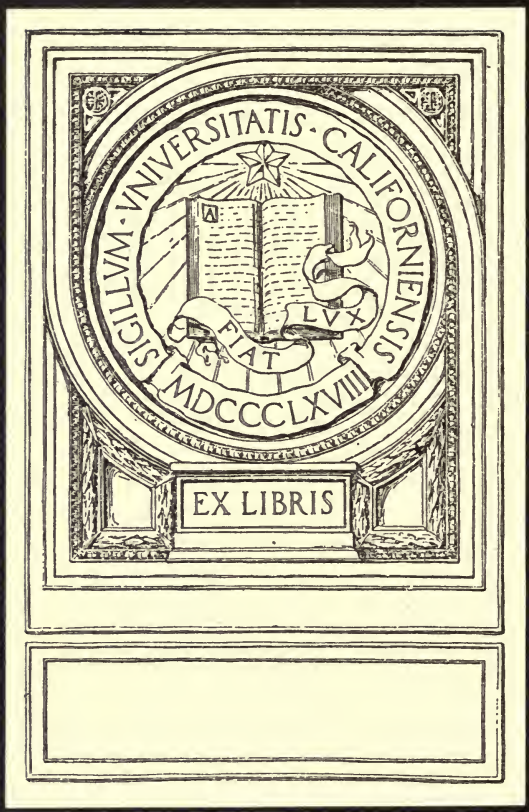
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INFORMATION CONCERNING

GRAPHITE

PRINTED FOR USE OF

COMMITTEE ON WAYS AND MEANS

HOUSE OF REPRESENTATIVES

WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

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COMMITTEE ON WAYS AND MEANS.

HOUSE OF REPRESENTATIVES.

SIXTY-SIXTH CONGRESS, FIRST SESSION.

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LETTER OF TRANSMITTAL.

UNITED STATES TARIFF COMMISSION,
Washington, September 26, 1919.

The COMMITTEE ON WAYS AND MEANS,
House of Representatives:

I have the honor to transmit herewith, in accordance with your request, information compiled by the United States Tariff Commission on graphite.

Very respectfully,

THOMAS WALKER PAGE,
Acting Chairman.

CONTENTS.

GRAPHITE.

INTRODUCTORY STATEMENT.

In the graphite industry interest centers in the material capable of being made into crucibles—the crystalline variety of the mineral. Its most important use is in the manufacture of crucibles for the melting of steel, brass and other metals and alloys, and it thus became a mineral of vital importance during the war.

In addition to its use in crucibles, it has a wide variety of industrial applications, for which a lower grade—the amorphous variety—is adapted. An artificial graphite made in the electric furnace is suitable for many of the minor uses. The crystalline graphite for the American crucible trade has in the past been almost entirely imported, coming from Ceylon, the world's main source of supply prior to the heavy demands of the war period. Recently Madagascar graphite has been replacing Ceylon material in the European markets, and American crucible makers have had considerable success, both in mixing up to 40 per cent of the domestic flake with Ceylon material and in utilizing 100 per cent Alabama flake.

Although experiencing a great stimulation of its graphite industry during the curtailment of imports from overseas in 1917–18, the United States is not yet independent in the matter of crucible graphite—15,000 tons of which are required per year. We produce, from deposits in Montana, Alabama, Pennsylvania, New York, Alaska, and Texas some 3,500 tons of flake (or crystalline) annually, of a grade inferior to Ceylon but similar to Madagascar flake. There are large undeveloped reserves of flake graphite in the United States carrying 5 per cent of the mineral. The Ceylon and Madagascar deposits contain 50 per cent or more. The flake graphite supply in normal times may come from Madagascar, but we can be fairly independent in case of necessity through the stimulation of graphite mining in this country.

Low grade amorphous graphite is abundant in the United States. An excellent grade of amorphous material is available from Mexican deposits owned by a United States graphite company. An extensive domestic development of amorphous mineral has never been profitable on account of this cheap Mexican material.

The growth of the industry in this country has been greatest in Alabama, which State produced 59 per cent of the quantity and 66 per cent of the value of the total domestic output in 1917. The production doubled in 1916, and there was a further increase of 50 per cent in 1917. Notwithstanding shipping difficulties, imports also increased. About one-sixth of the American consumption in 1916 was of domestic origin. In 1917 the proportion had increased to about one-fourth, and in 1918 to about two-fifths. Since the signing of the armistice, something of a collapse in domestic production of crystalline graphite has occurred.

The total requirements of the country for 1919 have been estimated at not over 30,000 tons, of which 50 per cent will be crystalline and 50 per cent amorphous. Of the crystalline only about 15 per cent is expected from domestic deposits; of the amorphous about 45 per cent. With the rumor of prospective tariff legislation and the resumption of more normal shipping conditions, the pressure of foreign material has increased. Consumers are accumulating imported stocks and domestic producers are being correspondingly restricted.

Summary table.[1]

Calendar year.	Domestic production, in short tons.	Imports for consumption in short tons.	Domestic exports, in short tons.	Ratio to production (per cent).		Value.[3]	Amount of duty.	Value per short ton.	Equivalent ad valorem rate.
				Imports.	Exports.				
1910	4,202	25,235	(2)	600.5	.....	$1,872,592	Free....	$74.20	Free.
1911	3,618	20,702	(2)	572.2	.....	1,495,729	...do....	72.28	Do.
1912	3,835	25,643	2,230	668.5	58.15	1,709,337	...do....	66.64	Do.
1913	4,775	28,879	2,692	604.7	56.37	2,109,791	...do....	73.07	Do.
1914	4,335	21,990	1,960	507.2	45.22	1,398,209	...do....	63.59	Do.
1915	4,718	23,075	529	489.0	11.21	2,241,163	...do....	97.09	Do.
1916	8,088	42,930	798	530.9	9.87	7,279,884	...do....	169.50	Do.
1917	13,593	42,577	2,573	312.5	18.92	8,961,988	...do....	210.50	Do.
1918	12,991	19,498	954	150.0	7.32	3,092,475	...do....	158.51	Do.

[1] Includes both crystalline and amorphous grades, but not artificial graphite.
[2] Included in "All other" prior to 1912.
[3] Imports for consumption.

The prices of imported graphite doubled in the early years of the war. The price of domestic flake increased correspondingly. At the war level (10 to 15 cents per pound) domestic mines were able to operate at a small profit, but the average cost of the best flake is close to 10 cents, as compared with about 4 to 8 cents per pound for the Madagascar product at New York.[1]

[1] Shelley, J. W., Graphite in Madagascar: Mining Magazine, vol. 14, p. 327, 1916. Prewar cost, Alabama flake, reported by Joseph Dixon Crucible Co., as 3 to 4 cents per pound.

GENERAL INFORMATION.

DESCRIPTION AND USES.

GENERAL.

Graphite is a soft, black, greasy form of carbon. It occurs in nature in two forms, crystalline and amorphous, each having its own peculiar uses. Artificial graphite, made from coal or other carbonaceous material in an electric furnace, is to a certain extent a competitor of the natural amorphous product. It is even better suited for certain purposes, notably in the manufacture of graphite electrodes, the demand for which has greatly increased on account of the rapid growth of electrochemical industries.[1] Graphite also goes by the names "plumbago" and "black lead."

Crystalline graphite is commonly understood to mean graphite in crystals large enough to be seen with the naked eye. It is used in the manufacture of crucibles, as a lubricant, in paints, foundry facings, batteries, and stove polish.

