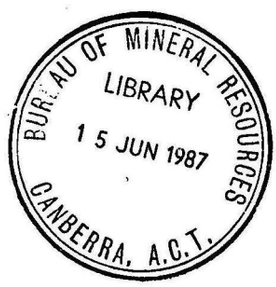
COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1950/39



STRATEGIC GRAPHITE SUPPLIES.

(by INTERIM REPORT.)

V.f. Graphite

CONFIDENTIAL.

3

BUREAU OF MINERAL RESOURCES GEOLOGY & GEOPHYSICS.

STRATEGIC GRAPHITE SUPPLIES.

(Interim Report).

STRATEGIC GRAPHITE SUPPLIES.

(Interim Report).

This report is CONFIDENTIAL, as it contains consumption data which have been supplied by certain firms on the understanding that the figures will not be disclosed to the public.

Contents.

Tables.

Figures.

STRATEGIC GRAPHITE SUPPLIES.

(Interim Report)

I. INTRODUCTION.

At the request of the Defence Supply Planning Branch of the Department of Supply an investigation of the Australian graphite industry was undertaken early in 1950. The particular aspects to be considered in this investigation were listed by the Planning Branch as follows:

(1) The specific defence significance of graphite and an estimate of peace and probable wartime demands;

(2) The experiences during World War II where applicable;

(3) The present and future supply position;

(4) Alternative methods of ensuring that demands are met in an emergency.

(5) Method recommended to meet demands in an emergency.

Owing to difficulties in obtaining consumption data and in securing the co-operation of certain State departments the progress of the investigation has been very slow. However, most of the basic information has now been collected, and at this stage an interim report can be prepared containing recommendations for early consideration by the Planning Branch.

A later full report on the investigation will include a more detailed discussion on the possibility of developing Australian resources in order to provide a higher proportion of strategic requirements. At the present time less than 10% of the local demand is met from domestic sources, and there is no prospect of improving the position in less than 12 months; it would probably take considerably longer to develop deposits and instal a treatment plant which would produce the higher grades of graphite for which the demand is greatest.

Australian Uses of Graphite.

The principal uses of graphite in Australia are as follows:

(i) Foundry facings, dusted on to foundry moulds to give a smooth finish so that castings part freely on cooling. For this purpose graphite is finely ground and either used by itself or blended with other minerals, according to the nature of the casting or moulds. Although graphite is by far the best material for this purpose, the principal suppliers of foundry facings are of the opinion that, in an extreme emergency, the consumption of graphite for facings could be curtailed by the use of charcoal, coke, other carbonaceous materials, talc, etc., but that these are much less efficient than graphite. Munitions production in wartime creates a heavy demand for foundry facings, and in this respect graphite has considerable strategic significance.

There is no standard specification for foundry graphite; Australian suppliers are at present using all types - flake, crystalline and amorphous, the grades ranging from as low as 40% carbon up to 98%. The majority of material used from 1947 to 1949 was 80-85% chip and lump grade from Ceylon.

(ii) Crucibles for use in general foundry practice, and for special castings and in the manufacture of non-ferrous alloys. These crucibles are essential to the metal manufacturing industry and consequently are vital to munitions production. Approximately 95% of the crucibles used in Australia are of local manufacture, the remainder comprising special shapes and types which are imported. Madagascar flake graphite (85-90% carbon) is regarded throughout the world as without equal for crucible manufacture (Gwinn, 1945), and Australian crucible manufacturers have to rely on supplies from that country. They have stated their willingness to use any Australian material which may prove suitable under test, but none so far produced in this country has been satisfactory.

(iii) Dry cells for a wide variety of uses - flashlights, radio sets, signal units, amplifiers, etc. Specifications for the graphite used in battery manufacture allow only small latitude in selection of material. Flake graphite is preferred but is not absolutely essential, and ash content should not exceed 20%. Undesirable impurities are copper, cobalt, nickel, arsenic, antimony, sulphates and carbonates. Most of the material used for battery manufacture in recent years was 85% Flying Dust grade imported from Ceylon.

(iv) Minor Uses. (a) Manufacture of pencils, for which only very finely ground graphite with carbon content of not less than 98% is required. Only one company is processing graphite for pencil leads, importing the raw materials from Mexico, Ceylon and U.K., but at least two other companies are importing manufactured leads.

(b) Graphite paints, for which specifications are vague except that finely ground air-floated material is required.

(c) Lubricants including dry graphite, colloidal suspensions in oil or water, and graphite greases. Grades and types used for these purposes are not standardised but they are mostly high in carbon and finely ground. Colloidal graphite lubricants are imported as such and are not manufactured in Australia at present.

(d) Electrical gear including brushes, furnace and arc welding electrodes, contacts, lightning arrestors, etc. Most of these are manufactured from specially prepared "artificial" synthetic graphite and are imported in the finished form.

(e) Stove polishes, for which relatively low grade amorphous graphite is used and no importations have been necessary in recent years.

(f) Pressure packings, jointing compounds, blasting powder, etc.

The first three uses listed above - foundry facings, crucibles, and dry cells - account for more than 85% of the Australian consumption and are all essential to Australian industry under normal conditions. Under emergency

conditions it would be imperative to maintain supplies to meet the expanded demand for munitions production and (in the case of dry cells) for communications equipment. Most of the minor uses listed are also related to important industrial requirements (e.g. the lubrication of machinery and the manufacture of electrical equipment). The strategic significance of graphite is therefore very high.

