts are required for the growing number of existing vehicles. Flexible graphite product lines, such as grafoil (a thin graphite cloth) will probably be the fastest growing market but will consume small amounts of natural graphite compared with major end-use markets.

In the event of any price increases, China may increase its production to take advantage of potential high profits, leading to a sharp price decline in certain grades and possibly to a production stoppage in other countries. If, however, the Chinese iron and steel industry expands its consumption of natural graphite, then Chinese exports may eventually decline, encouraging new producers to enter the market (Roskill Information Services Ltd., 1998).

Industry trends that appear to be common to advances in graphite technology and markets include higher purity and consistency in specifications for some specialized and high-tech applications. Production of higher purity graphite, using thermal processing and acid leaching techniques, for such applications as advanced carbon-graphite composites, continues to be the trend.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT NATURAL GRAPHITE STATISTICS 1/

		1995	1996	1997	1998	1999
United States:						
Apparent consumption 2/	metric tons	23,500	27,400	18,400	33,600	26,400
Exports	do.	37,300	26,000	39,700	28,000	29,400
Value	thousands	$17,900	$14,600	$20,500	$14,100	$15,200
Imports for consumption	metric tons	60,700	53,400	58,100	61,600	55,800
Value	thousands	$30,100	$28,600	$32,400	$34,800	$34,700
World, production	metric tons	584,000	550,000 r/	678,000 r/	683,000 r/	685,000

r/ Revised.
1/ Data are rounded to no more than three significant digits.
2/ Domestic production plus imports minus exports.

TABLE 2
U.S. GOVERNMENT STOCKPILE GOALS AND YEAREND STOCKS OF NATURAL GRAPHITE IN 1999, BY TYPE 1/

(Metric tons)

Type	National stockpile inventory
Madagascar crystalline flake	4,200
Sri Lanka amorphous lump	4,830
Nonstockpile-grade, all types	49

1/ Graphite no longer has a goal.

Source: Defense National Stockpile Center, Inventory of Stockpile Materials as of December 31, 1999.

TABLE 3
U.S. CONSUMPTION OF NATURAL GRAPHITE, BY END USE 1/

End use	Crystalline		Amorphous 2/		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1998:						
Batteries	W	W	--	--	W	W
Brake linings	889 r/	$1,100 r/	3,090 r/	$2,870 r/	3,980 r/	$3,970 r/
Carbon products 3/	388	1,430 r/	W	225	W	1,650 r/
Crucibles, retorts, stoppers, sleeves, nozzles	993	845	W	W	W	W
Foundries 4/	W	310 r/	W	W	W	W
Lubricants 5/	339 r/	544 r/	1,260 r/	986 r/	1,600 r/	1,530 r/
Pencils	W	W	W	W	W	W
Powdered metals	445	1,020	26	55	471	1,080
Refractories	W	3,460	5,010 r/	3,390 r/	W	6,850 r/
Rubber	W	W	W	394	W	W
Steelmaking	W	W	W	W	W	W
Other 6/	W	W	798 r/	514 r/	W	W
Total	14,500 r/	16,600 r/	13,000 r/	9,180 r/	27,400 r/	25,800 r/
1999:						
Batteries	W	W	--	--	W	W
Brake linings	1,090	1,290	5,280	4,540	6,380	5,830
Carbon products 3/	425	1,310	318	268	743	1,570
Crucibles, retorts, stoppers, sleeves, nozzles	W	711	W	W	W	W
Foundries 4/	W	494	1,780	825	W	1,320
Lubricants 5/	328	580	1,180	905	1,510	1,490
Pencils	W	W	W	W	W	W
Powdered metals	432	995	27	57	459	1,050
Refractories	W	W	5,580	3,670	W	W
Rubber	W	844	W	367	W	1,210
Steelmaking	W	W	W	W	W	W
Other 6/	W	W	788	510	W	W
Total	17,300	18,800	17,300	12,300	34,600	31,000

r/ Revised. 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 4
U.S. PRODUCTION OF SYNTHETIC GRAPHITE IN 1999, BY END USE 1/

End use	Quantity (metric tons)	Value (thousands)
Anodes	W	W
Cloth and fibers (low modulus)	W	$80,500
Electric motor brushes and machined shapes	W	W
Electrodes	172,000	535,000
High-modulus fibers	2,450	54,400
Unmachined graphite shapes	5,520	43,900
Synthetic graphite powder and scrap 2/	W	W
Other	W	W
Total	267,000	817,000

W Withheld to avoid disclosing company proprietary data; included in "Total."
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Includes lubricants (alone/in greases), steelmaking carbon raisers, additives in metallurgy, and other powder data.

