

Graphite

By David G. Willard ¹

Natural graphite remained in tight supply in 1972. Domestic consumption rose, largely as a result of the recovery in the metals industry, while domestic production declined further and production in certain key foreign countries fell. Since imports rose by a lesser amount than estimated consumption, and exports were also higher, a probable drawdown of supplier and consumer stocks was indicated, despite an increase in releases from the national stockpiles. Prices of imported supplies were up sharply, particularly for crystalline graphites, on account of both tightness in the market and devaluation of the dollar. Domestic prices temporarily held the line, but they also rose in early 1973.

The manufactured graphite industry enjoyed a booming year, especially in the second half, again due to the revitalized metals industry market. Demand for electrodes, the industry's staple product which accounts for the bulk of manufactured graphite tonnage, registered a strong increase. Sales of most other manufactured graphite products also exhibited a healthy upswing.

Legislation and Government Programs.—Tight supply markets kept up consumers' interest in disposal of surplus graphite from the national stockpiles. As a result, virtually all surplus graphite in the stockpiles was committed to purchasers in competitive

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Table 1.—Salient natural graphite statistics

	1968	1969	1970	1971	1972
United States:					
Consumption ¹short tons	38,507	37,164	32,908	39,172	47,774
Value.....thousands	\$5,904	\$6,354	\$5,866	\$7,610	\$9,536
Exports.....short tons	4,169	10,264	5,783	5,733	7,289
Value.....thousands	\$509	\$782	\$701	\$630	\$588
Imports for consumption ¹short tons	67,922	58,459	66,449	57,756	64,135
Value.....thousands	\$2,494	\$2,419	\$3,027	\$2,727	\$3,847
World: Production.....short tons	481,793	414,194	433,047	429,905	394,459

¹ Revised.

¹ Includes some manufactured graphite.

Table 2.—Government yearend stocks of natural graphite

(Short tons)

Type of graphite	National stockpile	Supplemental stockpile	Total all stockpiles
Malagasy crystalline flake:			
Objective.....	10,800	--	10,800
Uncommitted excess.....	83	--	83
Total.....	10,883	--	10,883
Malagasy crystalline fines: Objective.....	5,230	1,910	7,140
Ceylon amorphous lump: Objective.....	² 4,295	1,204	5,499
Other than Sri Lanka (formerly Ceylon) and Malagasy, crystalline: Objective.....	² 2,800	--	2,800

¹ Includes 1 short ton nonstockpile-grade material.

² Includes 56 short tons nonstockpile-grade material.

³ Includes 867 short tons nonstockpile-grade material.

Source: General Services Administration. Stockpile Report to the Congress July–December 1972, Statistical Supplement.

offerings, although actual shipments were scheduled over periods as long as 5 years. Inventories shown in table 2 omit all committed surplus stocks. Comparison with the December 31, 1971 inventory indicates a disposal of 10,363 tons during 1972; however, actual shipments totaled only about

3,000 tons, 45% greater than the 2,100 tons entering the market in 1971.

An administration proposal to reduce the objectives of many stockpiled materials, including graphite, and dispose of the resulting surpluses was under consideration in early 1973.

DOMESTIC PRODUCTION

Production of natural graphite in the United States declined further in 1972, although at a slower rate than the year before. The only operating mine continued to be that of Southwestern Graphite Co. near Burnet, Tex., which produced a small flake crystalline graphite.

Interest in domestic graphite mining was stimulated by the growing shortage and higher prices of imported natural graphite. Several former graphite mines and other properties were being considered for investigation during the year. A deposit in Alaska, estimated to be quite large, was investigated by the Geological Survey. Minor production has occurred there in the past, but its remote location and lack of access as yet render it uneconomic at current prices.

Production of manufactured graphite regained an upward trend in 1972 after slipping slightly the year before. Output of 275,311 tons was up 7% from the 256,137 tons produced in 1971. Total value of production increased 17% to \$183.6 million from \$157.3 million the previous year.