II. WORLD POSITION.

Production.

As a background for the Australian supply position the production of graphite in the principal producing countries of the world is given in Table I. The figures are mainly from Summary report No. 5 (Knight 1946, p.7), Imperial Institute Summary (1949) and Minerals Yearbook for 1947 (Gwinn, 1949). Russia is a major producer but statistics of that country are not available and no estimate of production is included in the totals.

Data which refer to total quantities and not broken down into grades are of limited value, but the figures in Table I give a fair indication of the effect of the war on graphite production. Although no precise estimates of total production during the early years of the war have been made, the world total is almost certain to have exceeded 250,000 tons per year from 1939 to 1944. At the end of the war, in 1945, there was a sharp fall in the production in the two principal countries - Germany (including Austria) and Korea. It is surmised that production during the latter part of the war, particularly in 1944, was considerably in excess of immediate requirements, in consequence of attempts by Germany and Japan to obtain as much as possible from their respective sources of supply. At the end of the war, world graphite stocks were probably rather high and as consumption fell very quickly production in 1946 was only at about one-third of the war-time rate. The meagre statistics available for 1947, 1948 and 1949 suggest that production is increasing but it is not possible to determine whether pre-war levels have been reached. The record Mexican production in 1947 was probably due to the demand on behalf of the American stockpile, purchases for which were declining in 1949.

Principal Producing Countries.

On the basis of average annual quantity of production for the ten years 1938 to 1947 (inclusive), the five most important graphite producing countries are Korea, Germany and Austria, Mexico, Ceylon and Madagascar in that order.

The partition of Korea at the 38th. parallel placed the better quality graphite deposits (in the north) under Russian control, a point which is illustrated by the figures in Table 2. These figures are based on the statistics quoted in S.C.A.P. Report No. 35 (1946), and show the amount of each grade produced in North and South Korea in 1944, expressed as a percentage of the total Korean production in that year.

The percentages in Table 2 illustrate the relative importance of Northern and Southern production in a peak production year under abnormal conditions, and when the proportion of crystalline to amorphous graphite was considerably above average (approx. 1 : 5).

TABLE I.

Graphite Production from Principal Producing Countries 1938 - 1949.

(Long tons)

Country.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947.	1948.	1949.
Ceylon (e)	11,783	22,396	24,028	26,747	27,432	20,051	12,264	7,820	8,082	9,005	14,000	n.a.
Madagascar	14,316	12,005	15,069	12,812	9,410	12,745	14,249	9,039	6,214	5,086	9,180 (e)	
Korea	49,553 (e)	77,216 (e)	12,392 (e)	n.a.	94,517	94,297	104,500	31,888	5,596 (e.s)	12,592 (e.s)	14,888 (s.b)	32,000 (b.s.c)
Germany & Austria	44,248	51,358	52,036	60,193	69,331	65,205	57,902	n.a.	3,932	24,500 (d)	38,000 (d)	12,817 (a)
Mexico	9,459	9,660	12,132	16,661	20,482	20,350	12,772	23,261	21,782	27,542	n.a.	n.a.
Italy	5,398	n.a.	n.a.	4,070	3,570	6,209	n.a.	1,764	2,552	4,085	n.a.	n.a.
U.S.A.	n.a.	n.a.	n.a.	2,453	6,357	8,874	4,829	4,364	4,978	3,917	n.a.	n.a.
Norway	3,724	4,265	n.a.	3,576	2,884	3,128	3,724	1,097	651	2,442	n.a.	n.a.
Canada	1,028 (e)	1,180 (e)	1,359 (e)	891 (e)	456 (e)	1,698	1,412	1,705	1,763	2,098	2,266	1,875
World Total (estimated)						281,000	266,000	154,000	85,000			

e - exports
(s) - South Korea only
(a) - Austria only (probably British zone)
n.a.- Not available
(b) - Amorphous graphite only
(c) - 10 months only
(d) - Estimates; excluding Russian zone of Austria.

Table 2.

Korean production by grades, 1944, expressed as percentages of total production.

	CRYSTALLINE			AMORPHOUS	TOTAL
	Crucible	Electrode	Other		
North Korea	6	12	1.5	36	55.5
South Korea	1	4	1.5	38	44.5
All Korea	7	16	3	74	100

The South Korean graphite industry collapsed in 1945 and the mines and mills were abandoned. Only one mine was operated in 1946, recorded production being at the rate of about 600 tons per year (S.C.A.P. 1946, b.). The rehabilitation of the industry has been fairly rapid and exports from January to October, 1949 indicate a return to pre-war rate of production and suggest that plant and equipment had been rehabilitated or replaced to a large extent. No information is available on the position of the industry in North Korea, or on the effect the recent war on South Korean production.

The German graphite deposits are in the Munich and Passau region (Bavaria), in the United States zone, and consist of fair grade flake graphite which can be used for pencils, lubricants, foundry requirements, and, when blended for crucibles. Estimated production in 1947 was 20,000 tons, which was sufficient for current requirements of western Germany and allowed some exports.

Good quality amorphous graphite occurs in a 30-mile belt between Loeben and Rottenmann in the British zone of Austria, and lower quality deposits occur along the north bank of the Danube, west of Vienna (Russian zone). Pre-war output from 7 treatment plants was about 18,000 tons per year and production from 3 plants (presumably in the British zone) reached about 10,500 tons in 1948. Rehabilitation of the industry in Germany and Austria has been hampered to some extent by the loss of foreign markets during the war, but the position is improving and it is probable that combined production from the western zones is now at the pre-war rate for all zones.