Amorphous graphite, while frequently showing a crystalline structure under the microscope, is a trade name applied to amorphous or very fine-grained graphite of varying degrees of purity. It is used for foundry facings, as a lubricant, in pencils (black lead), paints, high explosives, boiler compounds, electrodes, dry batteries, and shoe and stove polishes.

Flake graphite is crystalline graphite produced in flakes or scales, while vein graphite is crystalline graphite in other forms, such as lump, chip, and dust. The chief supply of high-grade crystalline graphite comes from Ceylon, and this is the standard grade of crystalline product.

SPECIAL USES.

(*a*) *Crucibles, retorts, stoppers.*—Demand for graphite crucibles comes from the makers of crucible steel and of various nonferrous metal and alloy castings. Crucible makers are the largest consumers of graphite. The material must be of high grade, either lump or chip, flake or vein, containing at least 85 per cent graphitic carbon and free from easily fused impurities.

(*b*) *Lubricants.*—Both crystalline and amorphous are used. Should be free from silica (sand).

(*c*) *Foundry facings.*—Chiefly amorphous. High-grade material is not required. Artificial graphite is also used to a considerable extent.

(*d*) *Pencils.*—For better grades, mixtures of crystalline and amorphous are needed. For poorer grades, amorphous is used alone. Artificial graphite may be, but rarely is, used for this purpose.

(*e*) *Polish for smokeless powder.*—Amorphous; relatively small consumption. (Used to make the grains flow better and permit more accurate filling of shells.)

[1] Artificial graphite, if imported, would doubtless be dutiable under par. 81, act of 1913, as carbon.

(*f*) *Electrodes.*—Artificial is considered most suitable. Products are usually formed from powdered amorphous carbon (e. g., anthracite coal) and "graphitized" in an electric furnace.

(*g*) *Boiler compounds.*—Pure material not essential. Either amorphous or artificial. Used for preventing hard scale.

(*h*) *Paints.*—Amorphous, artificial, or crystalline. High-grade material not necessary.

(*i*) *Stove and shoe polish.*—Chiefly amorphous.

(*j*) *Dry-battery fillers.*—Either amorphous, artificial, or crystalline. Pure material required, but size of grain not a factor

(*k*) *Fertilizer filler.*—Low-grade amorphous. Used only as an adulterant and to give the required dark color.

DOMESTIC VERSUS FOREIGN GRADES.

Since crucible making is by far the most important use of graphite, the adaptability of the different grades for making crucibles is the determining factor in quality. Most makers of crucibles have heretofore preferred Ceylon flake mixed with from 10 to 25 per cent of American flake. The principal reason assigned for preferring the Ceylon flake is that the flat flake of the domestic graphite has a far greater surface area in proportion to its volume than the more nearly cubical Ceylon flake, and hence requires a greater amount of clay as a binder.[1] Improved finishing methods may permit the use of a larger proportion of American graphite, and during the war period crucible manufacturers were required to use at least 20 per cent of domestic flake in all crucibles. For most purposes, other than crucible manufacture, amorphous graphite can be used and the American product, when properly cleaned, is as good as the imported. Crystalline varieties, however, with flakes large enough to add to the binding power of clay are essential to the making of good crucibles and for high-temperature work the proportion of clay should be very low. For such purposes the domestic product heretofore has not been considered as satisfactory as the Ceylon. However it has recently come into greater favor.[2] Foreign crucible makers, are using 100 per cent Madagascar flake, which differs little in quality from the domestic flake.

Estimated percentage (by quantity) of the world's graphite consumption used for various purposes.[3]

	Per cent of total.
Crucibles	55
Stove polish	15
Foundry facings	10
Lead pencils	5
Paint	5
Lubricants	5
All other uses	5
Total	100

[1] Some difficulty was experienced after the outbreak of the war in finding a domestic clay to take the place of the Bavarian clay formerly used, but domestic clays have been found and satisfactory crucibles have been made from domestic clay and 100 per cent domestic graphite.

[2] As high as 100 per cent has been successfully used. (Dr. Stull, Jour. Am. Cer. Society, Michigan, 1919.)

[3] E. S. Bastin, Mineral Resources, 1913. If value rather than quantity is considered, about 75 per cent of the world's consumption should be credited to crucibles.

SUBSTITUTES.

Artificial graphite can be used for certain purposes in place of amorphous graphite and crystalline dust. There is no present substitute for flake graphite in the making of crucibles, although experiments along the line of artificial graphite may evolve a satisfactory product. In this connection should be considered the possibility of substituting electric or open-flame furnaces for crucibles for the purposes for which the latter are now used. There has been some progress in this direction but not enough to keep pace with the growth in the production of alloy steel, brass, and other products.

Mica is used to some extent in lubricants, but is much inferior. The same may be said of talc. The latter, however, is a partial substitute for graphite in foundry work. Blast-furnace "kish" (graphite that separates from pig iron when it solidifies) offers undeveloped possibilities as a substitute for flake as a lubricant. There are numerous satisfactory boiler compounds that contain no graphite. Lampblack is used instead of graphite in paints and polishes.

OCCURRENCE.

Amorphous graphite may occur wherever coal or other carbonaceous beds have been folded and altered by geological agencies. Crystalline graphite is found in two principal types of deposits (1) as flakes in schist and (2) as larger crystals in veins. The second is of rather rare occurrence, but since it yields the most valuable kind of flake for crucible manufacture it is important. Vein deposits, however, almost invariably are found only in association with graphitic sediments containing the ordinary flake variety.

PRODUCTION.

Any general statements in regard to production are complicated by the difference in the quality of the different supplies. Data based solely on either quantity of production or on value give little indication of the relative importance of the various sources of supply.

In normal times Austria is the leading graphite producing country as regards quantity, producing in 1913 nearly twice as much graphite as Ceylon, the second largest producer. The value of the Ceylon product, however, was nearly seven times as great, and this British-owned island is the largest producer of high-grade crucible graphite in the world. Recently, the French island of Madagascar has come forward as a rival producer of crystalline material. The quality of the product is a little different from that of Ceylon. It is not satisfactory to domestic crucible makers, but is preferred abroad because of its low price. Less satisfactory supplies are available in many countries, notably Bavaria, Canada, and Japan.

Amorphous graphite is much more widely distributed than the crystalline variety, being produced in about 20 countries. The largest producers are Austria, Italy, Chosen, and Mexico. Certain deposits have been found better suited for special uses, but most countries are satisfied with near-by supplies, and this raw material is relatively unimportant compared with the high-grade flake product.

The following estimate of probable annual production was prepared by the United States Shipping Board (1918):[1]

1. PRODUCTION OF CRYSTALLINE GRAPHITE.[2]

Madagascar	35,000 tons, increasing.
Bavaria	12,000 tons, poorer grade.
United States	10,000 tons.
Ceylon	30,000 tons, likely to decrease.
Norway	1,000 tons.
Sweden	200 tons.
Japan	1,000 tons.
Transvaal	200 tons.
Canada	4,000 tons.
Greenland, Brazil	Reported large deposits.
German Southwest Africa	None likely to develop largely.
Baffin Island	Small amount produced recently.
Indian Island	Once abandoned, small production.
England	Worked out.
Rumania	Recent important discoveries reported.
Spain	Deposits being developed.

2. PRODUCTION OF AMORPHOUS GRAPHITE.

Austria	50,000 tons.
Italy	13,000 tons.
France	1,000 tons.
Spain	1,500 tons.
Chosen (Korea)	20,000 tons.
Siberia	Large uncertain amount available.
United States	6,000–8,000 tons manufactured.
Mexico	8,000 tons.
Rhodesia	Local supply only.
Brazil, Queensland	Some.