TABLE 5
REPRESENTATIVE YEAREND GRAPHITE PRICES 1/

(Per metric ton)

Type	1998	1999
Crystalline large flake, 94% carbon	$570-$750	$570-$750
Crystalline large flake, 90% carbon	480-550	480-550
Crystalline medium flake, 90% carbon	370-410	370-410
Crystalline small flake, 80% to 95% carbon	270-500	270-500
Amorphous powder, 80% to 85% carbon	220-235	220-235

1/ Prices are normally "cost, insurance, and freight" (c.i.f.) main European port.

Source: Industrial Minerals, no. 375, December 1998, p. 78; no. 387, December 1999, p. 70.

TABLE 6
U.S. EXPORTS OF NATURAL AND ARTIFICIAL GRAPHITE, BY COUNTRY 1/ 2/

	Natural 3/		Artificial 4/		Total	
Country	Quantity (metric tons)	Value 5/ (thousands)	Quantity (metric tons)	Value 5/ (thousands)	Quantity (metric tons)	Value 5/ (thousands)
1998:						
Canada	5,320	$3,330	9,410	$15,900	14,700	$19,200
France	10	49	8,820	5,040	8,830	5,080
Japan	450	562	19,200	9,540	19,600	10,100
Korea, Republic of	417	192	10,200	4,990	10,600	5,180
Mexico	14,400	5,320	4,550	2,740	19,000	8,060
Netherlands	257	131	8,670	3,600	8,930	3,730
Taiwan	1,280	697	1,370	2,120	2,650	2,810
Other	5,810	3,780	19,700	18,800	25,500	22,600
Total	28,000 r/	14,100	81,900	62,700	110,000	76,700 r/
1999:						
Canada	5,410	3,570	8,290	12,800	13,700	16,300
France	4	16	3,740	5,590	3,750	5,600
Japan	328	240	15,600	8,190	16,000	8,430
Korea, Republic of	238	202	8,470	4,870	8,710	5,080
Mexico	8,090	3,130	3,220	2,310	11,300	5,440
Netherlands	2,270	889	10,400	4,070	12,700	4,960
Taiwan	674	414	1,080	1,390	1,760	1,800
Other	12,400	6,760	21,600	28,400	34,000	35,100
Total	29,400	15,200	72,500	67,600	102,000	82,800

r/ Revised.

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 within the "Other" category under the "Country" list.

3/ Amorphous, crystalline flake, lump and chip, and natural, not elsewhere classified. The applicable Harmonized Tariff Schedule (HTS) nomenclature title and code (s) are: "Natural graphite in powder or in flakes"/"Other;" HTS numbers 2504.10/90.0000.

4/ Includes data from the applicable "Harmonized Tariff Schedule" (HTS) nomenclatures: "Artificial graphite" and "Colloidal or semicolloidal graphite;" their respective HTS code numbers are 3801.10/20.0000.

5/ Values are free alongside ship (f.a.s.).

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF NATURAL GRAPHITE, BY COUNTRY 1/ 2/

Country or territory	Crystalline flake and flake dust		Lump and chippy dust		Other natural crude; high-purity; expandable		Amorphous		Total	
	Quantity (metric tons)	Value 3/ (thou-sands)	Quantity (metric tons)	Value 3/ (thou-sands)	Quantity (metric tons)	Value 3/ (thou-sands)	Quantity (metric tons)	Value 3/ (thou-sands)	Quantity (metric tons)	Value 3/ (thou-sands)
1998:										
Brazil	--	--	--	--	3,450	$6,110	--	--	3,450	$6,110
Canada	13,400	$7,870	--	--	19	15	--	--	13,400	7,880
China	7,410	1,470	--	--	10,200	6,870	2,500	735	20,200	9,080
Germany	--	--	--	--	149	850	--	--	149	850
India	123	156	--	--	13	58	--	--	136	214
Japan	--	--	--	--	924	1,750	--	--	924	1,750
Madagascar	4,310	2,390	--	--	--	--	--	--	4,310	2,390
Mexico	--	--	--	--	--	--	15,400	2,560	15,400	2,560
Mozambique	1,900	1,620	--	--	--	--	--	--	1,900	1,620
Sri Lanka	--	--	838	1,000	--	--	--	--	838	1,000
Zimbabwe	440	200	--	--	--	--	--	--	440	200
Other 4/	384	721	--	--	49	320	84	138	517	1,180
Total	28,000	14,400	838	1,000	14,900	16,000	17,900	3,430	61,600	34,800
1999:										
Brazil	38	46	--	--	4,710	9,440	--	--	4,750	9,490
Canada	12,600	7,510	--	--	1	26	--	--	12,600	7,540
China	8,180	3,360	--	--	9,720	5,180	741	170	18,600	8,710
Germany	--	--	--	--	182	519	--	--	182	519
India	24	25	--	--	--	--	--	--	24	25
Japan	21	12	--	--	384	2,120	491	28	896	2,160
Madagascar	2,570	1,370	--	--	--	--	--	--	2,570	1,370
Mexico	--	--	--	--	570	264	12,500	1,820	13,100	2,080
Mozambique	1,190	1,050	--	--	--	--	--	--	1,190	1,050
Sri Lanka	--	--	418	530	--	--	--	--	418	530
Zimbabwe	200	81	--	--	--	--	--	--	200	81
Other 4/	815	552	--	--	207	581	216	53	1,240	1,190
Total	25,600	14,000	418	530	15,800	18,100	14,000	2,070	55,800	34,700