Deposits in Sonora State, Mexico, are of vital importance to the U.S.A., which has only meagre domestic resources, and the industry in Mexico is entirely dominated by American interests. From 1944 to 1947 the American total imports of Mexican graphite exceeded recorded Mexican production by about 6,000 tons; it is unlikely that any Mexican material reaches other markets. The graphite is all amorphous quality with a high carbon content.

The Ceylon graphite industry had a slightly lower average output (1938-1947) than the Mexican but has a much wider influence on the world supply position because it is not so closely linked with one consumer country. The world monopoly for most grades of graphite was held by Ceylon until exports from Madagascar were begun in 1908. Deposits occur over a large area of the island but mining is concentrated in three regions - in the north, south-west, and south - the principal mines being in the north. Most of the mines, numbering several thousands, are worked manually but a few of the larger mines are partly

mechanised. Flake and crystalline graphite predominates and only minor quantities of amorphous grades are mined; crucible flake is obtained in the south-western region. Domestic consumption has been very low and most of the graphite has been exported after simple grading treatment, consisting mainly of hand picking and screening. Grinding and flotation treatment is now being carried out on the island, and much money is being spent on mining mechanisation and other means of increasing production and reducing costs. The local consumption has increased by the manufacture of pencils and graphitic paints on the island. Reserves of graphite in Ceylon are not known but are believed to be large (Majumdar, 1949 p.82).

Madagascar is the principal world source of high grade crucible flake graphite, and is therefore of greater economic importance than some other countries which have larger outputs. The deposits are in the centre and east of the island and consist for the most part of irregular masses, up to 90 feet wide, containing an average of 7 to 8 per cent of graphite. Richer concentrations occur within some of the masses, but all deposits are deeply weathered and average flake size is coarse. Reserves have been estimated at from 20 to 100 million tons of marketable graphite to a depth of 325 feet.

Post-war developments in the industry have been affected by political and industrial disturbances, and a widespread rebellion in 1947 closed operations at most of the mines. Production in that year was the lowest since 1933, but price increases and direct assistance have enabled the companies to replace damaged equipment and it is believed that production is now returning to the normal level of from 9,000 to 11,000 tons per year.

III. AUSTRALIAN POSITION, PAST & PRESENT.

Production.

Australia has never produced sufficient graphite for domestic requirements, and at the present time no deposits are known to contain either the quantity or various qualities of graphite to ensure self-sufficiency. Production was first recorded in 1866, when 10 tons were obtained in South Australia, but it was not until 1894 that further production was recorded, from New South Wales.

Details of production of approximate grades by States from 1866 to 1949 are given in Table 3.

Table 3.

Australian Graphite Production by Grades and States 1866-1949.(Long tons

STATE.	FLAKE.		AMORPHOUS		UNSPECIFIED
	Average 66% C.	Average 75% C.	Below 50% C.	50-75% C.	
Queensland	-	-	-	1,851	-
New South Wales	-	-	2,712	-	-
Tasmania	-	-	22	-	-
South Australia	549	90	-	-	10
Western "	-	-	-	-	83
Nth. Territory	-	-	-	-	3
TOTAL:	549	90	2,734	1,851	96
Percentage of Grand Total	10	2	51	35	2

These figures indicate that more than half of the graphite produced in Australia has been very low grade, and that only about 12% has been of medium grade flake. Three deposits which have yielded 95% of the past production are still being worked in a rather perfunctory manner, and the outlook for any immediate improvement of output from them is not promising. They are situated at Jack's Creek, south-south-east of Collinsville, Queensland; Undercliffe Mountain, N.S.W., 16 miles east of Stanthorpe (Q.); and Uley, 14 miles south-west of Port Lincoln, S.A. Some details of these and other Australian deposits are given by Knight (1946).

(a) Collinsville, Queensland. Amorphous graphite containing up to 77% carbon has been mined at Collinsville since 1935. Production averaged about 15 tons per year for the first four years but none was produced in 1939. The wartime demand was assisted by a steep rise in production from 62 tons in 1940 to 315 tons in 1941, 221 tons in 1942 and 354 tons in 1943. To achieve this output assistance was given to the lessee by the Manpower authorities and £100 was voted from State funds for road repairs, but no direct financial assistance was offered by State or Commonwealth governments. It was intended that production should reach 100 tons per month, and that the Controller of Minerals Production should buy and stockpile any unsold graphite produced at that rate for one year, but the guarantee was later withdrawn and by September 1943 all paid labour was transferred to other projects. Attempts made by dry cell manufacturers and others to blend Collinsville graphite with imported material or to use it as a substitute were not entirely successful, and the comparatively large production did little more than meet the limited demand for lower grade graphite. The foundry trade and stove polish manufacturers are the principal users of Collinsville graphite.

Post-war production has steadily declined from 230 tons in 1946 to 184 tons in 1947, 145 tons in 1948 and 25 tons in 1949. The lessee has recently applied for suspension of the labour conditions of his lease on the grounds that the market is dwindling. The mine was flooded in July 1950 and some doubt exists as to whether it will be unwatered and operations resumed for some time to come.