DOMESTIC PRODUCTION.

QUANTITY.

The actual mine production of domestic crystalline graphite in 1917 was the largest in the history of the industry, amounting to approximately 14,000,000 pounds. (Only 10,584,080 pounds, however, were marketed in that year.) This production compares with an output of about 10,900,000 pounds in 1916 and a normal prewar production (average of six years) of only a trifle more than 5,000,000 pounds and reflects the great stimulation in demand for crucibles resulting from the war. Production in the first nine months of 1918 actually exceeded that for the entire year 1917. At the end of the year, however, after the signing of the armistice, production was on a much reduced scale.

In New York State, and intermittently in Pennsylvania, graphite has been mined for many years, and in 1913 Alabama became an important factor in the domestic output. But the domestic production was comparatively small in quantity and much smaller comparatively in value, as chiefly lower grades were produced. The growth in 1916 was over 100 per cent and in 1918 the output was more than treble the prewar average.

[1] Ferguson and Grout, Political and Commercial Control Series No. 2.

[2] "Only Madagascar flake, Ceylon grades, and Alabama or domestic flake No. 1 (which last is not more

Estimates furnished the Geological Survey by producers indicate that about 64 per cent by weight and 90 per cent by value of the total crystalline graphite marketed in 1917 was flake graphite, containing from 80 to 90 per cent graphitic carbon and in large part suitable for crucible making. This is a much higher percentage of flake than has been produced in any previous year. The increase may in large measure be attributed to improvements in processes of "ore" treatment.

The production of amorphous graphite during 1917 was 8,301 tons, valued at $73,481, as compared with 2,622 tons, valued at $30,723, in 1916, and a normal prewar output (average of five years) of only about 1,700 tons. As amorphous graphite is not suitable for making crucibles, there was not so marked an increase in the demand for it and the production had to meet the competition of both crystalline dust (a by-product in the preparation of crucible flake) and artificial graphite.

Production in the United States.[1]

Year.	Natural.						Artificial.	
	Crystalline.		Amorphous.		Total.			
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1909	3,147	$313,271	[2] 5,096	$32,238	[2] 8,243	$345,509	3,435	$467,196
1910	2,795	295,733	1,407	39,710	4,202	335,443	6,575	945,000
1911	2,395	256,050	1,223	32,415	3,618	288,465	5,072	664,000
1912	1,772	187,689	2,063	32,894	3,835	220,583	6,448	830,193
1913	2,532	254,328	2,243	39,428	4,775	293,756	6,817	973,397
1914	2,610	285,368	1,725	38,750	4,335	324,118	5,228	698,800
1915	3,537	417,273	1,181	12,538	4,718	[3] 429,811	2,790	.....
1916	5,466	914,748	2,622	20,723	8,088	[3] 935,471	4,461	.....
1917	5,292	1,094,398	8,301	73,481	13,593	[3] 1,167,879	5,237	.....
1918	6,431	1,454,799	6,560	69,455	12,991	[3] 1,524,254	4,591	.....

[1] Marketed production as reported to United States Geological Survey.
[2] Includes Georgia graphitic slate.
[3] Powdered graphite only; does not include electrode material after 1914.

MILLING METHODS AND PROCESSES.

There is no established method of recovering graphite from the containing rock. There are almost as many processes as there are mills. Most methods of treatment, however, take advantage of the tendency of the light, greasy flakes to float on a surface of water—sometimes, though more often otherwise, according to oil flotation methods similar to those employed for treatment of metallic ores. The degree of fineness to which the ore must be crushed depends upon the character of the flake. Huff electrostatic treatment has been very successful as a finishing process and is sometimes used as a primary method of treatment. A detailed study of the various processes (a copy of which is available in the auxiliary file of the Tariff Commission) has been made by the Bureau of Mines. Marked improvements are now (1918–19) being made in processes of treatment, but, since the greatest development of the industry has come only in the last two years, there are few plants where operating difficulties are not experienced.

RESOURCES.

Domestic supplies of graphite are large and capable of further development, but heretofore for the most part the flake has not been considered of as desirable quality as the imported material for crucible manufacture. The domestic deposits are mostly schists which contain the graphite in small flakes disseminated through the rock. The separation of the valuable material from the accompanying minerals, notably mica, is more difficult and expensive than is the case in some other countries. The grade of domestic deposits that have been successfully operated varies from 3 to 10 per cent and averages about 5 per cent of recoverable flake graphite. Amorphous graphite deposits must generally be of higher grade because of the lower value of the separated product.

EQUIPMENT.

A plant in the Alabama field capable of treating 10 tons of rock per hour costs from $35,000 to $60,000; a refining or finisning plant costing from $5,000 to $10,000 may also be needed. On the other hand, there are simple log-washing plants containing, in addition to ordinary crushing machinery, only home-made devices whose cost is very small. On certain classes of material, the cheap plants do exceptionally good work, but their field is limited.

LOCALITIES OF PRODUCTION.

The greater portion of the domestic output of crystalline graphite comes from Alabama. The remainder comes largely from New York and Pennsylvania, although small quantities were produced in California, Montana, and Texas in 1918. The productions of crystalline graphite in 1916 and 1917 are shown in the following table:

Crystalline graphite sold in the United States, 1916 and 1917.[1]

	1916		1917			
					Total.	
	Quantity (pounds).	Value.	No. 1 and No. 2 flake (pounds).	Other grades (pounds).	Quantity (pounds).	Value.
Alabama	5,226,940	$492,407	4,295,233	1,927,862	6,223,095	$719,575
New York	(2)	(2)	1,656,897	1,284,143	2,941,040	261,548
Pennsylvania	1,095,716	103,377	549,783	255,162	804,945	77,475
Other States [3]	4,609,333	318,964	315,000	300,000	615,000	35,800
	10,931,989	914,748	6,816,913	3,767,167	10,584,080	1,094,398

[1] Mineral Resources, U. S. Geological Survey.
[2] Included in "Other States."
[3] 1916: California, Montana, New York, and Texas; 1917: Alaska, California, Montana, and Texas.

Amorphous graphite was produced by six mines in 1917, as against five mines in 1916. The producing States were Colorado, Michigan, Nevada, and Rhode Island. On account of the small number of plants, productions by States may not be published, although they are recorded in the confidential files of the Geological Survey.

Alabama is credited with 59 per cent of the quantity and 66 per cent of the value of the domestic crystalline graphite sold in the United States in 1917. The output was worth three times that of 1913. In December, 1918, 30 plants were operating and the production for the year promised to greatly exceed that of 1917. The number of idle and abandoned mines was even greater. Only six of the plants were actually operating full time. Alabama ores do not contain amorphous graphite. All of the operating companies operate open pits. Only the upper 30 to 60 feet of the material is being mined. This consists of the decomposed (weathered) horizon and is normally rather soft and easily broken. The underlying unaltered "blue rock" is hard and since it is expensive to mine it is not worked. The average Alabama ore is very low grade, containing only about 2½ per cent of graphitic carbon, but the accessibility and comparatively even grade of the deposits make them the most important in the United States. The aim in concentrating is to produce as much No. 1 flake as possible (analyzing 85 per cent graphitic carbon and remaining on a No. 8 silk cloth of 86 mesh). No. 2 flake (analyzing 75 to 80 per cent graphitic carbon and finer than No. 1 flake) is a by-product grade that is difficult to dispose of, while "dust" (containing 30 per cent or more graphitic carbon) is a drug on the market. The production in Alabama plants varies from 4½ to 8 pounds of No. 1 flake per man per hour. The average is estimated at about 6 pounds per man-hour, figured on the total number of men and officials employed. Proportional amounts (about 2 pounds) of No. 2 and dust are made in addition.