All metallurgical uses of manufactured graphite showed marked improvement as the metals industries recovered from their slump of 1970-71. Most other uses, such as mechanical products made of graphite, also fared well. The outlook for graphite fibers brightened somewhat as the result of its initial commercial acceptance in specialty sporting goods, which represents its first nondefense application.

Manufactured graphite was produced in 26 plants owned by 18 companies during 1972. Some production may have taken place at other locations as well, particularly by users for in-house consumption. The considerably augmented list, as compared to that published last year, includes a number of plants making specialty products such as high-modulus fiber which had not

been included in the manufactured graphite survey in previous years. The companies and plant locations were as follows:

<i>Company</i>	<i>Plant Location</i>
Airco, Inc., Speer Div-----	Niagara Falls, N.Y. Punxsutawney, Pa. St. Marys, Pa.
Avco Corp., Avco Systems Div-----	Lowell, Mass.
The Carborundum Co., Graphite Products Div-----	Hickman, Ky. Sanborn, N.Y.
Celanese Corp., Celanese Research Lab-----	Summit, N.J.
Fiber Materials, Inc.---	Graniteville, Mass.
Great Lakes Carbon Corp-----	Rosamond, Calif. Niagara Falls, N.Y. Morganton, N.C.
Hercules, Inc-----	Magna, Utah
HITCO-----	Gardena, Calif.
Morganite Modmor, Inc-----	Costa Mesa, Calif.
Ohio Carbon Co-----	Cleveland, Ohio
Pfizer, Inc.; Minerals, Pigments & Metals Div-----	Easton, Pa.
Poco Graphite, Inc.---	Decatur, Tex.
Polycarbon, Inc-----	No. Hollywood, Calif.
Stackpole Carbon Co-----	Lowell, Mass. St. Mary's, Pa.
Super Temp Co-----	Santa Fe Springs, Calif.
Ultra Carbon Corp.---	Bay City, Mich.
Union Carbide Corp---	Niagara Falls, N.Y. Yabucoa, P.R. Columbia, Tenn.
Wickes Engineered Materials-----	Saginaw, Mich.

CONSUMPTION AND USES

A strong upsurge in consumption of natural graphite in 1972 reflected the increased output of the metal industry. Demand in most refractory uses and other mill and smelter applications was significantly higher than in the two previous years. Consumption was up only a little in other uses of natural graphite.

Table 3 excludes the consumption by numerous small consumers. It is estimated that consumption in 1972, including small consumers, totaled 70,000 tons, a gain of 15% to 20% above the 1971 total. Most of the increase is estimated to have been in refractories and steel mill uses.

Table 3.—Consumption¹ of natural graphite in the United States in 1972, by use

(Short tons)

Use	Crystalline		Amorphous ²		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Foundry facings.....	3,513	\$630,356	6,815	\$786,702	10,328	\$1,417,058
Steelmaking.....	492	88,713	9,198	1,366,608	9,690	1,455,321
Refractories.....	1,054	118,070	7,088	693,837	8,142	811,907
Crucibles, retorts, stoppers, sleeves, nozzles.....	4,174	829,944	639	150,661	4,813	980,605
Lubricants ³	1,083	610,062	2,353	726,028	3,436	1,336,090
Pencils.....	1,251	514,805	771	232,072	2,022	746,877
Brake linings.....	761	349,671	1,042	451,769	1,803	801,440
Batteries.....	651	268,512	473	240,021	1,124	508,533
Carbon brushes.....	260	177,139	221	115,876	481	293,015
Bearings.....	98	57,668	35	26,334	133	84,002
Other mechanical products.....	114	33,601	92	57,490	206	91,091
Rubber.....	91	49,713	190	46,105	281	95,818
Powdered metals.....	195	128,405	85	61,253	280	189,658
Paints and polishes.....	81	64,632	105	27,211	186	91,843
Other ⁴	4,563	795,540	286	136,806	4,849	932,346
Total.....	18,381	4,716,831	29,393	5,118,773	47,774	9,835,604

¹ Consumption data incomplete. Excludes small consuming firms.

