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OM88-9-C-230

REPORT ON THE 1988
SUMMER EXPLORATION PROGRAM AND
PHASE I EXPLORATION PROGRAM SUMMARY
LAURIER TOWNSHIP GRAPHITE PROSPECT
TROUT CREEK, ONTARIO
NTS 31E/4

PREPARED FOR

ASTWOOD PARK RESOURCES INC.

DERRY, MICHENER, BOOTH & WAHL

T. B. Dickson, B.Sc.

I. D. Trinder, B.Sc.

Toronto, Ontario
January 20, 1989

Ref.: 89-05

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SUMMARY

Astwood Park Resources Inc. holds a contiguous group of two patented and six unpatented mining claims in Laurier Township. The claims are located 5 km east of the town of Trout Creek, Ontario, which is situated on Highway 11, approximately 40 km south of North Bay, Ontario. The property is easily accessed by a two-lane gravel road running east from the town of trout Creek and by two cottage access roads running the length of the property.

The present program was initiated subsequent to the completion of the spring 1988 exploration program (DMBW, ref. 88-71 and 88-72) which delineated a disseminated flake and vein-type graphite deposit with a known strike length of over 1 km and widths varying between 50 m and 150 m.

The results from the initial program were very encouraging and outlined the potential for a significant large tonnage-low grade flake graphite deposit.

DMBW recommended that additional information concerning the metallurgical properties of the graphite mineralization, continuity of both the graphitic schist and massive graphite vein and topographic control be ascertained prior to the implementation of a diamond drill program. To achieve this object the current program involved the following: a geophysical self-potential (SP) survey, a topographic survey, additional trenching and channel sampling, and a bulk sampling and metallurgical bench-scale testing program.

The average combined grade of all eight trenches sampled during the current program was 2.67% graphitic carbon (Cg). When combined with the results from the previous program, a total of 290 trench and grab samples taken from the graphitic schist/paragneiss average 2.73% Cg. In addition, the massive graphite vein has now been exposed for over 50 m in two zones and as an isolated occurrence in a third. Assay values from samples taken across the vein ranged from 9.15% Cg to 39.13% Cg. Based on additional geological data obtained during the current program it appears that this vein, and the shear/fracture system which it emplaces, is continuous across the length of the property. It can,

therefore, be accepted that even the relatively small tonnage of the vein material will appreciably increase the overall grade of the deposit.

Results from each of the individual trenches shows that higher grade, potentially economically feasible zones exist within the deposit. Using a cut-off grade of 2.50% Cg, surface sampling has delineated three zones which, due to higher grade values obtained in trenches and surface exposures of the massive graphite vein, represent favourable areas for further investigation by diamond drilling.

Bench-scale metallurgical testing undertaken on three bulk samples from the property indicate that all three samples can be concentrated to a minimum of 85% Cg, which is of commercial quality. The bulk sample taken from the graphite vein was concentrated to 93.1% Cg, while two samples taken from the graphitic schist/paragneiss were concentrated to 89.1% Cg and 91.9% Cg through grinding and flotation processes. All three samples contained a very fine flake size suitable for applications in graphite powder markets.

The results to date from all programs conducted on the property continue to be excellent. DMBW, therefore, recommends that a 800 m definition diamond drilling program be implemented on the higher grade zones delineated by surface sampling. This will enable tonnage and grade estimates within these zones and, when combined with the results from previous work, provide the basis for an initial economic evaluation of the deposit and viability of commencing a small-scale mining operation. DMBW also recommends that additional bench-scale studies be conducted to increase the present concentrate grades of samples submitted to 95% Cg or better. The program and estimated costs are summarized below:

Pre-field Planning	$ 1,650
Mob/Demob	1,850
Diamond Drilling (all inclusive)	74,446
Data Compilation and Reports	6,850
Additional Bench-Scale Testing	3,000
Total	$87,796
Contingency (10%)	8,780
GRANT TOTAL	$96,576

DMBW recommends that the program outlined above be implemented as soon as possible. Current short-falls in the world-wide supply and increased prices for all types of graphite have created an excellent climate for potential producers capable of supplying a consistent quality and quantity of graphite. Following the completion of the proposed program, assuming positive results, a pilot-scale test run requiring 50 tons of graphite material is recommended to determine a commercial flowsheet. Also, DMBW recommends a market survey be implemented as soon as possible to determine market volume, value and trend. This study should concentrate on the graphite powder markets and be of sufficient scope to determine if the pilot plant test program is warranted.

INTRODUCTION

This report, prepared by Derry, Michener, Booth & Wahl (DMBW) on behalf of Astwood Park Resources Inc. (Astwood), summarizes the results of the 1988 summer exploration program carried out on the Laurier Township graphite prospect, located near Trout Creek, Ontario. The program was carried out in two stages; a self-potential geophysical survey was conducted from July 8 to July 14, 1988 and a follow-up program consisting of trenching and channel sampling, topographic surveying and bulk sampling was carried out from August 22 to September 5, 1988.

Mr. T. B. Dickson, B.Sc., DMBW contract geologist, supervised the field operations under the supervision of Mr. I. D. Trinder, B.Sc., DMBW staff geologist.

This report, in conjunction with DMBW report ref. 88-71 and 88-72, provides a complete summary of the Phase I exploration program carried out on the Laurier Township graphite prospect to date.

PROPERTY LOCATION, DESCRIPTION AND ACCESS

The Laurier Township property is located 5 km east of the town of Trout Creek, Ontario, located on Highway 11 and on the Canadian National Railway (Figure 1). The town of Trout Creek is located approximately 40 km south of North Bay, Ontario.

The property is easily accessed via two-wheel-drive vehicles by driving east from Trout Creek on an all-weather, two-lane gravel road for a distance of about 600 m, then southeastward along a two-lane forest access road for a distance of about 5 km. At this point two cottage access roads provide excellent access over the entire property. As shown in Figure 1, the roads crosscut the property.

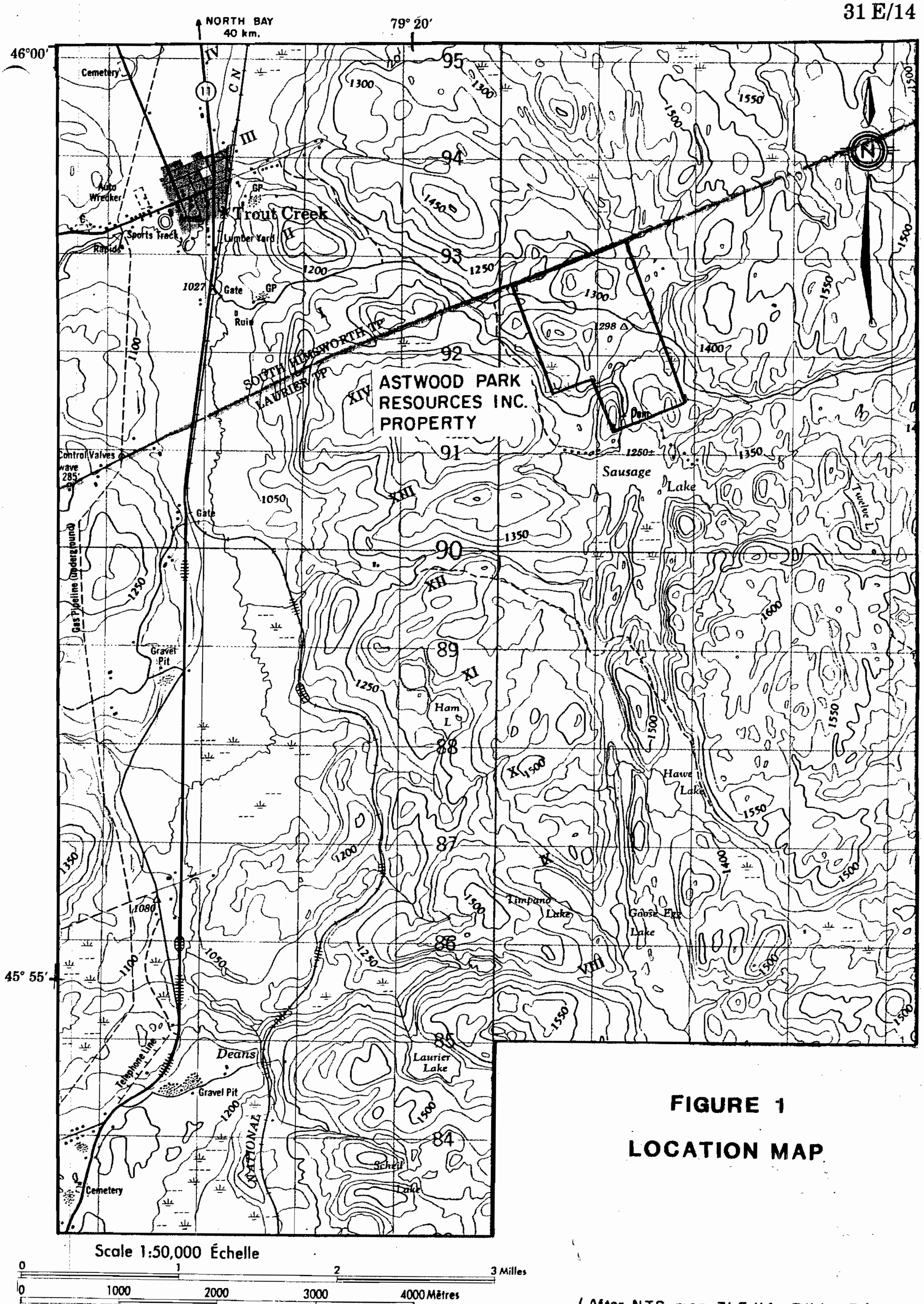

FIGURE 1

LOCATION MAP

(After N.T.S. map 31 E/14, Edition 3)

The property is situated immediately north of Sausage Lake, a man-made body of water controlled by a small timber dam on the Astwood property. There are no powerlines on the property.

The property consists of two patented mining leases and six unpatented mining claims for a total of eight contiguous claims (Figure 2). These are located in the District of Parry Sound, Southern Ontario Mining Division and are listed below:

PS5043 and PS5164
SO1000261 - 1000266 inclusive

Claim Numbers	Date Recorded	Total Days Credit Approved and Applied For	Anniversary Date
PS5043, PS5164	January 31, 1985	patented	January 31, 2006
SO1000261 - 1000266	August 4, 1987	40	August 4, 1989

Note: The anniversary dates given are based on the Report of Work form filed with the Ministry of Northern Development and Mines.

DMBW has not examined title to the claims nor substantiated their physical boundaries and, accordingly, expresses no opinion as to validity of title and property description.

PRESENT PROGRAM

The present program was initiated subsequent to the completion of the spring 1988 exploration program (DMBW ref. 88-71 and 88-72) which involved geophysical surveying, detailed geological mapping and an extensive trenching and channel sampling program. The results from the initial program were very encouraging and outlined the potential for a significant large tonnage-low grade disseminated flake and vein-type graphite deposit.