New York is the oldest producing State, graphite mining having started about 60 years ago. The ore is much higher grade than that of Alabama, averaging 4 to 6 per cent graphitic carbon and yields a cleaner, brighter flake. As a rule it is harder and more resembles the undecomposed Alabama "blue rock." Most of the ore comes from underground mines, power drills being used. In thickness the deposits average about 15 feet and seldom exceed 25 feet. There were three active producers in 1917–18. One or two other companies were prospecting.

Pennsylvania has five operators. The ore, with one exception, is a soft weathered schist, and contains from 3½ to 4½ per cent graphitic carbon. Several of the producers make an unrefined concentrate analyzing 60 to 70 per cent graphitic carbon. It is sold to an eastern refiner.

The number of operators in other States for 1917–18 were as follows: Alaska, 1; California, 1; Montana, 4; and Texas, 1. The deposits in these States have been described in detail in various publications of the United States Geological Survey. Most of these deposits are higher grade than those in Alabama but more difficult to mine. The recovery of flake is generally low since amorphous graphite is also present. The flake is small, and the rock hard, so that a large amount of the flake is destroyed in crushing. One Montana vein deposit warrants special mention. This product although somewhat softer, most nearly resembles the Ceylon variety. So far the output has been small.

PRODUCTION VERSUS CONSUMPTION.

The United States has heretofore not been considered independent in the matter of crucible graphite. Crucible makers have insisted on having Ceylon graphite, using some 15,000 tons a year.[1] The domestic output of flake has never exceeded the 1918 output of 6,431 tons. The request of the War Industries Board that, as a war measure for ship saving, the makers of crucibles should use 20 per cent of domestic flake graphite during the second half of 1918, established a market for domestic flake. During the last two years of the war, imports of graphite were eight times the domestic production. In the last few months of the war domestic production had increased to a point at which it was supplying over one-third the demand for graphite of all grades.

There has been a larger degree of independence in the matter of amorphous graphite of which the consumption is in the neighborhood of 15,000 tons annually. Practically all of this can be furnished from domestic sources, including both natural and artificial, but American-owned mines in Mexico and Canada were drawn upon to some extent.

DOMESTIC EXPORTS.

In spite of the large importations of graphite, both unmanufactured graphite and manufactures of graphite have been consistently exported from the United States. Previous to the war, the amount of unmanufactured exported ranged from 3,000,000 to 6,000,000 pounds annually, averaging (for the five years preceding the war) 4,221,000 pounds. From 1914 to 1916 there was a considerable increase in the exports of manufactured articles and a marked falling off in the exports of the crude material. But in 1917 the situation was reversed and the export of crude graphite returned to the prewar level while the amount of graphite manufactures decreased about one-third. In 1918 graphite in any form was on the export conservation list and exports were not permitted except by special license from the War Trade Board.

Domestic exports.

GRAPHITE (UNMANUFACTURED).

[Fiscal years.]

Exported to—	1910		1911		1912	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Belgium	629,478	$41,542	675,129	$56,848	910,526	$66,277
France	409,234	26,846	482,500	32,286	385,412	26,083
Germany	1,127,178	82,851	1,252,802	96,376	1,265,456	98,370
Netherlands	8,627	613	335,383	27,443	271,422	20,754
United Kingdom	613,588	38,298	729,371	37,852	473,110	32,261
Canada	131,357	4,382	46,796	2,327	176,050	8,230
All other	346,270	24,955	499,147	37,783	453,908	33,622
Total	3,265,732	219,487	4,021,128	290,915	3,935,884	285,597

[1] There is, however, one deposit in Montana which has lately been producing graphite that is being accepted by crucible makers as equal to the Ceylon material. The quantity ultimately available has not been proved, but is believed by the operators (letters in auxiliary files, U. S. Tariff Commission) to be sufficient to supply domestic demands for many years to come. Alabama flake is also accepted by certain companies as satisfactory crucible material, and has shown even superior results in crucible tests reported by Dr. Stull in the Journal of the American Ceramic Society, March, 1919.

Domestic exports—Continued.

GRAPHITE (UNMANUFACTURED)—Continued.

Exported to—	1913		1914		1915	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Belgium	699,046	$52,997	930,977	$65,853	221,088	$16,783
France	692,457	48,522	285,870	17,903	394,002	31,487
Germany	1,057,799	82,144	2,082,464	164,648	376	30
Netherlands	241,696	20,518	485,406	38,129	769,914	49,888
United Kingdom	992,375	64,346	1,064,050	69,808	486,409	30,436
Canada	250,704	10,630	346,147	16,939	171,367	8,698
All other	569,492	42,522	181,966	13,795	280,925	15,124
Total	4,503,569	321,679	5,376,880	387,075	2,324,081	152,446

Exported to—	1916		1917		1918	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
France	133,014	$6,540	418,954	$28,969	1,059,712	$70,037
Netherlands	20,863	1,090				
United Kingdom	308,420	15,989	1,003,903	69,628	2,187,535	147,591
Canada	220,141	9,539	607,176	26,742	566,492	29,833
All other	254,431	13,749	470,024	37,994	1,098,991	83,908
Total	936,869	46,907	2,500,057	163,333	4,912,730	331,369

ARTIFICIAL GRAPHITE.

Artificial graphite is made by a large company at Niagara Falls, N. Y. The output has increased greatly in recent years and now forms an important element in the country's supply. Bulk graphite is made either from anthracite coal or from petroleum coke. This product, utilized mainly for foundry facings, lubricants, paints, boiler compounds, and battery fillers, enters into direct competition with the amorphous or "dust" grades of natural graphite. The most important use of artificial graphite, however, is in electrodes for electric furnaces, and to the extent that the latter are displacing crucibles this source of graphite may be said to add to the domestic resources. Graphite electrodes are generally made without admixture of natural graphite and are employed in most electric steel furnaces, for the production of aluminum, and in various electrochemical industries. Many of the larger consumers manufacture their own electrodes.

COSTS.

The Tariff Commission has, as yet, made no independent investigation of costs. However, it is known that operating costs in all the domestic mining districts are high. At present (1918–19) they are said to range from 6 to 14 cents per pound, with an average of 10 cents per pound of No. 1 flake.[1] In ascertaining costs, the No. 1 flake is charged with the whole operating expense and credited with the income received from the sale of by-product No. 2 flake and dust.

[1] George D. Dub, Preparation of Crucible Graphite. Bureau of Mines, War Minerals Investigation Series, p. 22.

In these costs no allowance has been made for depletion and depreciation. Making these allowances would perhaps add 1 or 2 cents per pound.

The wide range between the upper and lower limits of domestic costs as estimated above reflects differences in efficiency at the various plants more than it does varying grades of the ore; although the latter is, of course, a factor. Transportation difficulties, especially in the Alabama field, are also an important feature and serve to raise the costs in that State in spite of the comparative cheapness of mining and crushing the crude material.

FOREIGN PRODUCTION.

Ceylon.—Since 1901 the United States has been the largest consumer of Ceylon graphite. In 1917 this country took 81 per cent of the total output. In normal times about two-thirds of it is allowed by the British Government to go to American crucible manufacturers who, because of its peculiar quality of flake, have been willing to pay a much higher price than for any other raw graphite. The Ceylon deposits are believed, however, to be approaching exhaustion.