² Includes mixtures of natural and manufactured graphite.

³ Includes ammunition and packings.

⁴ Includes antiknock and other compounds, drilling mud, electrical and electronic products, insulation magnetic tape, small packages, and miscellaneous and proprietary uses.

PRICES

Domestic price quotations for natural graphite continued unchanged in 1972, the second successive year of price stability. Price guidelines under Phase II and the availability of substitute materials together held prices in line. Such stability could not be maintained in the face of higher prices for imports and other cost increases, however, and the prices of most graphite rose in early 1973.

Domestic prices, as quoted by the Chemical Marketing Reporter (formerly Oil, Paint, and Drug Reporter), January 1, 1973, on an exwarehouse basis, were as follows:

	Per pound
No. 1 flake graphite, 90% to 95% carbon.....	\$0.32-\$0.42
No. 2 flake graphite, 90% to 95% carbon.....	.239- .32
Powdered crystalline graphite:	
88% to 90% carbon.....	.184- .27
90% to 92% carbon.....	.255- .275
95% to 96% carbon.....	.29- .399
Powdered amorphous graphite.....	.0626- .195
Powdered amorphous or crystalline graphite, minimum of 97% carbon.....	.28- .36

Prices of imported crystalline graphite rose during the year, as is shown by the comparison below of yearend prices, f.o.b. sources, quoted in the Engineering and Mining Journal (after conversion from metric tons). Factors causing import prices

to go up included higher world demand, smaller production in Sri Lanka (formerly Ceylon), and devaluation of the dollar. Amorphous graphite prices showed no change from the year before.

	Per short ton	
	1971	1972
Flake and crystalline graphite, bags:		
Sri Lanka.....	\$133-\$241	\$152-\$259
Germany, West.....	143-855	163-929
Malagasy Republic.....	86-281	122-336
Norway.....	83-132	91-145
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Mexico (bulk).....	22	22
Korea, Republic of (bags).....	22	22

These quotations represent a total range of prices. Actual prices are negotiated between buyer and seller for each individual shipment. A better guide to price trends is the average value per ton, which can be determined from table 5, although it should be kept in mind that these prices are largely for shipments of unprocessed graphite. The average values for the major types of imported graphite in 1972 were as follows:

Crystalline flake, lump, chip, or dust	\$160 per ton
Other natural, crude and refined	\$ 47 per ton

FOREIGN TRADE

Exports of natural graphite rose sharply in 1972, in contrast to the previous year's small decline. The total of 7,289 tons was 27% greater than the 5,733 tons sold abroad in 1971 and exceeded the shipments in all previous years on record except 1969.

Canada remained the best customer, taking 3,523 tons, almost double the amount of the previous year. Sizable increases also occurred in exports to Japan and West Germany.

Imports for consumption were also higher

Table 4.—U.S. exports of natural graphite, by country

Destination	Amorphous, crystalline flake, lump, or chip, and natural, n.e.c. ¹			
	1971		1972	
	Short tons	Value	Short tons	Value
Argentina.....	28	\$3,444	35	\$4,737
Australia.....	201	17,952	174	15,487
Bahamas.....	69	15,522	--	--
Belgium-Luxembourg.....	70	9,649	60	8,258
Brazil.....	135	11,218	85	10,905
Canada.....	1,902	221,768	3,523	411,872
Chile.....	15	1,913	30	4,038
Colombia.....	61	5,591	--	--
Denmark.....	--	--	11	951
France.....	202	23,758	169	21,809
Germany, West.....	256	28,773	454	58,474
India.....	4	550	--	--
Italy.....	389	39,707	286	26,983
Jamaica.....	20	1,289	20	1,905
Japan.....	249	31,705	539	68,610
Mexico.....	634	80,926	396	51,692
Netherlands.....	18	2,340	135	18,618
New Zealand.....	50	3,180	20	1,450
Norway.....	--	--	7	840
Panama.....	--	--	102	14,856
Peru.....	133	18,963	95	14,150
Philippines.....	35	13,126	4	511
Portugal.....	--	--	38	3,988
Singapore.....	50	6,144	79	6,688
South Africa, Republic of.....	22	2,118	50	4,390
Spain.....	206	16,940	--	--
Sweden.....	58	4,976	6	704
Switzerland.....	3	675	10	1,636
Taiwan.....	--	--	10	746
United Kingdom.....	641	77,914	518	73,549
Venezuela.....	211	37,346	381	53,533
Other.....	21	2,150	52	6,960
Total.....	5,733	679,637	7,289	888,290