DMBW recommended that additional information concerning the metallurgical properties of the graphite mineralization, continuity of the

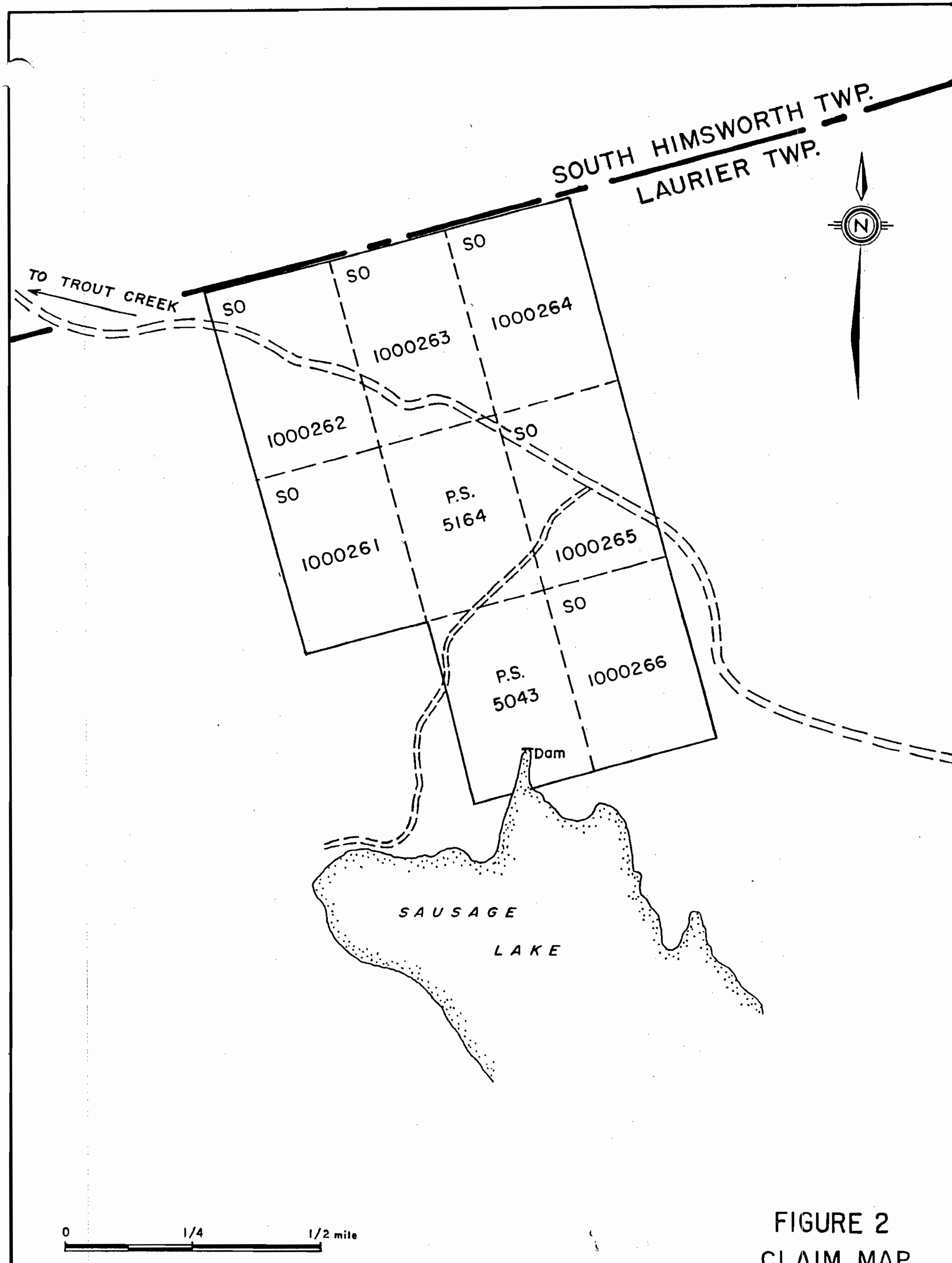

FIGURE 2
CLAIM MAP

graphitic horizon and topographic control be ascertained prior to the implementation of a diamond drill program. To achieve this objective the following programs were conducted; a geophysical self-potential (SP) survey, a topographic survey, additional trenching and channel sampling and a bulk sampling and metallurgical testing program. The following is a discussion of each of the programs with particular attention paid to the purpose, method and results of each.

Geophysics

Introduction

In April, 1988, magnetic and VLF electromagnetic surveys were completed over the property (see report ref. No. 88-72). The graphitic schist unit occupies an ill defined regional magnetic low amplitude area. A semi continuous conductive horizon marks the central part of the schist unit. Local outcroppings of highly conductive high grade graphitic lenses present on the property could not be resolved by the VLF survey probably because the regional conductive response of the shear zone dominated. More detailed information was needed in order to further assess the continuity and grade of the graphitic schist discovered in the first phase of mapping and trenching. Graphite produces a high amplitude natural self-potential response and the position of near surface graphite lenses can be accurately located using the self-potential (SP) method.

Self-Potential Survey

The self-potential method is a measurement of the natural potential field of the earth. Background voltages in overburden and bedrock can vary by as much as +/-25 to +/-50 millivolts when no electrically conducting mineralization is present. Sulphides and especially graphite, produce responses from 200 to 600+ millivolts below background. The exact mechanism that produces these responses is not fully understood. Natural telluric current which are known to be present in the earth probably are part of the source of the potential effects. When these telluric currents are affected by sun-spot activity or other atmospheric perturbations, such as thunderstorms, the self-potential field varies considerably over short time intervals and the survey cannot proceed. This phenomena is similar to magnetic storms although the actual source of the disturbances may be different.

Survey Parameters and Presentation

The SP survey was conducted from July 8 to July 14, 1988 by DMBW personnel. The survey utilized a Scintrex RSP-6 DC resistivity and self-potential measuring unit. Porous pots containing a saturated solution of copper sulphate were used as a non-polarizable electrode contact with the earth. Measurements were obtained by measuring the field potential between a base pot on the baseline and a field pot which traversed east and west from the baseline. The survey was conducted over the extent of the known graphite horizon, from L0+00 to L10+00N and 200 m either side of the baseline. Readings were taken at intervals of 12.5 m along the grid lines.

The potential difference between the field pot and the base pot was measured at regular intervals to obtain a pot correction. The correction was subtracted from all the field readings to compensate for the inherent variable difference in the relative potential of the field pot and the base pot. The relative potential from line to line was measured by first reading along the baseline and establishing base pot locations that could be reoccupied as the survey progressed along the baseline.

Following the initial survey, the locations of any anomalous areas were profiled in detail. Station intervals of 1 m were often necessary to locate the exact position of the peak of the anomaly. This detail was necessary as many of the high grade graphite seams are quite narrow and an accurate location reduced the amount of trenching needed to uncover the graphitic material for sampling. A total of 34 SP anomalies were profiled in detail (Appendix 2).

All of the survey data were entered into a computer plotting system and profile and contour maps at a scale of 1:1,000 were generated. Preliminary contour map plots showed that a few lines had elevated or depressed background levels relative to the rest of the survey levels. As the baseline generally follows an anomalous area, the base pot was usually on or within an anomalous zone. It is suspected that the same pot location was not used when surveying the cross lines subsequent to tying in the survey lines along the baseline. Changes in ground moisture can also effect the relative amplitudes of SP effects and this may be another factor causing the background shift. As a result, the background levels were adjusted on four lines to produce a smoother contour map (see maps 89-05-03 andd 89-05-04).

Results

The SP values seen on the profile map are relative. At the beginning of the survey a background datum level around 0 to +50 millivolts (mv) is assumed. In this particular survey the first reading datum was known to be in an anomalous area and an arbitrary value of -100 mv was chosen as datum at line 600 north and the baseline. Examination of the final profile plots on the east side of the survey lines, where responses are essentially flat, indicated that background is approximately -60 mv.

The self-potential survey mapped a wide anomalous area about 200 mv below background marked by the 300 mv contour on map 89-05-04. The area delineated marks the approximate limits of the graphitic schist unit mapped on the property. Within this anomalous zone there are numerous sharp anomaly peaks which are best illustrated on the profile map 89-05-03.

Topographic Survey

A surveyed topographic relief map was required to aid in the positioning of drill holes, to accurately locate existing trenches and other surface features, and to provide the necessary data for calculation of preliminary ore reserve calculations.

The survey was conducted from August 25 to September 1, 1988 by DMBW staff members. The topographic survey was conducted using a Norman Wade 15 second Theodilite and initiated from a known surveyed point at the southwest corner of patented claim PS5164. From this point the two cottage access roads were surveyed in to tie-in the previously surveyed patented claims to the grid established on the property. The topographic survey was then conducted, following the cut grid, from L0+00N to L10+00N comprising a total distance of 6.3 km. This encompassed the known extent of the graphitic horizon. Readings were taken every 25 m along the lines, or where topographic relief changes dictated, and approximately 600 stadia shots were recorded and then calculated. All topographic stations were referenced to a known elevation of 384 m above sea level which was recorded at the timber dam used to control the Sausage Lake water level and maintained by Ontario Hydro. Similarly, the co-ordinate system used was based on a "best fit" to the geologic grid co-ordinates established on the property. This necessitated an azimuth rotation of 5^{o}E to all co-ordinates.

All calculated points were then plotted at a scale of 1:1,000 (Map 89-05-02) and the results contoured at one (1) meter intervals. Over the extent of the survey there is a maximum relief of 38 m. Air photos were used to aid in the interpretation of the results. In addition, all other features noted during traverse were recorded.

Trenching and Channel Sampling Program

Subsequent to the completion of the SP geophysical survey, additional trenching and channel sampling was implemented over the SP anomalies exhibiting the best potential. The aim of the program was two-fold; to ascertain any correlation between sharp SP anomalies peaks and higher grade graphite mineralization and to further define the continuity of both the graphitic schist/paragneiss and massive graphite vein.

During the present program a total of eight trenches (T-1A to T-8A) were escavated on the property, ranging in length from 8 m to 49 m with an average width of 2 m (Map 89-05-01). The trenches were located on the basis of accessibility and to verify the presence of higher grade graphite mineralization associated with the SP anomalies. Trenches were escavated using a Case 560 backhoe and then manually cleaned with shovels before being cleaned to bedrock with a high pressure Wajax water pump. The excellent exposures that resulted facilitated detailed mapping and sampling.

Channel sampling of the exposed trenches was done using a Sthil portable rocksaw equipped with a dry-use diamond blade. Channels 3 cm wide and 6 cm deep were cut the length of the trenches and then chipped out using a rock chisel and crack hammer. Samples were bagged in intervals ranging from 1 m to 3 m for assay. All trenches were sampled east to west and granitic intervals within each of the trenches were not sampled. A total of seventy-six channel samples were taken across the graphitic schist/paragneiss and submitted for assay.

All samples submitted were assayed for graphitic carbon weight percent (Cg) using the nitric acid bath - Loss of Ignition (L.O.I.) method. Assays were conducted by Assayers Ontario Laboratories, Toronto, Ontario. Assay certificates are presented in Appendix 1.

The results for each individual trench tabulated in Appendix 3 and illustrated on Map 89-05-01, are summarized below:

Trench 1A	1.56% Cg over 42 m
Trench 2A	1.63% Cg over 12 m
Trench 3A	2.10% Cg over 49 m
Trench 4A	3.48% Cg over 13 m
Trench 5A	4.56% Cg over 14 m
Trench 6A	2.33% Cg over 12 m
Trench 7A	2.64% Cg over 27 m
Trench 8A	3.04% Cg over 8 m

The average combined grade of all samples taken from the trenches is 2.67% Cg. In addition, one grab sample (R-2A), taken across the massive graphite vein as exposed in Trench T-3A (L5+50N), assayed 18.97% Cg.

sufficient material of a suitable size for transport. Samples were collected in 5 gallon pails and shipped to the Ortech International facilities located in Mississauga, Ontario.

Three individual bulk samples were taken in order to provide representational results of both the massive vein and disseminated graphite mineralization. Locations are illustrated on Map 89-05-01.

Bulk sample No. 1 was taken from an exposure of the massive graphite vein located just south of Pit No. 1 at L6+00N/0+70W. A channel sample taken across this vein during the 1988 spring exploration program assayed 29.03% Cg over its 1.5 m wide exposure. Bulk sample No. 1 weighed 128 kg (282 lb.) and the head sample assayed 34.4% Cg.

Bulk sample No. 2 was taken from the east end of Trench 6 located at 5+70N/0+40W. The sample was from an interval of the graphitic schist/paragneiss (Unit 1b) which previously assayed 4.46% Cg. The head sample from bulk sample No. 2 assayed 4.1% Cg and the sample weighed 130 kg (287 lb.).

Bulk sample No. 3 was also blasted from an interval of the graphitic schist/paragneiss (Unit 1b). Taken from the east end of Trench 9, located at 2+10N/0+30E, the interval was previously channel sampled and assayed 5.09% Cg. Bulk sample No. 3 weighed 140 kg (308 lb.) and the head sample returned an assay of 4.0% Cg. The head samples sent for assay are representational of the entire bulk sample and were prepared for assay at -100 mesh size.

The Ortech International report is presented in Appendix 4. The report describes in detail all testing procedures and results, along with their conclusions and recommendations for any further work. The report will be discussed in the following section.

DISCUSSION OF RESULTS

The results of the trenching and channel sampling program continue to be very encouraging. The average combined grade of all eight trenches sampled during the present program was 2.67% Cg, slightly below that of 2.91% Cg for the thirteen trenches sampled during the 1988 spring program. A review of the results from each of the individual trenches illustrated on Map 89-05-01 shows that higher grade, economically feasible zones exist within the graphitic schist/paragneiss. Using a cut-off grade of 2.50% Cg, there exists three zones, as defined by surface sampling, which represent excellent targets for further investigation by diamond drilling.