Most of the mines are operated by native Singhalese. About 50,000 persons—men, women, and children—are employed in graphite production, which, next to tea, is the most important industry of the island. The work is done almost exclusively by hand. The care there given each tiny fragment of material is possible in a country where native labor is exceptionally cheap and abundant.[1]

Madagascar.—This African island probably has the world's best future supplies of flake graphite. The deposits are large, conveniently situated, remarkably rich—containing 50 per cent or more of graphite—and are capable of greatly increased production. From 1914 to 1917 the output trebled. Anticipating the decline in production from Ceylon, British crucible makers as well as the French now obtain their graphite supplies from Madagascar. Madagascar plumbago is of increasing importance in the United States, but the Madagascar flake is more like the domestic flake than is the Ceylon lump.[2]

Austria.—In normal times Austria has been the largest producer of graphite, as regards quantity. The producing districts in order of importance are Bohemia, Styria, Moravia, and lower Austria. The

[1] The Ceylonese graphite industry has been described at length by Bastin. (Econ. Geology, vol. 7.) The following notes are based on his work: The mining is both by open pit and through vertical shafts, the latter being rarely over 100 feet deep, although a few extend to depths of 400 to 500 feet. Hoisting from even the deeper shafts is done almost wholly by hand, using windlasses. The important deposits are veins consisting almost wholly of graphite. Quartz and pyrite are the only accessory minerals at all common, and they are present in generally minor amounts. The mineral, as it comes to the surface, however, may contain as much as 50 per cent of impurities, due to admixture of wall rock.

The impurities are reduced to 5 or 10 per cent by hand picking at the mines and then the crude product is shipped to the coast. At the ports the material is further treated or "cured." This seems to be a strange process, varying in detail at the different "compounds" (yards), but it consists essentially of screening and hand sorting. Women chop up the larger lumps with little hatchets, pick out the coarser impurities by hand, and then polish the pure material with wet burlap. The last operation is the blending of the various grades from several mines in order to meet the requirements of purchasers—a process demanding skill and long experience.

Poorer material is beaten to a powder and sorted. In some places it is washed by hand (the graphite floating off into the tub or pit of water, leaving the heavy impurities in the saucerlike basket used for "panning"). Another process, used for very fine material, is to throw it up in the air. The heavier particles are caught in a basket (shaped like a dustpan), while the graphite is blown forward and falls on the floor.

[2] Madagascar deposits and methods of mining are described in detail by Bastin (Mineral Resources, 1913, Vol. II) and in other publications that are available in the auxiliary files of the United States Tariff Commission.

product, however, is almost exclusively of the amorphous variety. Before the war a large part of the output was exported chiefly for making pencils. Overproduction has made it possible at times to buy the Austrian product in the United States below cost.

Germany (Bavaria).—The German supply of graphite comes from Passau near the Austrian frontier, is of the flake variety, and found in decomposed schist. It was formerly used largely in the manufacture of crucibles, but before the war German crucible manufacturers used a large amount of Ceylon graphite.

Other countries.—Since the exclusion of Austria from outside markets, Mexico, Chosen, and Italy have been the principal sources of amorphous graphite. The Mexican product is of excellent grade and is available in large amounts. The largest productive deposit is owned by a graphite company in Saginaw, Mich. (who ship the crude ore from Mexico to Michigan for separation). American capital is interested in most of the other Mexican producing properties and also in Canada and Chosen (Korea). The product of the latter country, however (consisting largely of amorphous but with some flake), has been largely shipped to England during the war period. The Canadian flake is similar to the American, but most of the properties produce only one-half as much flake as dust. About 25 per cent of the product is large flake, and a large part of the remainder must be sold at a reduced price as "foundry plumbago."

Italy has become a less important producer of amorphous graphite since the war. The American market has been lost, so the product is largely exported to England and France.

Aside from the above-mentioned countries, though graphite deposits have been opened in various parts of the world, none has become of more than local importance. Roumania and Japan appear to have promising deposits of flake material that may enter the world market.

Production in principal foreign countries.[1]

[Short tons.]

Countries.	1907		1908		1909	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Austria	53,013	$387,930	48,970	$349,118	44,875	$320,289
Canada	579	16,000	251	5,565	863	45,999
Ceylon	36,406	2,889,596	28,916	2,593,160	36,056	3,237,751
France	138	1,206	.....	.....	.....	.....
Germany	4,409	47,671	5,340	60,264	7,467	64,724
India	2,725	35,949	3,218	69,814	3,508	60,972
Italy	12,125	61,374	14,235	71,758	12,768	71,148
Japan	115	5,222	195	8,592	136	5,290
Mexico	3,530	54,339	1,742	28,426	1,878	25,301
Norway	1,543	14,974	1,192	13,005	.....	.....
Sweden	36	946	73	2,046	29	779
Queensland	34	965	22	292	.....	.....
Total	114,653	3,516,172	104,154	3,202,040	107,580	3,832,253

[1] Mines and Quarries: General Report and Statistics for 1909, pt. 4, London.

Production in principal foreign countries—Continued.

Countries.	1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Austria	36,520	$281,220	46,855	$332,489	50,017	$378,867
Canada	1,392	74,083	1,269	69,576	2,059	117,117
Ceylon [1]	35,310	2,577,600	30,183	2,159,529	36,660	2,707,973
China	.....	.....	22	1,728	(2)	(2)
Chosen	.....	56,719	.....	[1] 65,727	.....	82,108
France	606	5,353	408	3,601	661	1,635
Germany	8,174	76,404	12,454	72,754	13,814	81,514
India	4,761	99,661	4,533	45,867	(2)	(2)
Italy	13,790	74,808	13,912	74,701	14,517	77,236
Japan	162	5,202	126	8,911	163	10,935
Madagascar	601	21,218	1,373	48,534	3,011	239,291
Mexico	2,571	36,207	3,050	36,353	3,158	96,668
Norway [1]	882	8,575	.....	.....	285	1,898
Sweden	1,526	1,844	72	2,097	87	2,535
South Africa	40	6,755	44	6,365	42	5,621
Russia	(2)	(2)	(2)	(2)	(2)	(2)
Total	106,335	3,325,649	114,301	2,928,232	124,474	3,803,398

Countries.	1913		1914		1915	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Austria	54,501	$412,745	(2)	(2)	(2)	(2)
Canada	2,162	90,282	1,647	$107,203	2,635	$124,233
Ceylon [1]	28,540	2,935,529	15,929	1,142,000	24,436	2,569,434
Chosen	[1] 10,264	[3]	[1] 12,000	[3]	7,767	101,141
France	1,194	3,441	(2)	(2)	(2)	(2)
Germany	13,263	63,308	(2)	(2)	(2)	(2)
India	.....	.....	78	769	1,476	7,304
Italy	12,282	65,790	9,441	[4] 50,000	6,793	[4] 33,000
Japan	773	[3] 116,389	632	[3] 156,000	(2)	(2)
Madagascar	6,958	[4] 423,000	8,540	[4] 536,000	13,060	[4] 686,000
Mexico [1]	4,435	198,000	4,259	190,075	1,680	75,000
Sweden	97	2,831	62	1,813	87	(2)
South Africa	39	6,117	(2)	(2)	46	5,856
Australia	.....	.....	38	4,718	77	144
Spain	.....	.....	.....	.....	33	[4] 2,000
Total	134,508	4,317,432	52,626	2,188,578	58,090	3,504,112