(b) Undercliffe, N.S.W. The graphite obtained at Undercliffe Mountain is very low grade and has been used only in foundry facings and polishes, although tests for other uses have been made. Intermittent mining operations have been carried on since 1894, the highest recorded production being 500 tons in 1900. No production was recorded between 1936 and 1939; the average for the next three years was 57 tons per year. In 1944 output reached 140 tons, but has since steadily declined and was only 25 tons in 1949. The comparatively slight effect of the war on the production at Undercliffe is an indication of the minor economic importance of the material. Reserves have not been estimated but they are probably sufficient to supply the limited market for very low grade graphite for many years. Geological exploration along the granite contact in the region may disclose other seams which could contain higher grade graphite.

(c) Uley, South Australia. The only deposits of flake graphite being worked in Australia at present are at Uley, about 14 miles by road south-west of Port Lincoln, (Armstrong, 1945). Before 1941 these deposits had yielded less than 100 tons, but they came into prominence during the war when the Commonwealth Government granted financial assistance to the operating company, and it was hoped that production of medium

to high grade flake would relieve the domestic shortage. These hopes were not fully realised, and the 1944 production of 249 tons of concentrates was less than 25% of the target. Some details of the wartime operations at Uley are of interest as they reveal weaknesses which should be avoided in the future.

The mineral claims were pegged in 1940 and transferred to South Australian Graphites Ltd. in January 1941. At first the ore was shipped to Port Adelaide, where it was beneficiated by air-separation and, later, by flotation, but this proved to be unsatisfactory and recorded production was only 49 tons of concentrates in 1941 and 70 tons in 1942.

In December 1942, the company was in financial difficulties and was granted a loan of £1,000 by the Commonwealth Government to assist in the procurement of plant. Subsequent loans were granted in July, 1943, March 1944, June 1944 and July 1944, raising the total liability of the company to the Government to £22,600. A treatment plant was erected in Port Lincoln and it was planned to stabilise output at 50 tons of 60-80% concentrates and 35 tons of 80-90% concentrates per month. Actual output was at the rate of 15 tons per week for a short period.

By the end of 1944 it was apparent that the company could not carry on without further financial assistance, and as the world supply position was considerably easier by that time the Government declined to advance funds and exercised the option under terms of the previous loans to appoint a receiver. The mine was closed in February 1945 and the receiver completed the realisation of assets in October 1946. The total expenditure by the Government amounted to £24,463; the loss after realisation of all assets was £20,975. It must be recognised that the whole venture was not only a financial failure but that it failed in its purpose - to relieve a shortage of high grade graphite in Australia. Perusal of the voluminous records make it clear that failure was mainly due to:-

1. Mismanagement and technical ineptitude on the part of the company in the early stages. This was partly overcome by the Government in the later stages.

2. Poor treatment equipment, which failed to produce the higher grades required.

3. Insufficient capital. The company had no funds and Treasury assistance was slow and inadequate.

4. The scheme came too late. The bulk of the production reached the market after the emergency had passed, and could not be sold profitably in competition with overseas material.

Uley Graphites Co. Ltd. (successor to S.A. Graphite Co.) has carried out some mining in recent years, producing a 68% concentrate which has found a limited market within Australia. Production in 1949 was 69 tons. It is understood that the company does not possess adequate treatment plant and it is unlikely that better quality material will be produced with present equipment.

Other Australian sources. Graphite deposits are also recorded at Koppio, S.A. (Armstrong & Broadhurst, 1946) Munglinup, Young River, Kendenup and Donnelly River, W.A. (Ellis 1944 and 1945), and in the Northern Territory and Tasmania.

The Koppio graphite (28 miles north of Port Lincoln) is fairly high grade and concentrates containing up to 90% carbon have been produced on a small scale, but cost of production was too high to be competitive. Total production has been less than 100 tons from proved ore reserves of 3,900 tons assaying 12.2% carbon; probable reserves are an additional 14,000 tons.

Of the Western Australian deposits the most important are those at Munglinup, 70 miles west of Esperance, where probable reserves of 27,000 tons of ore are available down to an inclined depth of 100 feet. A composite sample assaying 12.2% carbon was tested in the Kalgoorlie Metallurgical Laboratory with the following result:

+80 mesh	...	4.2% of sample;	94.4% carbon
-80 mesh	...	14.4% " " ;	96.0% "

This was a high grade material and further investigation might be warranted. The isolation of the locality has made exploitation costly and difficult, and no commercial production has been recorded specifically from this area, although a little may have been included in the Western Australian total.

Imports.

The statistics relating to imports of graphite are incomplete inasmuch as they do not specify grades, but the figures given in Table 6 give a general indication of the quantities imported during the period July 1939 to June 1949 from the principal countries of origin.

Table 4.

Imports of Graphite - July 1939 to June 1949.

(Long tons).

Country of Origin.	1939/ 40.	1940/ 41.	1941/ 42.	1942/ 43.	1943/ 44.	1944/ 45.	1945/ 46.	1946/ 47	1947/ 48	1948/ 49
Ceylon	605	629	875	839	552	436	663	601	756	922
M'gar.	-	-	-	-	302	25	49	94	144	-
U.S.A.	4	138	-	-	36	12	307	14	10	-
Others	92	102	3	96	5	31	40	20	21	60
Total:	701	869	878	935	895	504	1,059	729	931	982

Consumption.