¹ Not elsewhere classified.

in 1972, amounting to 64,135 tons which was 11% above the 57,756 tons imported in 1971. The total was the third highest on record, surpassing all years except 1968 and 1970. Crystalline flake graphite imports rose 44% to 7,043 tons, the largest amount since 1956. Imports of other types of

graphite increased from 52,874 tons in 1971 to 57,092 tons in 1972, a gain of 8%. Increased demand plus the drop in 1971 imports combined to boost the requirement for foreign supplies to these near record heights.

Table 5.—U.S. imports for consumption of natural and artificial graphite, by country

Year and country	Natural								Artificial ¹		Total	
	Crystalline flake		Crystalline lump, chip or dust		Other natural crude and refined		Short tons	Value (thousands)				
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)			Short tons	Value (thousands)		
1970.....	5,713	\$770	76	\$28	60,551	\$2,197	109	\$32	66,449	\$3,027		
1971:												
Canada.....	--	--	--	--	r 4	1	277	19	r 281	20		
France.....	--	--	--	--	28	16	(²)	(²)	28	16		
Germany, West.....	759	228	15	5	823	171	4	3	1,601	407		
Italy.....	--	--	--	--	--	--	27	25	27	25		
Japan.....	--	--	2	3	1	1	2	2	5	6		
Korea, Republic of.....	--	--	--	--	116	6	--	--	116	6		
Malagasy Republic.....	4,063	458	--	--	302	41	--	--	4,365	499		
Mexico.....	(^r)	(^r)	--	--	r 46,182	r 962	--	--	46,182	962		
Norway.....	--	--	--	--	2,830	304	--	--	2,830	304		
South Africa, Republic of.....	--	--	--	--	28	3	--	--	28	3		
Sri Lanka (formerly Ceylon).....	60	11	56	13	2,159	448	--	--	2,275	472		
Switzerland.....	--	--	--	--	--	--	15	7	15	7		
U.S.S.R.....	--	--	--	--	3	(²)	--	--	3	(²)		
United Kingdom.....	--	--	--	--	(²)	(²)	--	--	(²)	(²)		
Total.....	r 4,882	r 697	78	21	r 52,476	r 1,953	325	56	r 57,756	2,727		
1972:												
Austria.....	--	--	--	--	16	3	--	--	16	3		
Canada.....	--	--	--	--	7	2	111	7	118	9		
China, People's Republic of.....	--	--	--	--	734	115	--	--	734	115		
France.....	12	4	--	--	4	--	--	--	12	4		
Germany, West.....	823	302	--	--	1,350	288	9	6	2,187	596		
Hong Kong.....	--	--	--	--	5	1	--	--	5	1		
Italy.....	--	--	2	2	--	--	232	26	234	28		
Japan.....	--	--	--	--	--	--	3	7	3	7		
Korea, Republic of.....	--	--	--	--	144	8	--	--	144	8		
Malagasy Republic.....	5,855	784	--	--	446	86	--	--	6,301	870		
Malaysia.....	316	40	--	--	--	--	--	--	316	40		
Mexico.....	--	--	--	--	47,438	1,068	11	7	47,449	1,075		
Norway.....	30	4	119	11	3,419	397	--	--	3,568	412		
South Africa, Republic of.....	--	--	--	--	40	4	--	--	40	4		
Sri Lanka (formerly Ceylon).....	--	--	--	--	2,810	634	--	--	2,810	634		
Switzerland.....	--	--	--	--	--	--	6	3	6	3		
Taiwan.....	--	--	--	--	99	19	--	--	99	19		
Thailand.....	--	--	--	--	60	15	--	--	60	15		
U.S.S.R.....	--	--	--	--	31	3	--	--	31	3		
United Kingdom.....	2	1	--	--	--	--	--	--	2	1		
Total.....	7,043	1,135	121	13	56,599	2,643	372	56	64,135	3,847		

^r Revised.