Countries.	1916		1917		1918	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Austria	(2)	(2)	(2)	(2)	.....	.....
Canada	3,971	$285,362	3,714	$402,892	3,114	$248,970
Ceylon [1]	37,420	7,298,128	(2)	(2)	17,307	2,685,000
Chosen [1]	18,704	[4] 243,000	(2)	(2)	.....	.....
France	(2)	(2)	(2)	(2)	.....	.....
Germany	(2)	(2)	(2)	(2)	.....	.....
India	1,476	7,304	(2)	(2)	.....	.....
Italy	9,017	(2)	(2)	(2)	.....	.....
Japan	1,261	25,903	(2)	(2)	.....	.....
Madagascar	28,080	[4] 2,213,000	[4] 38,500	(2)	[4] 18,000	1,800,000
Mexico [1]	5,331	238,000	7,570	285,568	5,600	134,183
Sweden	214	(2)	(2)	(2)	.....	.....
South Africa	67	8,657	(2)	(2)	.....	.....
Australia	(2)	(2)	(2)	(2)	.....	.....
Spain	1,364	[4] 79,000	(2)	(2)	.....	.....
Total	106,905	10,398,354	49,784	688,460	44,021	4,868,153

[1] Export figures, practically equal to marketed production
[2] Statistics not available.
[3] Value of Japan and Chosen production not separated in 1913–14.
[4] Estimated.

IMPORTS.

Both amorphous and flake graphite are imported. In the last two years of the war imports of graphite totaled eight times the domestic production. The principal source of imported graphite is the island of Ceylon. Approximately 90 per cent of this Ceylon material has been used in the manufacture of crucibles. Amorphous graphite, formerly imported in large amounts from Korea (partly via Japan) has been replaced by similar material obtained from Mexico. Before the war the Mexican product was imported chiefly for making pencils.

The import statistics show the effects of war conditions and the rearrangement of trade routes. The later increase of imports from France are wholly of Madagascar origin, while the graphite attributed to Great Britain had its origin in Ceylon. Since the imports credited to Canada in 1914 and 1915 were in excess of the Canadian production in those years, it is probable [1] that they include a certain amount of Ceylon graphite.

Imports by countries.

PLUMBAGO OR GRAPHITE.

[Fiscal years.]

Imported from—	1910		1911		1912	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
United Kingdom	214	$9,795	97	$9,543	6	$743
Germany	98	3,048	25	1,409	33	2,641
Italy	848	12,562	578	7,758	430	6,674
Austria-Hungary	400	9,513	329	6,544	200	3,996
Canada	1,614	82,410	1,972	85,724	2,481	95,355
Mexico	2,620	28,826	3,005	238,399	1,988	115,818
Ceylon	15,454	1,737,094	13,112	1,307,980	12,787	1,192,521
Japan	447	10,938	1,015	20,159	661	10,452
France	.....	.....	1	53	.....	.....
Belgium	.....	.....	2	128	5	186
All other	1	80	20	928	.....	.....
Total	21,696	1,894,266	20,156	1,778,625	18,591	1,428,386

Imported from—	1913		1914		1915	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
United Kingdom	182	$23,605	598	$74,724	2,038	$266,821
Germany	115	3,766	60	3,015	1	149
Italy	323	5,846	166	3,380	109	1,279
Austria-Hungary	525	10,332	408	6,896	8	137
Canada	1,874	120,656	1,535	97,198	1,721	85,952
Mexico	3,520	174,474	4,283	214,075	2,840	112,000
Asia—Ceylon	16,137	1,591,756	10,957	1,321,764	6,402	759,009
Japan	2,528	41,322	6,668	113,319	3,190	48,393
British India	.....	.....	.....	.....	113	9,815
France	16	365	38	6,141	451	51,340
Madagascar	.....	.....	18	2,716	152	18,541
Belgium	1	25	20	1,462	22	2,281
All other	1	30	117	1,436	21	2,156
Total	25,222	1,972,177	24,868	1,846,126	17,068	1,387,873

[1] Ferguson, Mineral Resources (1917), U. S. Geological Survey.

Imports by countries—Continued.

PLUMBAGO OR GRAPHITE—Continued.

Imported from—	1916		1917		1918	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
United Kingdom	504	$166,902	3	$749	6	$1,783
Italy	139	4,774	40	706	98	3,367
Canada	3,650	210,783	3,509	357,261	2,959	318,042
Mexico	3,980	199,000	6,759	293,568	3,507	106,779
Ceylon	16,981	3,235,045	24,577	7,812,246	15,360	4,800,004
Japan	3,245	59,579	2,901	79,884	1,091	59,432
British India	151	45,327	1,211	400,342	611	204,407
France	2,232	354,663	2,929	720,440	1,848	592,184
All other	165	22,457	310	12,964	345	41,889
Total	31,047	4,298,530	42,239	9,678,160	25,825	6,127,887

The Ceylon product is imported largely for its special qualities. Its lump form, purity, and the unusual care given to its grading and blending make it especially suitable for making crucibles. Much of the Madagascar product needs to be refined after arriving in this country. Madagascar flake is not as satisfactory as the Ceylon material. It competes with domestic flake chiefly because of its lower price. Among amorphous graphite imports, the Mexican graphite is preferred, for pencil making, to similar grades produced in the United States. Imports from Korea and certain European countries are strictly competitive with the home product. Austrian and other European graphite imports are reported to have been sold in this country below cost because of overproduction, but normally they can not be sold here in competition with the cheap Korean (Chosen) and Mexican supplies and, even before the war, had practically disappeared from the American market.

Imports for consumption.

Fiscal years.	Rates of duty.	Quantities.	Value.	Duties collected.	Value per ton.	Actual and computed ad valorem rate.
		Tons.				Per cent.
1907	Free	20,553.73	$1,626,730		$79.14	
1908	...do	13,361.61	1,206,016		90.26	
1909	...do	15,985.79	1,463,717		91.56	
1910	...do	21,596.93	1,894,266		87.71	
1911	...do	20,152.56	1,677,963		83.26	
1912	...do	18,589.85	1,428,386		76.84	
1913	...do	25,232.85	1,972,177		78.16	
1914	...do	24,865.70	1,846,074		74.24	
1915	...do	17,057.00	1,387,873		81.37	
1916	...do	30,938.00	4,298,530		138.94	
1917	...do	42,270.00	9,678,160		228.96	
1918	...do	25,440.00	6,018,662		236.58	

PRICES.

On account of its qualities and reputation, Ceylon graphite has always commanded the highest price of all grades, and since the difficulty of shipment due to war conditions, its prices have been relatively higher in comparison with other kinds of flake. The average price before the war was 10 cents per pound for lump, 6 cents for chip,

and 4 cents for dust. There was a sharp increase in 1913 (about 30 per cent), due chiefly to severe floods on the island and to increased mining cost, but in 1914 prices returned to about the normal level. In 1915 prices of Ceylon flake rose very rapidly. On account of the submarine menace in the Mediterranean, shipments could no longer go by way of the Suez Canal and had to round the Cape of Good Hope. The freight increased first to three times and later to nearly six times its former level. The highest prices of Ceylon flake reached during the war were 30 cents a pound for lump, 22 cents for chip, and 14 cents for dust. In spite of the embargoes placed upon the material there was at no time any great shortage of the Ceylon material, and the policy of the War Industries Board in ordering the substitution of a certain amount of domestic flake for overseas product in making crucibles resulted in a conservation of stocks. In January, 1919, lump was quoted at 18 cents, chip 14 cents, and dust 11 cents per pound. (All these prices are f. o. b. New York and include excess freight charges and war risk insurance.) But in June (1919) the best grades of Ceylon were quoted at 12¼ to 12¾ cents per pound; other grades are nominal. There has been practically no market for Madagascar or domestic grades for three months.[a]

There are no regular quotations for other grades of graphite. Madagascar, domestic, and other material are sold on the basis of supply and demand for the individual product, although the general market exhibits the same tendencies as the Ceylon market. Average annual prices for several grades are tabulated above. These are for the domestic market—chiefly New York. Since June, 1917, weekly quotations have been published by the Mining Journal (London). These showed an average cost of about 10 cents per pound for Madagascar flake[b] at Marseille, which can be compared with current American prices in the neighborhood of 13 cents for the same period.