Table 5 shows the consumption of graphite by end uses and grades for the years 1939, 1942, 1944, 1947, 1948 and 1949. Information for the first three years has been taken from Table XIII of Summary Report No. 5 (Knight, 1946), and for the three years 1947-1949 from a recent canvass of consumers. The grade designations shown in the Table are those used by the consumers and it is quite likely that different consumers apply different terms to the same material. An example is the amorphous graphite from Collinsville (Queensland), which is variously described as 50-60%, 70%, 75% and 77% carbon, although only one grade is obtained from this source.

TABLE 5.

AUSTRALIAN CONSUMPTION OF GRAPHITE BY GRADES AND USES.

(Long Tons)

USE.	GRADE.	SOURCE.	1939.	1942	1944.	1947.	1948.	1949.
Foundry Facings	95-98% lump	Ceylon				5	8	1
	80-85% chip, lump & dust	Ceylon				175	219	182
	70-75% " " "	Ceylon				5	139	105
	60% fines	Ceylon				180	73	-
	60-70% Flake	South Australia				31	11	41
	40-70% Amorphous	Queensland				50	30	30
	40% Amorphous	N.S.W.				15	15	14
	TOTAL (All grades)		430	610	550	461	495	373
Crucibles	85-87% crucible flake	Madagascar				139	131	142
	TOTAL		Nil	17	164	139	131	142
Dry Cells.	80-85% flying dust	Ceylon				213	354	269
	90-92% crystalline	Ceylon				Nil	12	12
	95% flake	Ceylon				16	18	20
	77% amorphous	Queensland			100	-	-	-
	?	South Australia			6	-	-	-
	TOTAL (All grades)		310	240	360	229	384	301
Pencils (excluding imported lead)	+98% C (amorphous	Mexico				6	5	4
	+98% C (crystalline	United Kingdom				3	3	3
	+98% C (flake	Ceylon				2	7	10
	TOTAL (All grades)		Nil	Nil	Nil	11	15	17
Paints	50-60% powder	Ceylon				(a)	(a)	(a)
	70% amorphous	Queensland				1	1	(a)
	Grades unspecified					1	6	8
	TOTAL (All grades)		(b)	(b)	(b)	3	7	9
Lubricants (excluding preparations-colloids &c.)	Fine flake	United Kingdom				1	2	3
	95-98% flake	Madagascar				2	2	2
	97-99% flake & lump	Ceylon				33	39	32
	Grades unspecified					11	14	16
	TOTAL (All grades)		50(c)	50(c)	50(c)	47	57	53
Electrical gear (excluding manufactured articles)	98% flake	? Ceylon				3	4	4
	80-90% flake					1	1	2
	75% amorphous	? Queensland				1	1	1
	50-60% amorphous	? Queensland				(a)	1	1
	Acheson synthetic amorph.	U.S.A.				(a)	-	(a)
	TOTAL (All grades)		(b)	(b)	(b)	6	7	8
Polishes	70% amorphous	Queensland	40	90	88	53	29	39
	Flake	? (Disposals)				3	2	3
	TOTAL (All grades)		110	90	88	56	31	42
Miscellaneous uses (Packings, munitions, explosives &c.)	Grades unspecified					10	14	15
	TOTAL		30	100	40	10	14	15
TOTAL - All grades and uses.			930	1107	1252	962	1141	960

(a) - less than 1 ton. (b) - total probably included under "Miscellaneous". (c) - estimated.

Consumption by grades during the years 1947-1949 is given in Table 6. Whilst this information may be more generalised than that in Table I, it should give a more concise picture of Australian requirements. The Collinsville (Q.) graphite is listed as less than 70% carbon, although some samples may have a higher carbon content.

Table 6.

Consumption of Graphite by grades-1947-1949

(in tons.)

Carbon Content.	1947.		1948.		1949.	
	Flake	Other.	Flake	Other.	Flake	Other.
Less than 70%	31	302	11	150	41	86
70 - 79%	-	5	-	139	-	105
80-89%	140	388	132	573	144	451
90-94%	-	-	-	12	-	12
95% and over	57	14	72	16	71	8
TOTAL	228	709	215	890	256	662
Grade not specified & synthetic	25		36		42	
GRAND TOTAL: (All grades)	962		1,141		960	

The figures in Table 6 give some indication of Australian approximate requirements by grades. Market conditions during the years 1948 and 1949 were much nearer normal than in the war years and consumers generally had a wider range of grades from which to choose. Selection of material is governed by three main factors - suitability for the particular use, availability, and cost - and in the absence of market restrictions these factors tend to be integrated so that each consumer buys the material best suited to his technical requirements and the economics of production.

In determining the average annual consumption by grades, the 1947 figures had been omitted as the market was affected by release of wartime stocks. From the average consumption for 1948-1949 an estimate has been made of the relative amounts of each grade used, expressed as a percentage of the total:

Less than 70% C	13.7
70 - 79%	11.6
80 - 89%	61.9
90 - 94%	1.1
95% and over	7.9
Unspecified grades	3.8
	100

Although these figures are an approximation, they emphasise the predominant demand for grades containing from 80 to 89% carbon.

FIG. 1.