The first zone occurs between L6+00N and L5+00N where trenches T-4, T-5, T-6, T-3A and T-4A average 3.25% Cg. In addition, the massive graphite vein is exposed within this zone for a strike length of over 50 m and is open along strike at both ends. Assay values taken across the vein range from 9.25% Cg over 5 m to 38.15% Cg over 1 m. A prime objective of diamond drilling within this zone will be to define the down-dip extensions and continuity of the vein as it will appreciably increase the overall grade of the zone.

A second zone of higher grade graphite mineralization exists between L2+50N and L2+00N where surface channel sample results from trenches T-5A, T-9 and T-7A average 4.54% Cg. The graphite vein is also exposed within this zone in three isolated exposures separated by 45 m. Again, diamond drilling in this zone should focus on the down-dip extensions of the graphite vein.

A third zone exists south of L1+00N where trenches T-11, T-12 and T-13 average 2.79% Cg. Although no outcroppings of the graphite vein have been discovered south of L1+00N, the graphitic schist/paragneiss is over 125 m wide in this zone with assay values from both trench and grab samples consistently over 2.50% Cg.

The results of the self-potential (SP) geophysical survey demonstrate that it was successful in defining numerous conductive anomalies over the extent of the graphitic horizon. Subsequent trenching of some of these anomalies has confirmed the presence of higher grade graphite mineralization. Other anomalies occur in deeply weathered or glaciated areas where trenching was not undertaken or failed to reach bedrock. These areas occur, for the most part, on strike with known significant graphite mineralization and, therefore, represent favourable areas for further investigation by diamond drilling.

The results of the preliminary bench-scale metallurgical testing conducted by Ortech International on three bulk samples submitted by DMBW are very favourable. The results indicate that all three bulk samples can be concentrated to a minimum of 85% graphitic content, which is of commercial quality, through grinding and flotation processes. Recovery rates for all three samples, as indicated in Appendix 4, Figure 2, are excellent and indicate that a low grade tailings fraction can be rejected at each grinding stage.

In the case of bulk sample No. 1, taken from the massive graphite vein, four stages of grinding and flotation produced a concentrate grade of 92.1% Cg at a high recovery rate of 97%. Cyclosizing tests performed on this concentrate indicate a very fine-grained flake size on the order of 5 to 14 microns. Leaching at atmospheric conditions improved the concentrate grade only marginally from 92.1% Cg to 93.1% Cg.

In the case of bulk samples No. 2 and 3, taken from the graphitic schist/paragneiss, three stages of grinding and flotation resulted in concentrate grades of 89.1% Cg and 87.5% Cg at recovery rates of 90% and 85% respectively. Cyclosize tests were not performed -- concentrate size was insufficient -- however, preliminary test results indicate and confirm that the graphite mineralization is very finely disseminated and that no high grade large diameter flake can be recovered in the +100 mesh size fractions. Leaching at atmospheric conditions improved the concentrate grade of bulk sample No. 2 from 89.1% Cg to 91.9% Cg and of bulk sample No. 3 from 87.5% Cg to 89.1% Cg.

Although commercial quality grades of greater than 85% Cg were obtained for all three samples through grinding and flotation, Ortech International reports that additional bench-scale testing should be conducted. Preliminary results indicate that increased initial grinding times along with optimization of reagents used in the flotation process will increase both the grade and recovery of graphitic carbon in all three bulk samples. The aim of additional bench-scale testing would be to increase the graphite carbon content to 95% or better for all samples.

Ortech reports that no large diameter graphite flake was recovered from any of the three bulk samples submitted. Given the very fine flake size of the graphite concentrates, markets for the potential product will have to be targeted for powder applications.

Graphite powders are used in non-refractory applications such as moulded brake linings, batteries, brushes, metallurgical sintering products, lubricants, conductive coatings, pencils and mechanical carbons. Although the above markets will purchase a powder containing 85% Cg, they prefer a powder containing 96% to 99% graphite. Higher graphitic content commands a premium on the market -- US$300/tonne for 85% graphite powders to US$2,000/tonne for 99% graphite powders.

CONCLUSIONS

(1) The results from two trenching and channel sample programs undertaken on the Astwood Park Resources Trout Creek graphite prospect are very encouraging and have outlined the potential for a significant large tonnage-low grade disseminated flake and vein-type graphite deposit.

(2) The average combined grade of all 290 trench and grab samples taken from the graphitic schist/paragneiss is 2.73% Cg. This disseminated graphite mineralization has been delineated over a length in excess of 1 km with widths varying between 50 m and 150 m. In addition, assay values from samples taken from the massive graphite vein ranged from 9.15% Cg to 39.13% Cg. The vein has been exposed for over 50 m in two zones and as an isolated occurrence in a third. Based on geological data it

appears likely that this vein, and the shear/fracture system which it emplaces, is continuous over the length of the deposit. It can, therefore, be expected that even a relatively small tonnage of the vein material will appreciably increase the overall grade of the deposit.

(3) Using a cut-off grade of 2.50% Cg, surface sampling has delineated three higher grade, potentially economically feasible zones within the deposit which, due to higher grade values obtained in trenches and surface exposures of the massive graphite vein, represent favourable areas for further investigation by diamond drilling.

(4) The topographic survey was successful in defining surface elevations and features on the property and will provide the necessary data for the locating of drill holes and preliminary ore reserve calculations.

(5) The self-potential geophysics survey was successful in defining several conductive anomalies. Subsequent trenching of some of these anomalies confirmed that they mark zones of higher grade graphite mineralization.

(6) The results of the bench-scale metallurgical testing undertaken on three bulk samples from the property are very encouraging and indicate that all three samples can be concentrated to a minimum of 85% Cg, which is of commercial quality.

(7) All three samples contain a very fine flake size suitable for applications in graphite powder markets. Graphite powders are used in brake linings, brushes, sinter products, lubricants, conductive coatings, batteries, pencils and mechanical carbons.

RECOMMENDATIONS

To enable a further assessment of the economic viability of this deposit, additional information is needed. DMBW recommends that a diamond drill program be implemented on the property, the results of which should provide information on the down-dip continuity and variability in width and grade of the higher grade, potentially economically feasible zones which have been delineated by the surface sampling program. In our opinion, emphasis should be placed on definition drilling within these higher grade zones which, when combined with the results from surface sampling, topographic surveying and preliminary metallurgical testing, will enable an initial economic evaluation of the deposit.

The 400 m diamond drilling program originally proposed in the September 30, 1987 qualifying report (Mayer and Tyler, 1987) will not be sufficient to properly assess the economic potential of the deposit. Wide-spaced drilling at this point will not provide the necessary data for initial tonnage and grade calculations.

DMBW, therefore, recommends that an 800 m definition diamond drilling program be implemented. This will enable tonnage and grade estimates within the higher grade zones of the deposit and provide an initial estimate of the viability of commencing a small-scale mining operation.

DMBW also recommends that additional bench-scale studies be conducted on the samples submitted to Ortech International to increase the graphite carbon contents from the present levels of 87% Cg - 92% Cg to 96% Cg - 99% Cg. This test work should establish to what extent grades may be increased by improvements in grinding and flotation concentration.

The results to date have been excellent from all programs conducted on the property and, as a result, DMBW feels a revision to the originally proposed budget is merited. The above outlined program and estimated costs are detailed in Appendix 6 and summarized below:

Pre-field Planning	$ 1,650
Mob/Demob	1,850
Diamond Drilling (all inclusive)	74,446
Data Compilation and Reports	6,850
Additional Bench-Scale Testing	3,000
Total	$87,796
Contingency (10%)	8,780
GRAND TOTAL	$96,576

DMBW recommends that the program outlined above be implemented as soon as possible. There have been a number of recent developments within international graphite markets which have contributed to a sharp decrease in world supply. The details are presented in an article from Industrial Minerals Magazine (Appendix 5). As a result, not only has the price of all graphite types increased, but also demand from the largest net importers of graphite, the United States and Japan. There has never been a more optimum time for a North American deposit capable of supplying a consistent quantity and quality of graphite to come into production.

Should the above described diamond drilling program and additional bench-scale testing prove successful, a pilot scale test run is recommended to determine a commercial flow sheet. This would require a minimum of 50 tons of graphite material. Also, concurrent or subsequent to the additional bench-scale studies, it is recommended that a market survey be conducted to determine the market volume, value and trend in the graphite powder market. This study should be of sufficient scope in order to determine if the pilot plant test program is warranted.

REFERENCES

Dickson, T. B.
1985: Petrology of Rock Units and Graphite Horizon in Mannella Claim Group, Trout Creek, Ontario. Unpublished B.Sc. thesis, University of Western Ontario.

Dickson, T. B. and Hartwick, P.A.
1988: Report on the 1988 Spring Exploration Program, Laurier Township Graphite Prospect, Trout Creek, Ontario, NTS 31E/4, prepared for Astwood Park Resources Inc., DMBW unpublished report, 50 pp.

Industrial Minerals Magazine
1988: December, 1988 issue.

Melbardis, J. et al.
1988: Report on Preliminary Bench Scale Testing on Three Graphite-Bearing Bulk Samples, prepared for DMBW, Ortech International unpublished report, 17 pp.

Woolham, R. W.
1988: Report on Geophysics Surveys, Trout Creek Property, Laurier Township, Ontario, NTS 31E/4, prepared for Astwood Park Resources Inc., DMBW unpublished report, 6 pp.

CERTIFICATE OF QUALIFICATION

I, Tim B. Dickson, of 105-212 St. George Street, Toronto, Ontario, do hereby certify that:

(1) I am an exploration geologist working as an outside consultant for Derry, Michener, Booth & Wahl, Consulting Geologists and Engineers of Toronto.

(2) I am a graduate of the University of Western Ontario, London, Ontario, in Honours Geology with the degree of B.Sc. in 1985.

(3) I have been practising my profession since 1982 and full-time since 1984.

(4) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the properties or securities of Astwood Park Resources Inc.

(5) The statements contained in this report and the conclusions and recommendations made are based upon my review of all data available. I supervised the field operations during the exploration program.

(6) I hereby consent to the use of this report in a Statement of Material Facts of the Company for the preparation of a prospectus for submission to the Ontario Securities Commission and other regulatory authorities.

Tim Dickson

T. B. Dickson, B.Sc.

Toronto, Ontario
January 20, 1989

CERTIFICATE OF QUALIFICATION

I, Ian D. Trinder, of Apt. 2025, 30 Denton Avenue, Scarborough, Ontario do hereby certify that:-

1. I am an exploration geologist employed with Derry, Michener, Booth & Wahl, Consulting Geologists and Engineers of Toronto.

2. I graduated from the University of Manitoba in 1983 with a degree of Bachelor of Science, Honours Geology.

3. I have not received, nor do I expect to receive, any interest, directly or indirectly, in the properties or securities of Astwood Park Resources Inc.

4. The statements contained in this report and the conclusion and recommendations made are based upon my review of all data available. I have visited the property.

5. I hereby consent to the use of this report in a Statement of Material Facts of the Company for the preparation of a prospectus for submission to the Ontario Securities Commission and other regulatory authorities.

I. D. Trinder, B.Sc.

Toronto, Ontario
January 20, 1989

APPENDIX 1

ASSAY CERTIFICATES

ASSAYERS ONTARIO LABORATORIES

A DIVISION OF ASSAYERS CORPORATION LTD.