Prices of natural domestic graphite.

[Cents per pound f. o. b. mines.[1]]

Years.	No. 1 flake.	No. 2 flake.	Inferior flake.	Dust.	Amorphous.	Miscellaneous.[2]
1910	6–8½	4–6	.....	1½–2	2½–3½	
1911	5–7	4–6	2½–4	¾–2½	.....	1½ (Mexican amorphous), 1.3–1.275 (Chosen).
1912	6–7	.....	.....	.....	.....	1.25 (Chosen).
1913	6–8	.....	.....	.....	.....	1–1¼ (Chosen).
1914	6½–8	.....	.....	.....	.....	4–6 (Mexican), a few grades 8, 5–7.5 (Madagascar), 1¼ (Chosen).
1915	7–10	.....	.....	.....	.....	6 to 11–12 Madagascar, 4–4.5 (Mexican), 1.25–2.5 (Chosen).
1916	10–16	.....	.....	.....	.....	
1917	17–19	.....	.....	.....	.....	
1918	16–17	10	.....	[3]	.....	

[1] Largely from data collected by U. S. Geological Survey.
[2] At New York.
[3] 25 to 30 per cent, 1 cent per pound; 85 to 90 per cent, 12 cents per pound.

[a] It is stated that Madagascar was offered in large quantities in April at 7 cents with but few sales.
[b] Based on 80 to 85 per cent graphitic carbon with allowance of 15 francs per metric ton per unit of variation.

IMPORTED CEYLON FOR CRUCIBLE MANUFACTURE.

[Average prices in cents per pound paid by crucible makers.]

Kinds or grades.	1911	1912	1913	1914	1915[1]	1916[2]	1917[3]	1918[4]
Ordinary lump (approximately 90 per cent graphitic carbon):								
Best	8¼–9	8¼–10	9½–11	8½–10½	9 –22	26 –28	28–30	18
Medium	7 –8	7 – 8	7½– 9	7 – 9	7½–15	.....	.....	.....
Poor	6 –7	5½– 7	6½– 8	6 – 8	6 –12	.....	.....	.....
Chip (approximately 80 per cent graphitic carbon):								
Best	5¼–5¾	5½– 7	7½–10	7 – 9	7 –15	19 –20	19–21	14
Medium	4 –5	4½– 6	6½– 8½	6 – 8	6 –13	.....	.....	.....
Poor	3½–4	3½– 4½	4 – 7	4 – 7	5 –10	.....	.....	.....
Dust (approximately 70 per cent graphitic carbon):								
Best	3½–4	3 – 3½	4 – 5½	4 – 5½	5 – 7½	10½–12	11–12	11
Medium	2¾–3¼	2½– 2¾	3 – 4	3 – 4	4 – 6	.....	.....	.....
Poor	2 –2½	1⅝– 2⅜	2 – 3	2 – 3	3 – 6	.....	.....	.....
Flying dust:								
Best	3½–3½	2 – 2½	2½– 3½	2½– 3½	3 – 5	(5)	(5)	(5)
Medium	2 –2½	1¾– 2	2 – 3	2 – 3	2½– 4	.....	.....	.....
Poor	1½	1¼– 1½	1½– 2	1½– 2	2 – 3	.....	.....	.....

[1] In general, the lower figure is the price in January and the higher that for December. Prices rose quite steadily throughout the year.
[2] From Mineral Industry. Prices fairly steady.
[3] March quotation, ex-dock New York. Similar quotations with few sales continued into 1918.
[4] Quotations at end of year.
[5] No longer on market.

ALL GRADES.

[Import valuations and average values at mines, in cents per pound.]

Year.	Ceylon.[1]	Madagascar.[1]	Chosen.[1]	Mexico.[1]	Canada.[1]	Domestic.	Artificial.[2]
1910	.....	.....	.....	.....	.....	4.90	7.19
1911	4.30	.....	0.74	3.80	1.70	5.30	6.54
1912	4.10	.....	.70	2.30	2.30	5.30	6.44
1913	4.90	.....	.70	2.20	3.00	5.00	7.14
1914	5.50	5.50	.76	2.20	2.60	5.50	6.68
1915	6.30	6.30	.74	2.20	1.90	5.90	[2] 1.96
1916	[3] 12.00	7.40	.96	2.20	3.80	8.40	.....
1917	14.60	12.30	1.70	1.90	5.00	10.30	.....
1918	13.20	13.60	[4] 2.15	1.20	3.80	11.30	12–30.00

[1] Calculated from import valuations calendar year totals of all classes of graphite.
[2] From Mineral Industry. Prices previous to 1915 include electrodes; for 1915 and later, powdered graphite only.
[3] Increase due partly to larger percentage of better grades.
[4] Japan.

COMPETITIVE CONDITIONS.

CRYSTALLINE GRAPHITE.

In normal times the domestic graphite-mining industry is not in a position to compete successfully with unrestricted imports from Madagascar and Ceylon. The domestic product costs more and must be sold at a lower price. In both Ceylon and Madagascar the deposits are of large extent and so free from impurities that comparatively little treatment or refining is necessary. Most of the domestic flake as found disseminated in low-grade deposits requires comparatively complicated machinery and processes to prepare it for market. It has the further disadvantage of being thinner. The Ceylon flake especially has had some technical and much popular reputation as being more desirable for making crucibles. At present Alabama flake producers claim, and are seeking to establish, that war

experiments have shown that such a reputation and its resulting differential in prices are unwarranted, so far as their product is concerned.

Labor in the Far East is much cheaper than in the United States and, partly by virtue of the natural advantages of the deposits, has no difficulty in producing in quantity.

In spite of the great distance from the American market, graphite from these islands used to be sold continually in the United States at prices that allowed no profit to domestic producers. Before the war the highest grade of Ceylon graphite was sold in New York at less than 10 cents a pound, as against a maximum of about 8 cents for domestic flake. The gradual exhaustion of the deposits and increasing cost of production in Ceylon are more than offset by the rapid development of Madagascar deposits. Canada is the only other country from which flake graphite is imported, but the amount is too small to exert any marked influence on the domestic market and its quality is similar to that of the American product.

Many of the Alabama plants are situated 6 to 9 miles from railroads and in a region where wagon roads (clay) are difficult to maintain. For certain companies, therefore, the transportation problem is serious. But the gravest handicap is the universally low grade of the deposits. Even if a price of 10 cents per pound can be obtained for No. 1 flake—nearly 50 per cent higher than before the war—only the most efficient plants will be able to survive. Improvements in treatment of ore and refining of the product are strengthening the position of the producers, and the possible establishment of plants for the manufacture of graphite finished products close to the mines and the consequent ready sale of by-products (No. 2 flake and dust) would be of even more assistance; but it is an open question whether the industry, which has so lately been established, can maintain itself against the competition of foreign producers having better natural resources.