¹ Includes only that received in raw material form; excludes products made of graphite.

² Less than 1/2 unit.

WORLD REVIEW

World production of graphite decreased in 1972. The downswing, coupled with a probable rise in world demand, further aggravated the supply problem. Supplies of

premium grades remained especially tight. A decline in exports by Sri Lanka (formerly Ceylon), stemming from the adjustment problems of their newly nationalized indus-

try, was a primary cause of the supply shortage, and an increase in the demand for high-purity graphite in electronic and other specialized uses added to the imbalance. The large decline in output of low-grade material in the Republic of Korea was less serious in nature. Rising production of metals increased the demand for other grades, but supplies were adequate to meet the needs.

Brazil.—Graphite deposits were discovered near Niteroi in the vicinity of Rio de Janeiro.²

Malagasy Republic.—Riots brought about the fall of the Tsiranana Government in May, and it was replaced by a military administration under General Ramanantsoa. Amid conflicting political pressures the new government has maintained the existing private enterprise system but has not clearly indicated its future economic policies. The resulting uncertainty created apprehension about the future supply of Malagasy graphite, but at yearend appeared to have had little adverse effect on production.³

Riots closed the port of Tamatave, outlet for all of the country's graphite exports, during part of the month of December. Potential further disturbances caused ocean shipping companies to avoid Tamatave for a period thereafter, following which ships would dock at the port only on payment

of a 20% surcharge. As a result, graphite shipments were greatly delayed.⁴

Sri Lanka (formerly Ceylon).—Adjustment problems resulting from takeover of the graphite mines by the State Graphite Corporation caused production to drop in 1972. However, a renewed interest in prospecting was shown by the increased activity of the Geological Survey. Geophysical investigations and drilling were carried out near Bogala, the country's largest graphite mine, and at two other locations in the southwestern part of the island.⁵

The export duty on graphite, which had been raised to 50% in 1970, was reduced back to 25% in January 1972. However, no comparable reduction in prices occurred.⁶

Yugoslavia.—A deposit estimated to contain 11 million short tons of high-grade graphite ore was discovered near Razanj in Serbia. Plans were announced to begin exploiting the deposit in 1973.⁷

² Industrial Minerals, Companies and Minerals. No. 58, July 1972, p. 38.

³ U.S. Embassy, Tananarive, Malagasy Republic. State Department Airgram A-129, Oct. 17, 1972, pp. 9-13; and conversations with members of the U.S. graphite industry.

⁴ Joint Publications Research Service. Translations on Africa No. 1279. JPRS 58460, Mar. 13, 1973, p. 16.

⁵ World Mining. V. 8, No. 7, June 25, 1972, p. 115.

⁶ Industrial Minerals. Graphite: Nationalization Still Rankles. No. 55, April 1972, p. 28.

⁷ Engineering and Mining Journal. Exploration Round-up. V. 173, No. 3, March 1972, p. 272.

Table 6.—Graphite: World production by country
(Short tons)

Country ¹	1970	1971	1972 ^p
Argentina.....	84	162	^e 165
Austria.....	30,570	23,581	20,701
Brazil.....	^e 2,800	3,057	3,458
Burma.....	86	163	239
China, People's Republic of ^e	33,000	33,000	33,000
Germany, West.....	18,084	² 13,986	^e 14,000
Italy.....	2,302	701	852
Japan.....	1,615	1,162	940
Korea, North ^e	83,000	83,000	83,000
Korea, Republic of.....	65,621	79,934	44,939
Malagasy Republic.....	21,903	22,074	^e 20,012
Mexico.....	61,341	56,125	60,748
Norway.....	11,447	9,172	^e 9,000
Romania.....	6,635	^e 6,600	^e 6,600
Sri Lanka (formerly Ceylon).....	¹ 10,788	7,921	7,871
South Africa, Republic of.....	771	1,262	934
U.S.S.R. ^e	83,000	88,000	88,000
United States.....	W	W	W
Total.....	^r 433,047	^r 429,905	394,459

^e Estimate. ^p Preliminary. ^r Revised. ^W Withheld to avoid disclosing individual company confidential data.