33 CHAUNCEY AVENUE, TORONTO, ONTARIO M8Z 2Z2 • TELEPHONE (416) 239-3527
FAX (416) 239-4012

Certificate of Analysis

SEP 20 1988

Certificate No. DMBW-04/01/8105 Date: September 14, 1988

Received 78 Samples of Rock Chips

Submitted by Derry, Michener, Booth & Wahl Attn: Mr. Perry Hartwick

Sample No.	Graphitic Carbon %		Sample No.	Graphitic Carbon %
T1A - 1	1.71	1.80	T2A - 6	2.77
T1A - 2	2.32		T3A - 1	2.34
T1A - 3	1.45		T3A - 2	2.23
T1A - 4	1.19		T3A - 3	3.57
T1A - 5	1.15		T3A - 4	4.18
T1A - 6	.88		T3A - 5	2.33
T1A - 7	.85		T3A - 6	1.61
T1A - 8	1.53		T3A - 7	1.03
T1A - 9	2.29		T3A - 8	1.32
T1A - 10	2.24	2.13	T3A - 9	1.43
T1A - 11	.94		T3A - 10	1.37
T1A - 12	.70		T3A - 11	.98
T1A - 13	1.28		T3A - 12	1.15
T1A - 14	1.69		T3A - 13	.89
T1A - 15	2.31		T3A - 14	3.67
			T3A - 15	4.28
T2A - 1	1.24		T3A - 16	1.39
T2A - 2	.93		T3A - 17	.85
T2A - 3	1.44		T3A - 18	2.24
T2A - 4	1.19		T4A - 1	.05
T2A - 5	2.21			

ASSAYERS ONTARIO LABORATORIES

Per ______________________

J. van Engelen Mgr.

ASSAYERS ONTARIO LABORATORIES
A DIVISION OF ASSAYERS CORPORATION LTD.
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FAX (416) 239-4012

Certificate of Analysis

SEP 2 3 1988

Certificate No. DMBW-04/02/8105 Date: September 14, 1988

Received 78 Samples of Rock Chips

Submitted by Derry, Michener, Booth & Wahl Attn: Mr. Perry Hartwick

Sample No.	Graphitic Carbon %
T4A - 2	1.93
T4A - 3	1.89
T4A - 4	3.72
T4A - 5	5.21
T4A - 6	4.60
T4A - 7	3.52
T5A - 1	4.17
T5A - 2	4.03
T5A - 3	4.69
T5A - 4	4.54
T5A - 5	4.63
T5A - 6	4.91
T5A - 7	4.93
T6A - 1	1.84
T6A - 2	2.12
T6A - 3	1.51
T6A - 4	2.41
T6A - 5	3.57
T6A - 6	2.55
T7A - 1	1.51
T7A - 2	2.27
T7A - 3	1.46
T7A - 4	1.67
T7A - 5	2.55
T7A - 6	3.39
T7A - 7	4.71
T7A - 8	2.93
T7A - 9	3.14
T7A - 10	2.81
T8A - 1	1.03
T8A - 2	.79
T8A - 3	.03
T8A - 4	2.65
T8A - 5	3.24
T8A - 6	3.16
T8A - 7	3.11
R1A	2.51
R2A	~~18.97~~ 18.95

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Per J. van Engelen Mgr.

APPENDIX 2

TABULATION OF DETAILED SELF-POTENTIAL ANOMALIES

Detailed Self-Potential Anomalies

	Location	Trench		Location	Trench
(1)	10+00N/1+00W	T-1A(Vein)	(18)	4+00N/0+01W	X(?)
(2)	10+00N/1+32W	X	(19)	3+50N/0+16E	X(UA)
(3)	9+50N/0+15W	X(?)	(20)	3+00N/0+23E	X(UA)
(4)	9+50N/1+25W	X(UA)	(21)	2+50N/0+26W	T-6A(Vein)
(5)	9+50N0+30E	T-1	(22)	2+50N/0+17E	T-5A
(6)	9+00N/0+38E	X	(23)	2+00N/0+40W	T-8A(?)
(7)	8+50N/0+27E	X(?)	(24)	2+00N/0+33W	T-8A(?)
(8)	8+50N/0+27E	T-2A	(25)	2+00N/0+22E	T-7A
(9)	8+00N/0+12E	X(?)	(26)	2+00N/0+27E	T-7A
(10)	7+00N/0+16W	X(UA)	(27)	1+50N/0+51W	X(UA)
(11)	6+50N/0+25E	X(?)	(28)	1+50N/0+91E	X(UA)
(12)	6+00N/0+50W	T-4	(29)	1+00N/0+66W	T-12
(13)	6+00N/0+68W	T-5(Vein)	(30)	1+00N/0+87E	X(UA)
(14)	5+50N/0+41W	T-3A	(31)	0+50N/0+52W	X
(15)	5+50N/0+65W	T-3A(Vein)	(32)	0+50N/0+95W	X(UA)
(16)	5+50N/0+77W	T-3A	(33)	0+50N/0+97E	X(UA)
(17)	5+00N/0+23W	T-4A	(34)	0+00/0+39W	X

X: not trenched
?: questionable SP anomaly
UA: unaccessible by backhoe
Vein: massive graphite vein exposed by trenching

APPENDIX 3

TABULATION OF ASSAY RESULTS

Sample No.	Sample Interval (m)	Graphitic Carbon (Cg) wt.%
Trench 1A-1	2.0	1.80
T1A-2	2.0	2.31
T1A-3	2.5	1.45
*water	6.5	NS
T1A-4	2.0	1.19
T1A-5	2.0	1.15
*2a dyke	4.0	NS
T1A-6	2.0	0.88
T1A-7	2.0	0.85
T1A-8	2.0	1.53
T1A-9	2.0	2.29
T1A-10	2.0	2.24
T1A-11	2.0	0.94
T1A-12	2.0	0.70
T1A-13	2.0	1.28
T1A-14	2.0	1.69
T1A-15	2.5	2.31
Trench 2A-1	2.0	1.24
T2A-2	2.0	0.93
T2A-3	2.0	1.44
T2A-4	2.0	1.19
T2A-5	2.0	2.21
T2A-6	2.0	2.77
Trench 3A-1	2.0	2.34
T3A-2	2.0	2.23
T3A-3	2.0	3.57
T3A-4	3.0	4.18
*water	4.5	NS
T3A-5	2.0	2.33
T3A-6	2.0	1.61
T3A-7	2.0	1.03
T3A-8	2.0	1.32
T3A-9	2.0	1.43
T3A-10	2.0	1.37
T3A-11	2.0	0.98
T3A-12	2.0	1.15
T3A-13	2.0	0.89
T3A-14	2.0	3.67
T3A-15	2.0	4.28
*2a dyke	7.0	NS
T3A-16	2.0	1.39
T3A-17	1.5	0.85
*2a dyke	1.5	NS
T3A-18	1.0	2.24

Sample No.	Sample Interval (m)	Graphitic Carbon (Cg) wt.%
Trench 4A-1	2.0	0.05
T4A-2	2.0	1.93
T4A-3	2.0	1.89
T4A-4	1.5	3.72
*road	8.0	NS
T4A-5	2.0	5.21
T4A-6	2.0	4.60
T4A-7	3.0	3.52
Trench 5A-1	2.0	4.17
T5A-2	2.0	4.03
T5A-3	2.0	4.69
T5A-4	2.0	4.54
T5A-5	2.0	4.63
T5A-6	2.0	4.91
T5A-7	2.0	4.93
Trench 6A-1	2.0	1.84
T6A-2	2.0	2.12
T6A-3	2.0	1.51
T6A-4	2.0	2.41
T6A-5	2.0	3.57
T6A-6	2.0	2.55
Trench 7A-1	2.0	1.51
T7A-2	2.0	2.27
T7A-3	2.0	1.46
T7A-4	2.0	1.67
T7A-5	2.0	2.55
T7A-6	2.0	3.39
T7A-7	2.0	4.71
*water	6.0	NS
T7A-8	2.0	2.93
T7A-9	2.0	3.14
T7A-10	3.0	2.81
Trench 8A-4	2.0	2.65
T8A-5	2.0	3.24
T8A-6	2.0	3.16
T8A-7	2.0	3.11

APPENDIX 4

REPORT ON BULK SAMPLE RESULTS
(Ortech International)

Preliminary Bench Scale Testing on three Graphite-Bearing Bulk Samples

for

Derry, Michener, Booth and Wahl
20 Richmond St. East
Toronto, Ontario
M5C 2R9

Attention: Mr. T. Dickson

Submitted by:

J. Melnbardis
C.A. Booth
V.I. Lakshmanan

ORTECH Account No. 40-31496
December 19, 1988

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ORTECH

Bench Scale Testing on three Graphite-Bearing Bulk Samples
for Derry, Michener, Booth and Wahl

TABLE OF CONTENTS

SUMMARY

Three Graphite-bearing bulk samples were submitted to ORTECH by Derry, Michener, Booth and Wahl for preliminary bench-scale testing. The bench scale program included grinding, flotation, cyclosizing and leaching methods on the three bulk samples.

The results indicate that all three bulk samples can be concentrated to produce products for graphitic powder application. Large diameter flake Graphite was not found in all three bulk samples.

Further test work is recommended to produce a higher grade concentrate of graphite from the three bulk samples. Concurrent to the bench scale test program, a market study should be conducted in order to determine if a pilot scale test program is warranted.

1. INTRODUCTION

Derry, Michener, Booth and Wahl (DMBW) are currently investigating a Graphite deposit, located in Ontario, for its commercial feasibility. ORTECH International has been requested by DMBW to conduct a bench-scale test program on three bulk samples from the deposit. This report describes the test work that was conducted on the three bulk samples.

2. TEST PROCEDURE AND RESULTS

2.1 Receipt and Preparation of Test Feed.

The ore samples received at the ORTECH pilot plant in August 1988 included the following:

Sample identification	Weight (kg)	Graphitic Carbon (%)
Bulk No. 1 (VEIN)	128	34.4
Bulk No. 2	130	4.1
Bulk No. 3	140	4.0

The total amount of the 3 individual samples received was first crushed to -6 mesh size using jaw and rolls crushers. The -6 mesh product was then riffled to obtain representative test feed batches and a head sample that was prepared for assay at -100 mesh size.

Samples of the three bulk samples were subjected to X-ray Diffraction (XRD) analysis for qualitatine determination of mineral content and degree of crystallinity of Graphite. the results are shown in Appendix A of this report.

2.2 Graphite Recovery Tests

The sequence of grinding and flotation stages applied on each of the 3 samples is shown in flowsheet of Fig. 1. The initial stage involved a rod mill grind and flotation at about -35 mesh size to determine whether any high grade graphite flake would be liberated and recoverable at the coarse mesh sizes.

The results were negative. In the case of sample No. 1 (vein) assaying 34.4% graphitic carbon the concentrate obtained after a rougher and one cleaner flotation stage assayed lower than 58% graphitic carbon but with higher than 98% recovery. The concentrate screen fractions separated at the +48 mesh and -48+100 mesh sizes amounted to 0.3% and 7.0% by weight of original feed and assayed 78% and 57% graphitic carbon respectively.

In the case of bulk 2 and 3 samples the initial results were similar, but due to the relatively low head grade of 4.1 and 4.0% graphitic carbon both the initial cleaner flotation concentrate grades and recovery obtained were considerably lower values. There was practically no graphite recovered at +48 mesh size and the -48+100 mesh fraction assayed as low as the overall concentrate grades of 20-30% graphitic carbon.

These preliminary results indicated that the graphite mineralization of all samples was finely disseminated and that no high grade flake concentrares would be recoverable in the +100 mesh size fraction.

The cleaner 1 flotation concentrates were further reground (ball mill regrind 1) and refloated. This resulted in higher grade concentrates with relatively low additional loss in recovery. However the reground concentrate grades were still quite low grade assaying from 66% (No. 1 vein) to lower than 50% (Bulk No. 3) graphitic carbon, indicating that still further grinding was required.

To indicate the grinding fineness of the graphite product the flotation concentrate of the 3rd regrind stage of the vein sample 1 was submitted to a cyclosizer test (the amounts of concentrate available from samples 2 and 3 were not sufficient for this test). The results are shown in Table 4 and indicate the product as 96.8% weight passing 14 micron size with no particle larger than 36 micron size (400 mesh).

2.3 Reagent Consumption

The flotation reagents used included mineral spirits (VARSOL) as collector and methylisobutyl carbinol (MIBC) as frother/collector. The initial requirements for the rougher and cleaner 1 flotation stages were 2.2 kg/mT feed of mineral spirits and 0.33 kg/mT feed of MIBC.

Subsequent additions after each regrind stage amounted to 1/10 of the initial dosage, totalling up to 3.1 kg/mT feed of mineral spirits and 0.5 kg/mT feed of MIBC. No other pulp modifying reagents were used, although soda ash may have to be considered as a flotation selectivity promoting reagent and pH regulator.

The reagent requirements of course have not been optimized.

The natural pH of the flotation pulp was 6.7

2.4 LEACHING TESTS

Samples of the higher grade concentrates produced in the second series of tests were subjected to atmospheric acid and caustic leaching at room temperature using 10% hydrochloric acid solution in the first stage and 20% sodium hydroxide solution in the second stage. The duration of each stage was 16 hours.