Costs to New York and Pennsylvania producers are reported to be practically the same as to those of Alabama, chiefly because most plants have just begun producing; but for the future the industry in these States has a distinct advantage over the Alabama production because of the better grade of the deposits and greater ease of access. The slight disadvantage of underground mining as compared with the southeastern section is a minor factor. The Texas industry is favored by nature to an even greater degree. Its main handicap is the lack of outlet for by-product grades of flake.

The following statements made by Dub [1] reflect the status of the flake mining industry in this country:

> For domestic flake graphite the supply exists and can be obtained. If the demand can be created and extended by scientific rather than by artificial means, the supply will be forthcoming whenever the price is high enough to justify production.
>
> With the resumption of peace-time activities the demand for crucibles and other graphite products will probably slacken. This will, of course, react upon the domestic graphite mining industry. Until business in the United States has resumed its normal peace-time trend some method of control or regulation will be necessary to prevent the collapse of certain industries, which the lessons of the present war have taught should not be permitted to die. To be independent of foreign graphite, the use of 100 per cent domestic flake in crucibles will have to be developed if the graphite crucible continues as a medium for melting alloys of all kinds. It is possible, of course, that the use of some refractory other than graphite, or the extended use of melting furnaces requiring no crucibles may develop to such a point as to make present practice obsolete.

[1] Dub, Geo. D., Preparation of Crucible Graphite. Bureau of Mines, War Minerals Investigation.

AMORPHOUS GRAPHITE.

The production of natural amorphous graphite has never been an important industry in the United States. It has to meet the competition not only from foreign producers but also from the by-products of flake mining, as well as the more serious production of artificial graphite. There was little stimulus given this production during the war, and its after-war problems are no more complicated than were the prewar conditions. Both Chosen and Mexico have larger and higher grade deposits, but are handicapped by their greater distance from the market. In the case of this relatively cheap commodity transportation charges are a more important factor than in the case of the more costly crystalline grades.

ARTIFICIAL GRAPHITE.

Artificial graphite and graphitized carbon manufactures require mention, since they are competitive with natural grades. The American industry is large, important, and highly integrated. In view of the comparatively low value of the product, the acquired skill required in the manufacture, and the enterprise of its management, it is apparently proof against foreign competition in the American market and is reaching out into the export field.

TARIFF HISTORY.

Graphite has been on the free list under the name of plumbago since 1872. From 1846 to 1872 there was a duty ranging from 20 per cent to $10 per ton on the article as "plumbago or black lead."

COURT AND TREASURY DECISIONS.

An article of earth, slate, and shale, together with plumbago or black lead was held dutiable as a "mineral and bituminous substance in a crude state, n. s. p. f." at 20 per cent ad valorem under section 20 of the act of March 2, 1861, unless "approximating in value to plumbago," in which case it was classified as plumbago at $10 per ton under section 8 of the act of July 14, 1862, by virtue of section 20 of the act of August 30, 1842. (Dept. Order (1870), T. D. 691.)

Powdered plumbago, although having undergone a process of refinement for removal of iron, lime, or other foreign substances present in the crude article as taken from the mines, was held to be plumbago within section 5 of the act of June 6, 1872, and accordingly exempt from duty. (Dept. Order (1873), T. D. 1627.) But blocks of plumbago with other ingredients were held dutiable at 20 per cent as an unenumerated manufacture and not exempt from duty as plumbago. (Dept. Order (1874), T. D. 1947.)

So-called old broken crucible shells, parts of crucibles, composed chiefly of plumbago and imported for the purpose of recovering the plumbago, were held not exempt from duty as plumbago under paragraph 579 of the act of 1913, but dutiable as waste, n. s. p. f., under paragraph 384. (Dec. Treas. Dept., Apr. 18, 1918.)

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GRAPHITE PRODUCERS BY STATES (1917).

ALASKA.

Alaska Graphite Mining Co.
Uncle Sam Alaska Mining Syndicate.
(Both near Graphite Bay.)

MONTANA.

Crystal Graphite Co. (16 miles from Dillon).

NEW YORK.

Graphite Products Corp. (3 miles north of Saratoga Springs).
Hooper Bros. (4 miles west of Whitehall).
American Graphite Co. (Operated by Joseph Dixon Crucible Co. 4 miles west of Hague.)

PENNSYLVANIA.

Graphite Products Co., Uwchland, Pa., with mines at Byers.
T. D. Just & Co., Philadelphia; with mines at Byers and Chester Springs.
Harry Schmehl, Chester Springs.
Standard Carbon Co., Philadelphia, with mines at Pikeland.
Tonkin Graphite Co., Byers.

ALABAMA.

	Location of plant.
Chilton County:	
Flaketown Graphite Co., Mountain Creek	Mountain Creek.
Clay County:	
Acme Graphite Co., Ashland	Ashland.
Alabama Graphite Co., Ashland	Do.
C. B. Allen Graphite Co., Ashland	Do.
American Graphite Co., Gadsden	Do.
Ashland Graphite Co., Ashland	Do.
Atlas Graphite Co., Ashland	Do.
Axton Noe Graphite Co., Ashland	Do.
Clay County Graphite Co. (Inc.), Ashland	Do.
Crystalline Flake Graphite Co., Birmingham	Do.
Empire Graphite Co., Ashland	Do.
Griesemer Graphite Co., Ashland	Do.
Hood Graves Graphite Co., Alexander City	Do.
Jefferson Graphite Co., Birmingham	Do.
May Bros. Graphite Co., Ashland	Do.
National Flake Graphite Co., Ashland	Do.
Republic Graphite Co., Ashland	Do.
Southern Graphite Co., Ashland	Do.
Superior Flake Graphite Co., Ashland	Do.
Crucible Flake Graphite Co., 50 Broad Street, New York	Do.
Carbon Mountain Graphite Co., Lineville	Graphite.
Liberty Graphite Co., Birmingham	Lineville.
Jennings Graphite Co., Lineville	Do.
Morris Graphite Co., Lineville	Do.
King Graphite Co., Lineville	Do.
Lineville Graphite Co., Lineville	Do.
Peerless Flake Graphite Co., Lineville	Do.
Eagle Graphite Co., Ashland	Quenelda.
Norway Graphite Milling Co., Clairmont Springs	Do.
Quenelda Graphite Co., Quenelda	Do.

Coosa County:	Location of plant.
Ceylon Co., Birmingham	Hollins.
Duro Graphite Co., Sylacauga	Sylacauga.
Graphite Co. of America, Good Water	Good Water.
Parkdale Graphite Products Co., Talladega	Parkdale.
Good Water Graphite Co., Good Water	Good Water.

OTHER STATES.

Woodruff & Woodruff made shipments in 1917 from mine near Pitkin, Colo.

L. M. Nance opened an adjoining mine. The Federal Graphite Co. mined amorphous graphite at Turret.

Several companies in Llano and Burnet Counties, Tex. Production reported by Dixie Graphite Co., Llano.

California Graphite Co. reported output (1917) from Saugus. Other deposits prospected.

Detroit Graphite Co. mined graphite for its own use from mine at L'Anse, Mich.

Amorphous graphite for paint was also mined by Carson Black Lead Co., near Carson, Nev. Material for foundry facings was also mined in Rhode Island.