Consumption of Graphite

1939 - 1949

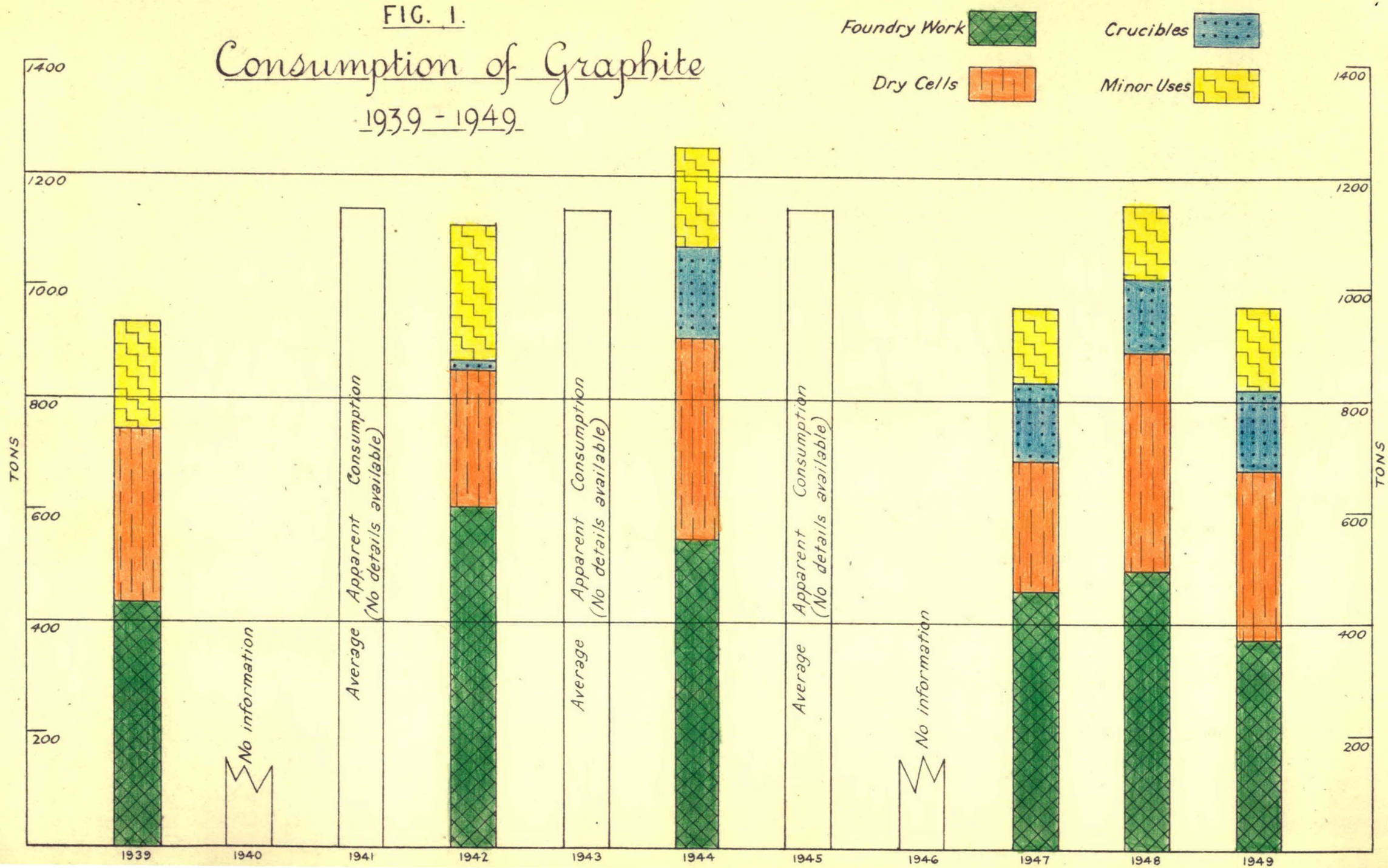


FIG. 1.

The consumption of graphite by principal uses is graphically shown in figure 1, which illustrates the relatively minor changes which have occurred during the period from 1939 to 1949. No figures of actual consumption are available for 1940, 1941, 1943, 1945 and 1946, but the "average apparent consumption" for 1941, 1943 and 1945 has been shown as it is believed to approximate to the actual consumption in those years (Knight 1946, p.21).

Three major events have influenced consumption during the eleven year period, viz.:

(a) World war II, which lifted consumption of graphite for foundry facings and some miscellaneous uses by several hundred tons per year. The industrial expansion which succeeded the war has tended to maintain the consumption of graphite at approximately the wartime level; this expanded demand for graphite is likely to continue for some considerable time or to become permanent.

(b) The introduction of crucible manufacture in Australia in 1941 which raised the consumption of graphite by about 150 tons per year, This also represents a permanent addition in the overall demand.

(c) The coal strike in 1949, during which many industries using graphite had to cease production for periods up to two months. The reduced graphite consumption was marked but should not be permanent.

Under normal trading conditions there seems to be little possibility that consumption will fall to pre-war levels and, as there is no immediate prospect of a substantial increase, it is reasonable to assume a stabilised consumption of approximately 1,100 tons per year for the next few years.

The data indicates that World War II had a comparatively small effect - approximately 200 tons - on the annual consumption of graphite, and it has been shown that there is a tendency for this higher level of consumption to be maintained during the post-war period. A war or similar emergency within the next (say) five years would not be likely to disturb the present demand, to an extent any greater than the last. The demands by individual industries would change, but the overall effect would be slight. It is not possible to forecast the trend of the demand more than about five years hence, as unpredictable developments and changes in technological practice may by then have an influence on the consumption of graphite.