There was some improvement in the product graphitic carbon grades (Tables 1-3) that was probably the result of removing the iron contamination resulting from ball mill grinding. Only a small weight loss was realized indicating that the residual gangue minerals were not leached under the conditions applied.

3. CONCLUSION AND RECOMMENDATIONS

There are a number of conclusions that can be drawn from the test work. The following are the most noteable:

* All three bulk samples contain a very fine flake size.

* Grade/Recovery curves for all three bulk samples indicate that a larger, initial grinding time is required for adequate product recovery.

* All three bulk samples can be concentrated to a minimum of 85% Graphitic content, which is of commercial quality.

* The average ore grade from the three bulk samples is 4% graphitic carbon content.

* Atmospheric leaching using both acidic and alkaline environments improved the graphitic carbon contents of all three bulk samples only marginally.

Based upon the test results and conclusions, the following is recommended:

* Markets for the graphite concentrate should be targeted for powder applications. Graphite powders are used in moulded brake linings, batteries, brushes, sinter products, lubricants, conductive coatings, pencils and mechanical carbons.

* Competition for the above market is primarily from Sri Lanka, China and Mexico.

* Although the above market will purchase a powder containing 85% graphitic carbon, they prefer a powder containing 96-99% graphite. Higher graphitic content command a premium (300 $/T for 85% graphite US 2000 $/T for 99% graphite powders).

* It is recommended that further bench scale studies should be conducted to increase the graphite carbon content from 85% to at least 95% and possibly 99%. This test work should establish to what extent the grades may be improved by just grinding and flotation concentration.

* The bench scale work should also include a Bond work index test at 200 mesh in order to determine the initial grind ability of the ore to that size.

* Should the above described bench scale program prove successful, a pilot scale test run is recommended to determine a commercial flow sheet. A tentative pilot scale flow sheet is shown in Figure 3, presented at the end of this report. A pilot plant test run will require a minimum of 50 tons of feed.

* Concurrent to the additional bench scale studies, it is recommended that a market survey be conducted to determine the market volume, value and trend in the graphite powder market. This study should be complete enough in order to determine if the pilot plant test program is warranted.

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Technologist
Mineral Resources

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Project Scientist
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V.I. Lakshmanan
Manager
Mineral Resources

TABLE 1

CONCENTRATION TEST RESULTS ON BULK SAMPLE NO. 1 (VEIN)

GRAPHITIC CARBON BALANCE

PRODUCT STAGE	WEIGHT %	GRAPHITIC CARBON ASSAY %	GRAPHITIC CARBON DIST.%
Head (Calc.)	100.0	33.5	100.0
Rougher Flotation Tailings	31.9	1.1	1.0
Rougher Flotation Concentrate	68.1	48.7	99.0
Cleaner 1 Flotation Tailings	10.6	2.1	0.7
Cleaner 1 Flotation Concentrate	57.5	57.3	98.3
Regrind 1 Flotation Tailings	7.6	1.6	0.4
Regrind 1 Flotation Concentrate	49.9	65.7	97.9
Total Flotation Tailings (Calc.)	50.1	2.1	2.1
Head (Calc.)	100.0	34.4	100.0
Rougher Flotation Tailings	13.2	1.2	0.5
Rougher Flotation Concentrate	86.8	39.4	99.5
Cleaner 1 Flotation Tailings	8.6	1.8	0.4
Cleaner 1 Flotation Concentrate	78.2	43.6	99.1
Regrind 1,2&3 Flotation Tailings	38.8	1.4	1.6
Regrind 3 Flotation Concentrate	39.4	85.2	97.5
Regrind 4 Flotation Tailings	3.1	5.2	0.5
Regrind 4 Flotation Concentrate	36.3	92.1	97.0
Total Flotation Tailings (Calc.)	63.7	1.6	3.0
HCl and NaOH leaching of regrind 4 Flotation Conc.:			
Leached Concentrate	--	93.1	97.0

TABLE 2

CONCENTRATION TEST RESULTS ON BULK SAMPLE NO. 2

GRAPHITIC CARBON BALANCE

PRODUCT STAGE	WEIGHT %	GRAPHITIC CARBON ASSAY %	GRAPHITIC CARBON DIST.%
Head (Calc.)	100.0	4.0	100.0
Rougher Flotation Tailings	81.8	0.4	8.2
Rougher Flotation COncentrate	18.2	20.2	91.8
Cleaner 1 Flotation Tailings	5.8	3.5	5.0
Cleaner 1 Flotation Concentrate	12.4	28.0	86.8
Regrind 1 Flotation Tailings	6.5	0.6	1.0
Regrind 1 Flotation Concetrate	5.9	58.1	85.8
Total Flotation Tailings (Calc.)	94.1	0.6	14.2
Head (Calc.)	100.0	3.17	100.0
Rougher Flotation Tailings	85.0	0.21	5.7
Rougher Flotation Concentrate	15.0	19.9	94.3
Cleaner Flotation Tailings	4.9	1.81	2.8
Cleaner Flotation Concentrate	10.1	28.7	91.5
Regrind 1,2&3 Flotation Tailings	6.9	0.74	1.6
Regrind 3 Flotation Concentrate	3.2	89.1	89.9
Total Flotation Tailings (Calc.)	96.8	0.33	10.1
HCl and NaOH Leaching of Regrind 3 Flotation Conc.:			
Leached Concentrate	--	91.9	89.9

TABLE 3

CONCENTRATION TEST RESULTS ON BULK SAMPLE NO. 3

GRAPHITIC CARBON BALANCE

PRODUCT STAGE	WEIGHT %	GRAPHITIC CARBON ASSAY %	GRAPHITIC CARBON DIST.%
Head (Calc.)	100.0	4.6	100.0
Rougher Flotation Tailings	72.0	1.1	17.2
Rougher Flotation Concentrate	28.0	13.6	82.8
Cleaner 1 Flotation Tailings	7.0	5.7	8.7
Cleaner 1 Flotation Concetrate	21.0	16.2	74.1
Regrind 1 Flotation Tailings	14.1	0.4	1.3
Regrind 1 Flotation Concentrate	6.9	48.6	72.8
Total Flotation Tailings (Calc.)	93.1	1.34	27.2
Head (Calc.)	100.0	3.68	100.0
Rougher Flotation Tailings	74.6	0.42	8.5
Rougher Flotation Concentrate	25.4	13.3	91.5
Cleaner Flotation Tailings	6.3	1.37	2.4
Cleaner Flotation Concentrate	19.1	17.2	89.1
Regrind 1,2&3 Flotation Tailings	15.5	0.83	3.5
Regrind 3 Flotation Concentrate	3.6	87.5	85.6
Total Flotation Tailings (Calc.)	96.4	0.55	14.4
HCl and NaOH Leaching of Regrind 3 Flotation Conc.:			
Leached Concentrate	--	89.1	85.6

TABLE 4

CYCLOSIZE TEST RESULTS

ON BULK 1 (VEIN) SAMPLE REGRIND 3 FLOTATION CONCENTRATE

CYCLONE NO.	PARTICLE SEPARATION MICRON SIZE		WEIGHT % RETAINED AT SIZE	GRAPHITIC CARBON ASSAY %
	PARTICLES OF S.G. 2.7 (SILICA)	PARTICLES OF S.G. 2.2 (GRAPHITE)		
1	48	55	--	
2	36	41	--	
3	24	28	0.4	89.4
4	17	20	1.2	
5	12	14	1.6	83.0
PASSING 5	12	14	96.8	85.2
TOTAL			100.0	85.2

FIG. 2 GRAPHITE CONCENTRATION GRADE VS. RECOVERY

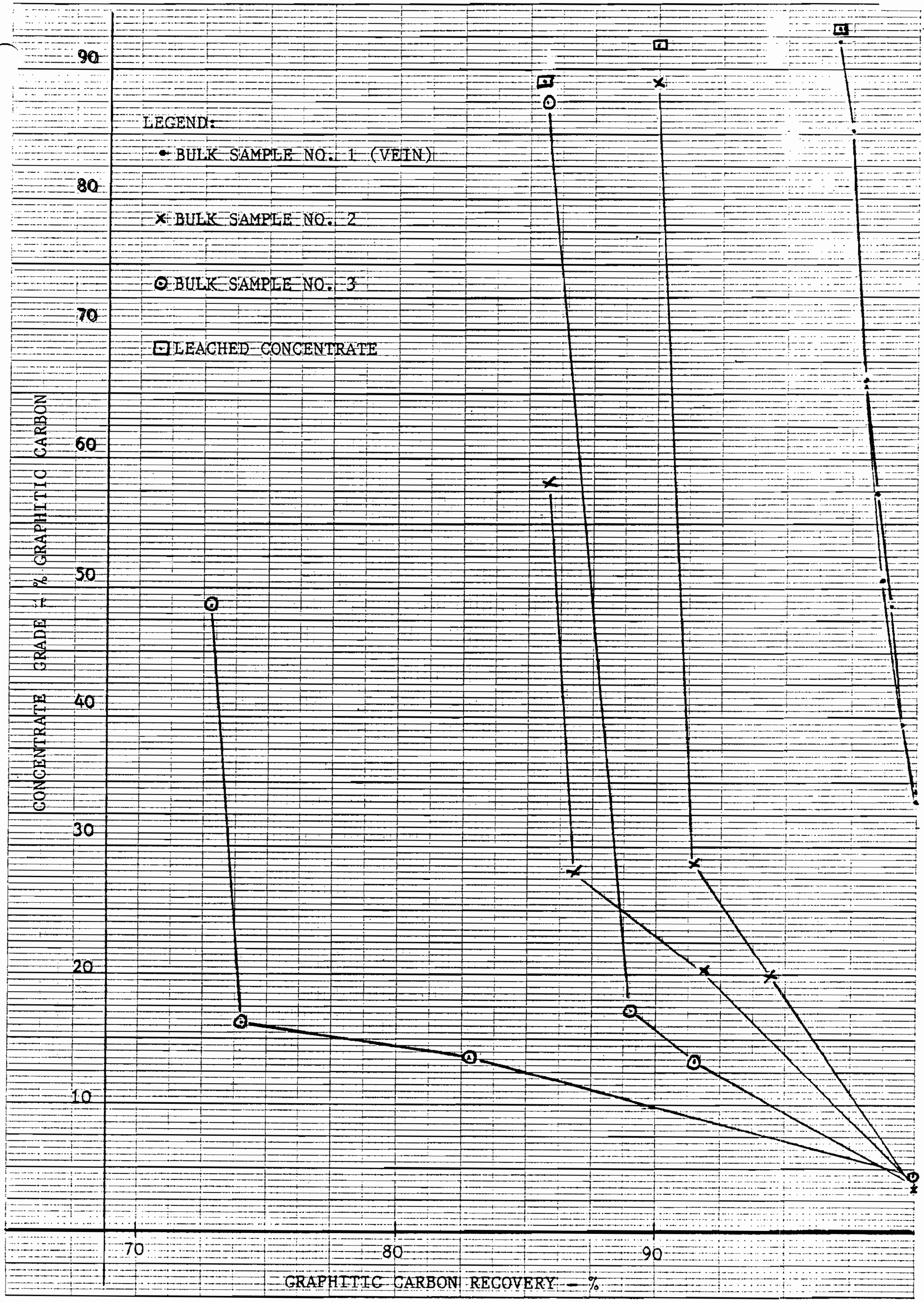
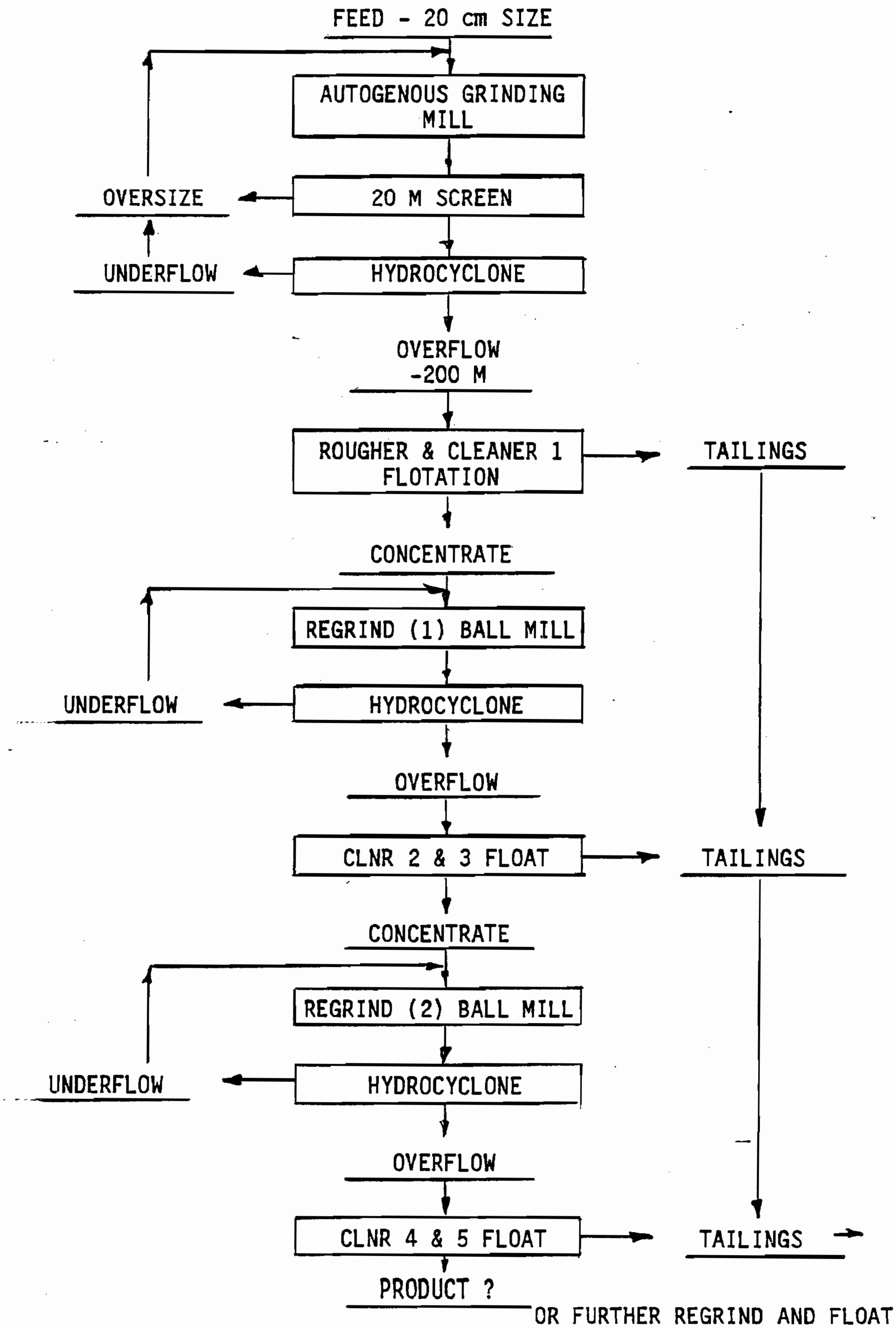