-- 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 (HTS) base data.

3/ Customs values.

4/ Includes Australia (1998), Austria (1998), Belgium (1998), Dominican Republic (1999), France, Greece (1998), Hong Kong , Italy, the Netherlands, Poland (1998), South Africa (1999), Sweden, Switzerland (1998), Ukraine, and the United Kingdom.

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

TABLE 8
U.S. IMPORTS FOR CONSUMPTION
OF GRAPHITE ELECTRODES, BY COUNTRY 1/ 2/

Country	Quantity (metric tons)	Value 3/ (thousands)
1998:		
Brazil	6,930	$17,700
Canada	11,300	32,700
China	2,690	5,120
Germany	4,590	14,600
India	5,510	11,700
Italy	8,420	17,100
Japan	9,170	31,700
Mexico	12,600	21,300
Other 4/	1,760 r/	3,240 r/
Total	63,000	155,000
1999:		
Brazil	4,890	11,700
Canada	9,010	22,300
China	1,980	3,490
Germany	3,360	9,450
India	3,480	7,130
Italy	6,700	13,500
Japan	8,730	25,900
Mexico	17,500	28,300
Russia	3,630	4,930
Switzerland	1,680	3,860
Other 4/	1,910	4,490
Total	62,800	135,000

r/ Revised.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ The applicable Harmonized Tariff Schedule (HTS) code and nomenclature title are (HTS 8545.11.0000); "Electric Furnace Electrodes."
3/ Customs values.
4/ Includes data for countries reflecting less than 1,000 metric tons for yearly imports.

Source: Bureau of the Census.

TABLE 9
GRAPHITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1995	1996	1997	1998	1999 e/
Austria e/	12,019 3/	12,000	12,000	12,000	12,000
Brazil (marketable) 4/	28,028	31,254 r/	40,587 r/	61,369 r/	61,400
China e/	204,000	185,000	310,000 r/	270,000 r/	280,000
Czech Republic e/	27,000	30,000	25,000	28,000 r/	30,000
Germany (marketable)	5,214	2,603	1,030 r/	1,000 r/ e/	1,000
India (run-of-mine) 5/	129,368	115,233	102,143 r/	143,333 r/	145,000
Korea, North e/	40,000	40,000	40,000	35,000	25,000
Korea, Republic of	1,938	1,113	83 r/	62 r/	60
Madagascar 6/	16,119	12,134	13,975 r/	13,000 e/	12,000
Mexico:					
Amorphous	32,938	38,967	46,707	42,893 r/	43,000
Crystalline flake	1,450	1,445	1,275	568 r/	1,000
Mozambique	3,019	3,283	5,125	5,889 r/	4,500
Norway e/	2,588 3/	2,500	2,600	2,500	2,500
Romania	2,179	2,931	2,563 r/	2,600 r/ e/	2,600
Russia e/	8,000	6,000	6,000	6,000	6,000
Sri Lanka	8,000	5,618	5,127	5,000 e/	5,000
Tanzania	359	6,776	11,000 e/	-- e/ 7/	--
Turkey (run-of-mine) e/ 8/	20,000	20,000	15,000	15,000	15,000
Ukraine e/	30,000	25,000	25,000	25,000	25,000
Uzbekistan e/	60	60	60	60	60
Zimbabwe	11,381	7,691	12,779	13,806 r/	13,800
Total	584,000	550,000 r/	678,000 r/	683,000 r/	685,000

e/ Estimated. 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 12, 2000.

3/ Reported figure.

4/ Does not include the following quantities sold directly without beneficiation, in metric tons: 1995--3,368; 1996--4,134; 1997--9,397 (revised); 1998--10,747 (revised); and 1999--10,700 (estimated).

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

6/ Exports. Source: United Nations, Department of International Economic and Social Affairs, Statistical Office.

7/ Graphtan Limited Mine closed. Only remaining stocks shipped in January-February 1998.

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