IV. THE AUSTRALIAN POSITION - EMERGENCY.

Sufficient information of Australian resources is available to justify the belief that probably 85% of the requirements for the next fifteen or twenty years could be obtained from domestic sources, the remaining 15% consisting of crucible and special grades of which no domestic sources of supply are at known at present. But it remains to be proved whether or not the known resources can be economically developed in competition with more accessible and higher grade deposits worked by native labour in other countries. This problem will be discussed in greater detail in the full report.

At this stage it may be stated, categorically, that no higher grade graphite could be produced from Australian sources in less than 12 months, and it would probably take much longer than that to develop the deposits and instal the necessary treatment plants. From the strategic point of view it would be safer to assume a period of two years before effective production could be achieved, and if overseas supplies should be interrupted during those two years Australia would be entirely dependent on stocks held at the time the emergency develops. There is, therefore, a very strong case for two simultaneous courses of action to ensure future security of supply under all circumstances, viz;

(a) Maximum development of Australian resources.

(b) Establishment of reserve stocks sufficient to provide for two years.

Although these should be initiated simultaneously, the former is a much longer term project and reserve stocks should be available as a security against an emergency while the Australian resources are being developed. For this reason, it is suggested that immediate steps be taken to establish reserve stocks.

To determine the quantity of material which would have to be stockpiled so that sufficient graphite for supply would be available in Australia, the stocks held by the major consumers must be estimated. It has been considered inadvisable to ask them to declare stocks, but sufficient information has been obtained to make a reasonable estimate of the stock position. In the following paragraphs dealing with each of the main consumer industries, it is assumed that consumption under emergency conditions would be at the average rate for the years 1947 to 1949, plus 10% for contingencies; the latter is a purely arbitrary figure based on the approximate difference between wartime and post-war consumption.

(i) Crucible manufacture. Stocks approximating 12-15 months consumption of crucible flake graphite are held by the two crucible manufacturers, and it is estimated that about 3 to 4 months supply of crucibles is held by distributors and others. As far as the raw material is concerned the position may be summarised as follows:-

Average consumption 1947-1949	137 tons/year
Emergency consumption (inc. 10% contingencies)	150 tons/year
Present stocks (estimated)	150 tons
Amount required for stockpile	150 tons

The current c.i.f. and e price of 85% crucible flake graphite from Madagascar (landed N.S.W. ports) is £A80 per ton, and the total cost of the 150 tons would therefore be £A12,000 at present rates of exchange. Prices in Madagascar are quoted in U.S.A. dollars.

(ii) Dry Cell manufacture. Stocks are held for about 3 months operations at present rate of consumption and only about one month's supply of batteries is held by distributors. Dry cells have a limited shelf life and manufacturers encourage a quick turnover. The raw material position is:

Average consumption (all grades) 1947-49	305 tons/year
Emergency consumption (inc. contingencies)	340 tons/year
Present stocks (estimated)	75 tons
Amount required for stockpile	600 tons.

As nearly 95% of the material used in 1947-1949 was 80-85% flying dust grade from Ceylon, it may be assumed that this grade could be used for all dry cell manufacture in an emergency. The estimated landed cost of 80% flying dust is £A42-10/- per ton, and the total cost for 600 tons would be £25,500; total cost for 85% dust would be about £27,300.

(iii) Foundry facings. It is unlikely that stocks exceed 3 month's requirements, but the supply position is not clear owing to the wider range and interchangability of grades used for facings. The 1949 coal strike affected the consumption of graphite in that year, and the average for 1947 and 1948 is a more reliable basis for estimating future requirements.

Below 70%C; Australian origin	76 tons/year
60% fines (Ceylon)	126 tons/year
70-75% chips, &c. Ceylon	72 tons/year
80-85% chips, &c. "	197 tons/year
95-98% lump. "	7 tons/year
Average all grades	478 tons/year

Experience during World War II suggests that there is little real need for a wide range of grades and it is probable that the above figures could be simplified to provide for only three grades, as follows:

Below 70% (Australia)	78 tons/year
60% fines (Ceylon)	160 tons/year
85% dust (Ceylon)	240 tons/year

If this assumption is reasonable, the estimated emergency consumption (including allowance for contingencies) would be:

Below 70% (Australian)	86 tons/year
60% fines (Ceylon)	180 tons/year
85% dust (Ceylon)	260 tons/year

Current reserves are estimated at about 100 tons of the higher grade and the amounts to be stockpiled to ensure a two-year reserve supply (of imported material only) would be - 60% fine, 360 tons; 85% dust, 420 tons. The present landed costs of these two grades are £A31-10/- and £A45-10/- respectively, and at these prices the net cost would be £30,450.

(iv) Minor Uses. The order of importance of the minor uses listed in Table I is: lubricants, polishes, electrical equipment, pencils and paints. As far as can be ascertained the paint and polish manufacturers depend almost entirely on locally produced graphite and they do not need to be considered for overseas supplies. Average consumption by grades for lubricants (1947-1949) was as follows:

98-98% flake (Madagascar)	2 tons/year
97-99% flake & lump (Ceylon)	35 tons/year
Unspecified grades	16 tons/year
Average all grades	53 tons/year.

The stock position is not known but it is unlikely that more than 3 months supply is held. Allowing 10% for contingencies the emergency requirements would be 60 tons per year and the amount to be stockpiled if 3 months stocks are available is approximately 100 tons. There is no apparent reason why there should be more than one grade (97-99% Ceylon lump). Price of this grade is not known, because there have

been no recent purchases, but it is estimated at £A85 per ton (landed) and the total cost of 100 tons would therefore amount to about £A8,500.