FIG. 5

DMBW GRAPHITE

TENTATIVE PILOT PLANT FLOWSHEET
BASED ON PRELIMINARY LAB RESULTS



APPENDIX A

Results for X-Ray Diffraction Analysis

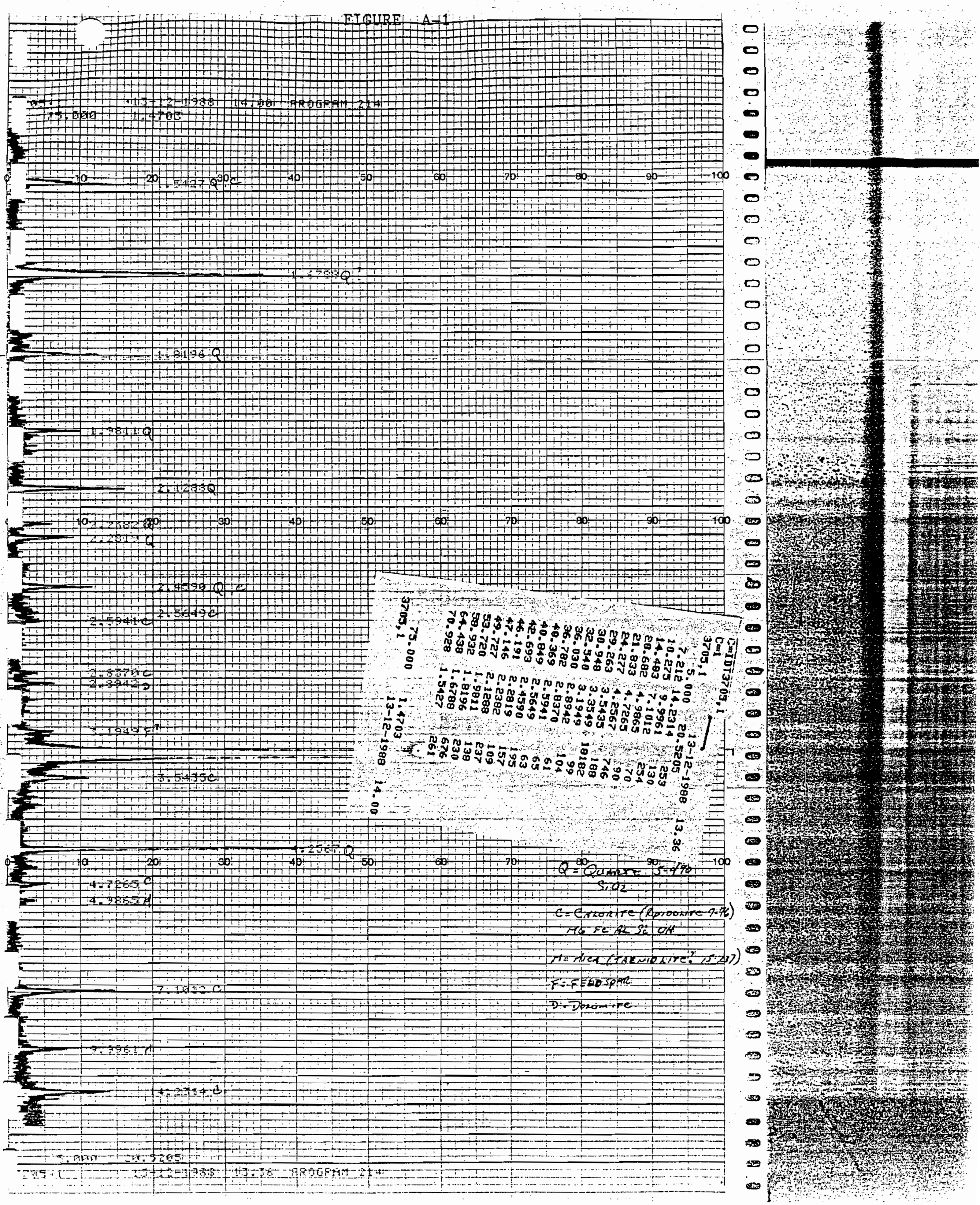
Representative sample from three graphite bearing bulk samples were subjected to X-Ray Diffraction (XRD) analysis for quantitative determination of mineral content. The XRD patterns are presented in Figures A-1, A-2 and A-3 for bulk samples designated as Bulk No. 1 (Vein), Bulk No. 2 and Bulk No. 3 respectively.

The XRD patterns indicate that each sample contained the following mineral compositions:

Sample	Major	Minor	Trace
Bulk No. 1	Quartz Graphite	chlorite mica	Feldspar Dolomite
Bulk No. 2	Quartz	Feldspar mica (phlopopite) Graphite	-
Bulk No. 3	Quartz	Feldspar (orthoclose) mica Graphite	-

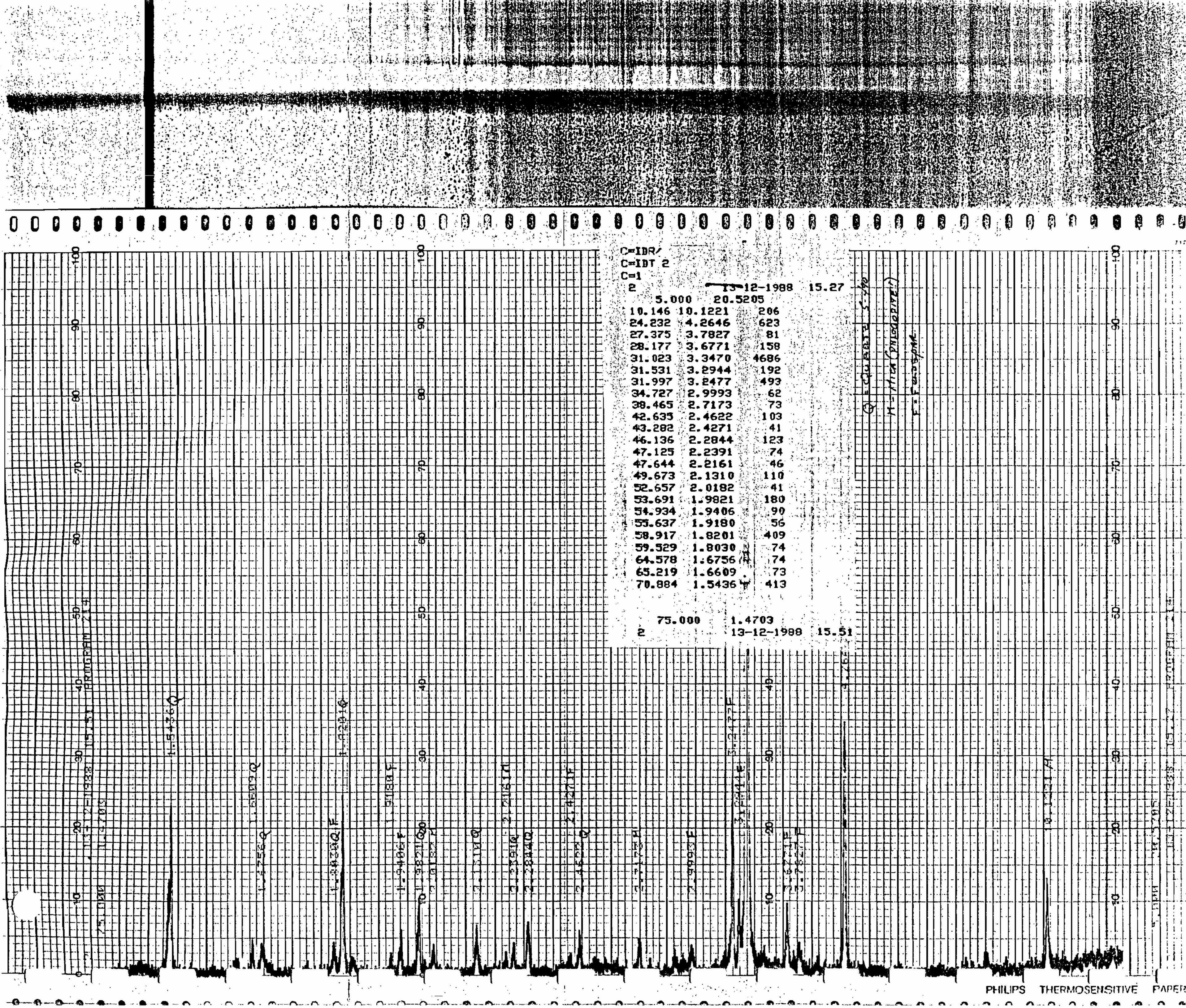
The major for Graphite corresponds to a major peak for Quartz and therefore, the degree of crystallinity of the Graphite can not be determined (peak at 2θ = 3.35 49) in the present analysis. In order to determine the degree of crystallinity for the Graphite, an XRD analysis should be performed on concentrates from the three bulk samples.