¹ In addition to countries listed, Czechoslovakia, India, Southern Rhodesia, and the Territory of South-West Africa produce graphite, but available information is inadequate to make reliable estimates of output levels.

² In part produced from imported crude graphite.

³ Exports.

Other Countries.—Studies of known graphite deposits with a view to future development or expansion were announced in India, Italy, and Mozambique.⁸

TECHNOLOGY

As in previous years, technological developments during 1972 centered on uses of manufactured graphite, particularly composite materials containing graphite fibers. But some advances affecting the use of natural graphite also occurred.

A study carried out in India demonstrated that column flotation can result in a higher percent recovery than conventional flotation methods because it reduces entrapment of gangue in the mineral during agitation.⁹

Research into the possibility of a reaction affecting graphite in contact with aluminum metal indicated that an oxide layer on the aluminum normally prevents the metal from wetting graphite, but the presence of cryolite can provide a flux which permits a reaction to occur.¹⁰

Significant growth is anticipated for the powdered metals industry. Graphite is the source of carbon in many powdered metal mixes. One important gain was the announcement that future rotary engines in General Motors cars will have powdered metal rotors.¹¹

The majority of manufactured graphite research continued to be applied to the development of composite materials using graphite fiber. Efforts to combine the fibers with metal matrixes, which would be stronger than graphite/plastics composites, concentrated on alumina and aluminum. Initial research on one such composite was carried out by the National Aeronautics and Space Administration (NASA) at the Marshall Space Flight Center.¹² Other pro-

grams have been directed toward combining the high-cost graphite fibers with lower cost glass fibers in order to produce a composite material at a lower overall cost.¹³

In another area of use, development of a nickel-coated graphite anode for the electrolysis of chloride salts eliminated contamination of the product which previously resulted from disintegration of uncoated anodes.¹⁴

Patents incorporating graphite covered a wide spectrum of uses in 1972. Two included graphite in lubricating compounds and one patent each made use of it in coatings, cleaning compounds, pigments, packings, and washers. A screening mechanism was developed for use with either graphite or mica.

⁸ U.S. Embassy, Rome, Italy. State Department Airgram A-653, Oct. 17, 1972, p. 7.

Sahu, K. C., and A. D. Mungee. Origin and Beneficiation of Low Grade Graphite from Sagtala in Panchmahal District, Gujarat. *J. Mines, Metals and Fuels*, v. 20, No. 3, March 1972, pp. 75-78.

U.S. Embassy, Lourenço Marques, Mozambique. State Department Airgram A-102, July 7, 1972, Enc. 1, p. 10.

⁹ Narasimhan, K. S., S. B. Rao, and G. S. Chowdhury. Column Flotation Improves Graphite Recovery. *Eng. and Min. J.*, v. 173, No. 5, May 1972, pp. 84-85.

¹⁰ Dorward, K.C. Reaction Between Aluminum and Graphite in the Presence of Cryolite. *Metallurgical Trans.*, v. 4, No. 1, January 1973, p. 386.

¹¹ American Metal Market. The Melting Pot. V. 79, No. 212, Nov. 20, 1972, p. 6.

¹² Materials Engineering. *Materials Outlook*. V. 76, No. 3, September 1972, p. 13.

¹³ Materials Engineering. What's New in Reinforced Plastics. V. 75, No. 3, March 1972, p. 46.

¹⁴ Journal of Mines, Metals and Fuels. *Plants, Equipment and Practice*. V. 20, No. 4, April 1972, p. 124.