Consumption of imported graphite for electrical purposes is confined to an average of 5 tons per year of high carbon flake. Stocks are not known, but are probably not less than 3 months. Estimated emergency requirements may be 6 tons per year and amount required for stockpiling would therefore be about 10 tons. Assuming that 95% flake would satisfy requirements the estimated cost of 10 tons would be about £900.

Consumption of graphite for pencil manufacture averaged 14 tons per year (1947-1949) of 98% flake, crystalline and amorphous. Specifications are exacting and the firm concerned has had difficulty in obtaining the special grades required. As the requirements are specialised and only one firm is engaged in the business it might be advisable for the Defence Supply Planning Branch to arrange for the company to procure its own stockpile for emergency uses.

The demand for graphite for miscellaneous uses (Table I) is small and it may be assumed that emergency requirements could be met from the amount stockpiled for other purposes. It is believed that most of the material for miscellaneous uses is fairly low grade and could be obtained within Australia.

The details in the foregoing paragraphs are summarised in Table 7.

Table 7.

Emergency Requirements of Graphite (Imported)

Use.	Grade.	Estimated requirements per year.	Amount to be stockpiled (a)	Estimated cost at present price
		tons	tons	£A
Crucibles	85% crucible flake	150	150	12,000
Dry Cells	80% flying dust	340	600	25,500
Foundry facings.	60% fines	180	360	11,340
	85% flying dust	260	420	19,110
Lubricants	97-99% lump	60	100	8,500
Electrical equipment	95% flake	6	10	900
TOTAL	All Grades	996	1,640	77,350

(a) This represents the amount to be purchased and which, with present estimated stocks, will provide a two-year reserve.

It would be possible to speculate at length on the advisability of stockpiling graphite at present available from Australian sources. It is sufficient to record, however, that the point has not been overlooked, but it is not of such immediate urgency as the procurement of overseas supplies and it will be dealt with in the full report.

V. SUMMARY AND CONCLUSION.

This is an interim report on an investigation of the graphite industry, with particular reference to the continuance of supplies in an emergency. It is shown that the post-war consumption of graphite has not dropped to pre-war levels and that an emergency within the next (say) five years would not increase the present rate of consumption to any considerable extent. The requirements of each consuming industry are discussed on the basis of the average yearly consumption from 1947 to 1949, and an estimate of their emergency requirements is made by allowing 10% for contingencies.

It is suggested that 1,640 tons of graphite in six different grades be imported and stockpiled to provide, with present stocks, a two year strategic reserve. The total cost is estimated at £A77,350.

The question of developing Australian resources and stockpiling from present sources of supply is to be discussed in the full report. It is considered that no commercial quantities of higher grades of graphite could be obtained from Australian deposits in less than 2 years.

VI. BIBLIOGRAPHY.

Armstrong, A. T. 1945 - Uley Graphite Mine. S.Aust. Min Rev. No. 81 92-111

Broadhurst, E. & Armstrong, A.T. 1946 - Koppio Graphite Mine. S.Aust. Min Rev. No. 82 93-109.

De Mille, J. B., 1946 - Strategic Minerals. McGraw Hill Book Co. Inc. New York & London.

Ellis, H. A., 1944(a) - The Munglinup Graphite Deposits. Ann Rep Dept. Mines W. Aust. for 1943, p.65

_____ 1944(b) - The Young River Graphite Deposits Ibid p.63

_____ 1944(c) - The Kendenup Graphite Deposits Ibid p.63

Ellis, H.A., 1945(a) - Report on the Munglinup Graphite Deposits Ann Rept Dept Mines W.Aust. for 1944, p.70

_____ 1945(b) - Report on the Donelly River Graphite Deposits of W.A. Ibid p.70

Gupta, B. C., 1949 - Graphite. Indian Minerals 3 (1), 17-31

Gwinn, G. R., 1945 - Graphite for the manufacture of Crucibles. Mining Technology 9(4) TP 1909

Knight, C. L., 1946 - Graphite. Min Res Surv Summary Report No. 5.

Majumdar, K. K., 1949 - Graphite Industry in Ceylon. Indian Minerals 3(2) 80-83.

Mantell, C. L., 1946 - Industrial Carbon. D. Van Nostrand Co. Inc. New York.

Morton, C. C., 1934 - Graphite at Collinsville. Qld. Govt. Min Jour 35, 404

Pallister, H. D., & Smith, R. W., 1945 - Alabama Flake Graphite in World War II. Mining Technology 9(4) TP 1908.

Raggatt, H. G., 1924 - Asbestos, Emery, Graphite etc. etc.. Dept. Mines N.S.W. Geol Surv Bull 14, 19-22

S.C.A.P., 1946 - The Mineral Industry of Korea in 1944. S.C.A.P. Rept. 35.

S.C.A.P., 1947(a) - Graphite Resources of Japan. S.C.A.P. Rept. 81.

_____ 1947(b) - Mineral Resources of Southern Korea S.C.A.P. Rept. 84.

Imp. Institute 1949 - The Mineral Industry of the British Commonwealth and Foreign Countries. Imp. Inst. Stat. Summary 1941-1949.

Gwinn, G.R., 1949 - Minor Non metals. U.S. Bur. Mines Min. Yrbk. 1947, 1265-1268.