FIGURE A-1



13-12-1988 14.00 PROGRAM 214
75.000 1.4703
1.5427 Q C
1.6788 Q
1.8196 Q
1.9811 Q
2.1288 Q
2.2382 Q
2.2819 Q
2.4590 Q C
2.5649 C
2.5941 C
2.8370 C
2.8942 D
3.1949 F
3.5435 C
4.2567 Q
4.7265 C
4.9865 M
7.1012 C
9.9961 M
14.2314 C
5.000 20.5205
13-12-1988 13.36 PROGRAM 214
C=IDT3705,1
C=1
3705,1
5.000 20.5205 13-12-1988 13.36
7.212 14.2314 253
10.275 9.9961 130
14.483 7.1012 254
20.682 4.9865 70
21.833 4.7265 90
24.277 4.2567 746
29.263 3.5435 188
30.948 3.3549 10182
32.540 3.1949 99
36.030 2.8942 104
36.782 2.8370 61
40.369 2.5941 65
40.849 2.5649 63
42.693 2.4590 195
46.191 2.2819 157
47.146 2.2382 109
49.727 2.1288 237
53.720 1.9811 138
58.932 1.8196 230
64.438 1.6788 676
70.928 1.5427 261
75.000 1.4703
3705,1 13-12-1988 14.00
Q = Quartz 5-490
SiO2
C = Chlorite (Aprochlorite 7-76)
Mg Fe Al Si OH
M = Mica
F = Feldspar
D = Dolomite

FIGURE A-2



C=IDR/		
C=IDT 2		
C=1		
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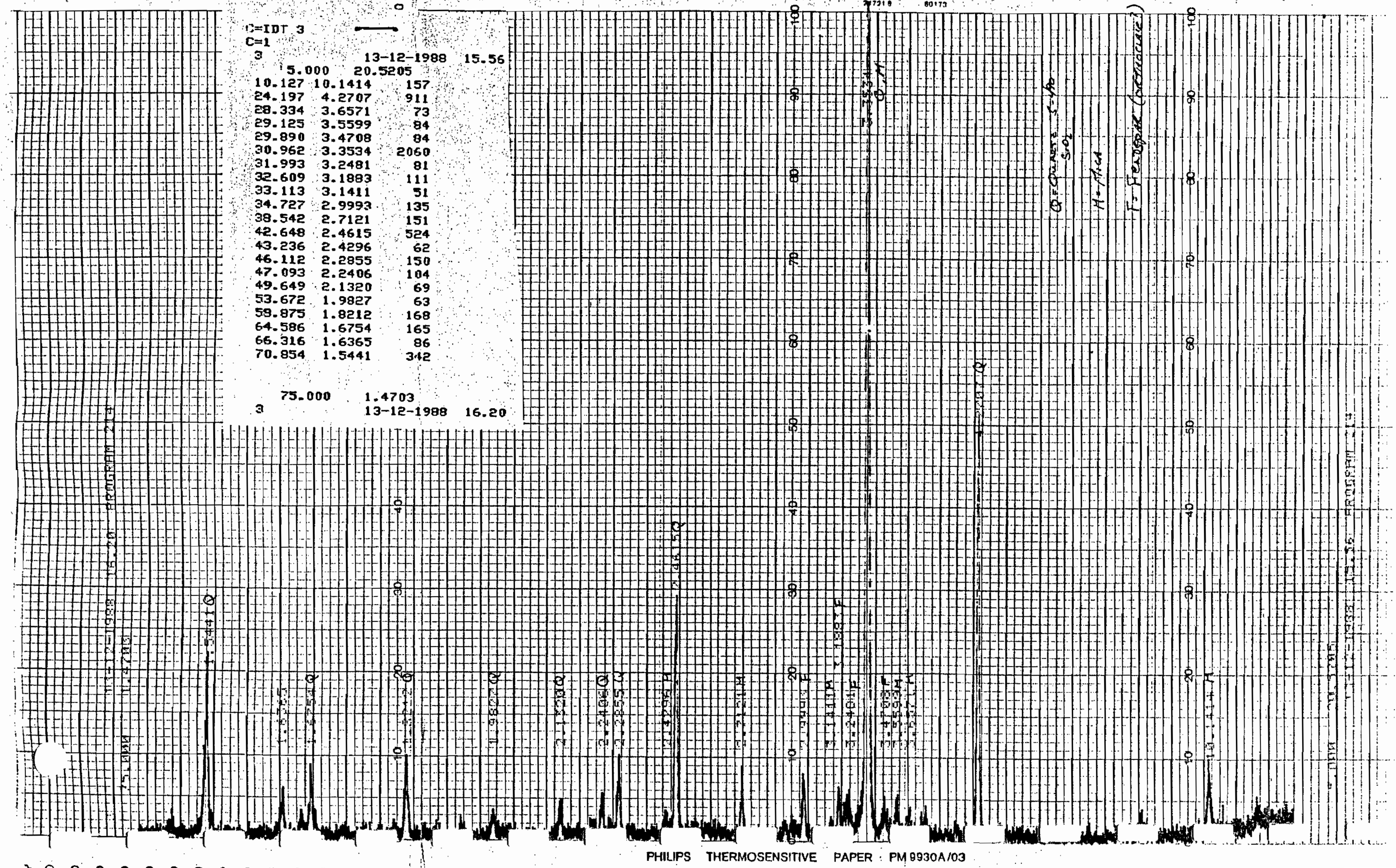
10.146	10.1221	206
24.232	4.2646	623
27.375	3.7827	81
28.177	3.6771	158
31.023	3.3470	4686
31.531	3.2944	192
31.997	3.2477	493
34.727	2.9993	62
38.465	2.7173	73
42.635	2.4622	103
43.282	2.4271	41
46.136	2.2844	123
47.125	2.2391	74
47.644	2.2161	46
49.673	2.1310	110
52.657	2.0182	41
53.691	1.9821	180
54.934	1.9406	90
55.637	1.9180	56
58.917	1.8201	409
59.529	1.8030	74
64.578	1.6756	74
65.219	1.6609	73
70.884	1.5436	413
75.000	1.4703	
2	13-12-1988	15.51

Q = Quartz 5-490
M - Mica (Phlogopite)
F = Feldspar

PHILIPS THERMOSENSITIVE PAPER

FIGURE A-3



C=IDT 3
C=1
3 13-12-1988 15.56

5.000	20.5205	
10.127	10.1414	157
24.197	4.2707	911
28.334	3.6571	73
29.125	3.5599	84
29.890	3.4708	84
30.962	3.3534	2060
31.993	3.2481	81
32.609	3.1883	111
33.113	3.1411	51
34.727	2.9993	135
38.542	2.7121	151
42.648	2.4615	524
43.236	2.4296	62
46.112	2.2855	150
47.093	2.2406	104
49.649	2.1320	69
53.672	1.9827	63
58.875	1.8212	168
64.586	1.6754	165
66.316	1.6365	86
70.854	1.5441	342
75.000	1.4703	

3 13-12-1988 16.20

APPENDIX 5

GRAPHITE: CURRENT SHORTFALLS IN FLAKE SUPPLY
(Industrial Minerals, December 1988 issue)

1M Dec 1988

Graphite

Current shortfalls in flake supply

by Alison Russell, *Assistant Editor*

Difficult times loom ahead for buyers of flake graphite, since currently producers appear to hold all the trumps with certain grades in short supply. Prices have risen sharply over the last six months and this trend looks set to continue in the short term at least. World production is dominated by China, whose current problems of supply have had repercussions globally. Amorphous graphite is more easily available, and the market therefore is not as dynamic and consequently prices have remained relatively stable. Demand for graphite has also risen with production increases in refractories for the iron and steel industry, and supply is tight. However, with planned increases in capacity and the commissioning of new facilities in Canada and Norway the situation should be easing by next year. This article surveys the current and developing world production and supply situation.

Graphite markets

The graphite market is characterised by typical business cycles, after a few years of depression and perhaps apparent oversupply there follows a period of shortage. Over the last year, graphite prices have recovered and increased by around 25% overall, with some grade such as large crystalline flake commanding price rises of up to 40%. Having fallen during 1987 prices climbed at the beginning of this year to reach their highest levels of 1986 and look set to rise again in 1988.

Prices for the lowest grades of flake material have risen by approximately $100, but owing to the nature of the graphite industry in which some 500 to 600 different grades are produced estimating specific prices is difficult. Graphite prices in the USA as measured by imports by the USBM averaged $712 per short ton for crystalline flake graphite as compared with $648 per short ton in 1986. Mexican amorphous graphite increased from $49 in 1986 to $52 in 1987.

China has supplied some 70–80,000 tpa of graphite to the world market over the last three years. This year industry sources have estimated that owing to increased internal consumption, closing of marginal mines, and the drought that has afflicted the country there will be a shortfall in supply of some 30–40,000 tonnes to the world market in 1989. This will mostly affect Japanese markets, but the effects will be felt by the rest of the world giving rise to temporary shortages. These shortages should be overcome in part by capacity increases or new projects in Brazil, Norway, and Canada, but not before major price increases have occurred during the year.

In the immediate future, therefore, it would appear that the market will be tight, for the next six months at least, and for certain flake grades producers will hold trump cards for longer. However, the iron and steel industry is also of a cyclical nature, and the current upsurge in demand cannot be maintained ad infinitum. New capacity will also come onstream in 1989 and 1990 and may fulfil some current shortfalls.

For many years graphite was sold as a specialised item with

World graphite production can be divided basically into two types — amorphous and natural crystalline, and the latter can be sub-divided into flake, vein, and powder.

Amorphous. This is a low carbon source of graphite supplied mainly from Mexico, China, and South Korea. Produced in sizes of approximately five inches or smaller it has a soft, black earthy appearance, which is in contrast to the metallic lustre of well defined crystalline graphite. Technically the description of the graphite as amorphous is not correct, and perhaps microcrystalline would be more appropriate as the graphite is crystalline, but microscopically so. It is graded primarily on graphitic carbon content of which commercial ores contain between 50% and 93% depending on the source.

Crystalline vein is a medium to high carbon graphite, and is sold in lump, chip, and dust forms.

Crystalline flake is another medium to high carbon graphite which, owing to its natural formation, is produced in sizes of around 0.25 inch and smaller. Many countries supply crystalline flake graphite, but the major producers are China and Madagascar.

The other type of graphite produced is **synthetic graphite,** which is manufactured by graphitising petroleum coke or anthracite in an electrical resistance furnace. As a general rule synthetic graphite and natural graphite have different functions, and as such are not competing for the same markets. Exceptions to the rule can always be found, and this is the case with the use of amorphous graphite by US and Japanese steel makers for recarburising, whereas in Europe this function is carried out by ground synthetic graphite.

the specifications agreed between the supplier and customer. Now in a few major applications, particularly in the area of refractories, it has become a commodity item, where deviations in the price are frequently associated with deviations in quality and customers constantly switch between suppliers in attempts to secure the best deals.

Continuous casting and other refractory applications have increased steadily the amount of natural graphite consumed over the last few years. Other major growth areas, particularly in the USA, have been in non-asbestos and metallic brake linings, and gasket materials as replacements for asbestos and carbon composites. In comparison with these growth areas, lost markets for graphite have been minimal.

There also have been some new developments for graphites in ceramics, fire retardant products, and as a filler in high density mouldings. In ceramics graphite is used as a filler to assist increases in density, mostly in carbon composites. Another potential growth area is the use of expanded graphite as a fire-retardant, eg. in foam-filled furniture which combusts easily and gives off toxic fumes when alight. However, unless the price and supply situation of flake graphite eases it could be that research will be directed to other materials. Another developing use of graphite is in high density mouldings, such as those used in defence systems and aerospace applications.

Principal uses of graphite

An idea of the varied uses for graphite is given in the accompanying table of US consumption of natural graphite in 1987. Owing to its unique structure and properties natural graphite has few substitutes and as such finds application in many diverse situations. It is commonly used for one or a combination of the following characteristics –

- lubricity
- low coefficient of thermal expansion
- good electrical and heat conductivity
- it is flexible and sectile over a wide temperature range
- chemically inert and non-toxic
- generally not wetted by metals
- as a carbon source

US consumption of natural graphite by use in 1987 *(short tons)*

	Crystalline	*Amorphous*[1]	*Total*[2]
Batteries	W	W	1,102
Brake Linings	1,627	2,643	4,270
Carbon products[3]	361	219	580
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	1,506
Foundries[4]	436	4,345	4,781
Lubricants[5]	805	3,606	4,411
Pencils	1,857	271	2,129
Powdered metals	461	121	582
Refractories	W	W	8,300
Rubber	130	279	409
Steelmaking	167	1,369	1,536
Other[6]	73	2,487	2,560
Withheld uses	6,559	4,348	–
Total[2]	12,475	19,690	32,165

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Withheld uses".
[1] Includes mixtures of natural and manufactured graphite.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes bearings and carbon brushes.
[4] Includes foundry facings.
[5] Includes ammunition, packings, and seed coating.
[6] Includes paints and polishes, antiknock and other compounds, soldering and/or

As the table indicates the largest amount of natural graphite is used in refractories, with some 8,300 short tonnes (26% of total consumption) consumed by the industry in the USA in 1987. If its uses in crucibles, retorts, stoppers, sleeves, and nozzles are also included this percentage rises to 30.5%. Other major applications include brake linings (13%), foundries (15%), lubricants (14%), and pencils (7%).

Refractories

The principal end-use of graphite is refractory manufacture, in a wide variety of end-products ranging from bricks to crucibles, continuous casting powders to core and mould washes, and hot top compounds. Over the last 20 years two of the most important changes in refractory manufacture have been the introduction, installation, and wide-spread acceptance of magnesia-carbon (mag-carbon) bricks, in steel furnace linings and the growing use of alumina-graphite refractories in continuous casting.

The fortunes of the refractories industry are inherently linked to those of the iron and steel industries. Figures suggest that the iron and steel industry consumes some 70% of all refractory products manufactured worldwide. Since the world recession and following decline in production and consumption of steel in many countries from 1980 through to 1985, the industry has started to pick up again, and production has increased. Having remained static at around the 710m. tonne mark, world production increased in 1987 to 730m. tonnes. The short term outlook for steel is for fluctuations, with more steady growth in production predicted in the long term to rise to an estimated 750m. tonnes.

Production has also increased sharply from 1980 to 1987 in countries that were previously net importers such as China (49.6%), Brazil (45.1%), Republic of Korea (95.3%), India (32.6%), and Taiwan (64.7%). On the other hand, developed countries, with the exception of the UK, had an overall decline in production during this time as can be seen from the table of changes of crude steel production. The table also illustrates the current upturn in production from 1986 to 1987, particularly by countries such as Japan and the USA. The reasons put forward for the increases in the developing countries have been advantageous production costs, including very low labour costs, and the ease of

Change in crude steel production for top 15 producing countries *(m. tonnes, %)*

Order	*Nation*	*1987*	*1986*	*1985*	*1980*	*87/86*	*87/80*
1	USSR	161.4	160.7	154.7	147.9	+ 0.4	+ 9.1
2	Japan	98.5	98.3	105.3	111.4	+ 0.2	–11.6
3	USA	81.0	74.0	80.1	101.5	+ 9.4	–20.2
4	China	55.5	52.5	46.7	37.1	+ 6.3	+49.6
5	FR Germany	36.3	37.1	40.5	43.8	– 2.2	–17.1
6	Italy	22.8	22.9	23.9	26.5	– 0.4	–14.0
7	Brazil	22.2	21.2	20.5	15.3	+ 4.7	+45.1
8	France	17.7	17.9	18.8	23.2	– 1.1	–23.7
9	UK	17.2	14.7	15.7	11.3	+17.0	+52.2
10	Poland	17.0	17.1	16.1	19.5	– 0.6	–12.8
11	RO Korea	16.8	14.6	13.5	8.6	+15.1	+95.3
12	Czechoslovakia	15.4	15.1	15.0	14.9	+ 2.0	+ 3.4
13	Rumania	15.0	14.3	13.8	13.2	+ 4.9	+13.6
14	Canada	14.7	14.1	14.6	15.9	+ 4.3	– 7.6
15	India	12.6	12.2	11.9	9.5	+ 4.1	+32.6
World total		734.0	715.0	719.0	716.4	+ 2.7	+ 2.5

technical transfer to developing countries from developed ones. The i⁀ortance of these developing countries will continue to grow, ıd their market share increase. For refractories this means that there could be potential shortages of certain grades of flake graphite for some refractory manufacture, especially with the advent of mag-carbon brick technology in countries such as China, India, and Brazil as they increase their own internal flake graphite consumption.

Refractory bricks

The major proportion of graphite is used in refractory brick and plastics, particularly in areas of high heat and corrosion "hot spots".

Magnesia-graphite (mag-carb)

There have been three main areas of growth for the use of magnesia-graphite refractories — in basic oxygen steel converters, in electric arc furnaces and slag lines, and in ladles. The first two areas of application are now established in North America, Japan, and Western Europe, and the third is still growing, particularly in the USA. However, the switch to mag-carbon has all taken place in the space of ten to fifteen years, largely at the expense of magnesia-chrome compositions, and world graphite consumption has risen accordingly. The main emerging supply of flake crystalline graphite for use in the bricks was from China, which produced a cheap source of the material and cornered a large market share. In 1976 the country exported approximately 12,000 tonnes of natural graphite. By 1980 this had risen to 38,100 tonnes and in 1986 China's exports totalled some 80,100 tonnes (see section on China).

1. Basic oxygen converters: Since the early 1980s mag-carb bricks have been making inroads into the lining of basic oxygen converters. As temperatures have increased pitch-bonded dolomite and magnesia-dolomite have been replaced by pitch-bonded magnesia, and then by magnesia carbon bricks. The main lining material in basic oxygen steelmaking in the UK is now magnesia graphite and current lining lives are in the order of 1,000–1,500 heats. This can be compared with Japan where linings will be replaced after 2,000–2,500 heats, because casting temperatures and scrap levels are lower than those in the UK. However, it is predicted that with lower casting temperatures refractory lives will increase, particularly if ladle furnaces are introduced into the manufacturing process.

The move towards magnesia-graphite linings has been slower in Continental Europe than the UK, but it has been forecast that the use of magnesia-graphite bricks in Europe will double by 1991–1992 and magnesia-graphite will become the standard lining material. The reason that European manufacturers have not turned to mag-carbon bricks sooner is probably owing to the fact that European dolomite is of superior quality for refractory usage.

2. Electric Arc Furnaces (EAF): As is well recorded, magnesia-carbon bricks in slag-lines and water-cooled side-walls have replaced most of the magnesia-chrome brick originally used. Initially magnesia-carbon bricks, with a carbon content in the region of 8%, were used by the Japanese EAF operators in the mid-seventies. Then, in the late seventies, a second generation of mag-carb bricks appeared which were characterised by carbon levels of between 10% and 30%. With advances in high powered water-cooled electric arc furnaces a notable improvement was required in thermal shock resistance, which was better than that of existing ceramic bonded materials, without sacrificing other properties. Initially used above the slag-line below water-cooled panels, their application has now spread to the slag-line in many plants. The combination of high-conductivity refractories and water cooling has significantly reduced production times. Then, with advances in technology and the growth in continuous casting, secondary steel making and other further refining processes, higher tapping temperatures are now used. Previously tapping temperatures were typically 1,600°C and below for conventional ingot casting. Currently tapping temperatures are around 1,700°C and over in order to provide sufficient superheat for continuous casting and other post-treatment, which obviously require the better refractories.

3. Steel ladles: Traditionally steel ladles have used a wide range of refractory materials, mainly fired and unfired aluminosilicates. With refining and trimming of steels now being carried out in ladles rather than in the furnace itself higher dwelling times and higher temperatures are required. To cope with these more arduous conditions different refractories are being used. This also applies to attempts to improve the economics of lining life and quality of steel produced. BOS shops in the UK still use large amounts of aluminosilicates, although basic slag lines in the form of magnesia graphite are now being used. EAF shops, on the other hand, again in the UK, use doloma linings to a large extent, and to date mainly fired doloma. However, the use of unfired doloma, both with or without graphite additions, has now been shown to be beneficial. The other products finding increasing acceptance in this field are graphite composite products.

Alumina graphite

Alumina graphite refractories are principally used in continuous casting, in shrouding tubes of slab and bloom castors, submerged entry nozles, and also in torpedo ladles. The important properties which the graphite imparts to the alumina refractory are a combination of thermal shock resistance and corrosion resistance.

1. Continuous casting: With the increasing trend towards continuous casting the use of alumina graphite refractories has risen. In most plants efforts are being made to increase the continuous casting ratios, and to achieve this new casters are being installed and other casters updated or modified to increase production.

In Japan continuous casting accounts for more than 90% of the total steel production. In the UK it now accounts for over 60% of steel production and forecasts predict that in the future more casting equipment will be installed. The almost worldwide adoption of continuous casting by protected teeming (ie. the steel is at no point open to the atmosphere) has meant an increase in refractory usage. The alumina graphite shroud conducts metal from the ladle to the tundish and an alumina-graphite/zirconia-graphite sub-entry tube takes the metal from the tundish to the mould. Some of the largest changes in the next few years will be in lining of tundishes. The materials used will change from insulating boards to auto-gunning for labour saving reasons. In general for gunning using tiled linings and the trend is towards usage of higher quality material. For lower tapping temperatures sintered fused alumina can be substituted. Nevertheless, with an absence of appreciable manganese content in the metal, most shrouds and sub-entry tubes contain graphite.

In the area of outlet flow control the refractories used usually differ between slab/bloom casters and billet casters. Alumina graphite is also used for isostatically pressed stopper rods in slab and bloom casters, although recently there has been a trend towards use of sliding gates to replace stopper rods. Material used for shroud tubes for slab and bloom casters is also mostly alumina graphite, especially in Europe and Japan. However, in North America the refractory material used for this purpose is fused silica and alumina. World wide zirconia-graphite products are most widely used in billet casting. The increase in the use of sliding gates is particularly noticeable in Japan, where the plates used for gates are a zircon refractory material, or high alumina carbon bonded or high alumina tar impregnated refractory. There has also been a trend noted towards sliding gates beginning in the USA and Europe, which is another potential area for growth for alumina-graphite refractories.

Reoxidation of the steel is inhibited by the shroud, which invariably contains isostatically pressed graphite. A new development for graphite usage has been in the addition of oxidation inhibitors. Although still at a research stage the incorporation of certain elements into the graphite structure, by changing process variables, namely temperature, can substantially increase its resistance to oxidation. This would enhance the performance of the refractory, and could be made to custom suit the application.

2. **Torpedo ladles:** This is another area where there could be potential growth for alumina-graphite refractories. Currently ladles continue to be lined with conventional aluminosilicate refractories, but in cases where the metal treatment includes desulphurisation and dephosphorisation unfired alumina refractories and/or andalusite graphite refractories are proving cost effective in operation.

Crucibles

Around 40% of flake graphite is thought to be used in crucible manufacture for several sectors including foundry melting of

Specifications for graphite for different applications

Application	*Average carbon content %*	*Average flake size*	*Comments*
Foundries (Amorphous)	40–70	Mesh size BSS 200 to 300	Sulphides deleterious, quartz and mica advantageous.
Crucibles	80–90	+100 BSS mesh	Primarily crystalline flakes, large flake size. Varies — can be typically 75% +30 mesh, 75% +40 mesh or 75% +50 mesh.
Refractory bricks — amorphous	70–80	−0.75 inch and −30 mesh	
— flake (higher quality bricks)	90–97	+80 mesh to +100 mesh (sometimes up to +200 mesh)	Over the last few years a trend has developed using to finer sizes as well as higher carbon materials.
Magnesia-carbon bricks	min 85% optimum 87–90	+150μm to −710μm or 70% on No 210 BSS mesh	Flake graphite used, Aspect ratio should be 20:1 (ie flake length to width). Ash content <2%. but up to 10% sometimes used.
Alumina graphite refractories	min 85%	−30 BSS mesh to +100 BSS mesh	
Expandable graphite	min 90	−10 to +60 BSS mesh	
Brake linings	min 98	−200 BSS mesh	Blends of 60:40 (natural, synthetic) are sometimes used.
Batteries Dry cell	min 88	85% passing. No 200 BSS mesh	Usually ground natural graphite
Alkaline	min 98	−200 BSS mesh — can be to sizes as low as 5μm	Pure natural graphite or synthetic. Requires no impurities such as Cu, Co, Sb, As.
Brushes	95% — more usually 99	ground to a min −100 mesh, usually passes through a No 300 mesh	Usually 99% C as application cannot stand more than a 1% silica and ash impurity.
Sintering	98–99	Average particle size 5μm	Can be natural or synthetic
Lubricants	98–99	No 150–300 BSS mesh	
Conductive coatings (amorphous)	50–55		May contain 20–25% silica.
Core & mold washes			
flake	80–90	particle size	
amorphous	70–80	200 mesh	

steel and in non-ferrous and precious metal metallurgy. Flake graphite is utilised because the large flake size improves thermal conductivity and thermal shock. A large flake size also facilitates bonding between clay and other materials during the manufacturing process. Other valued properties of the flake graphite include its flakiness, lightness, pliability, and burning rate. (The burning rate determines the effective life of a crucible). Purity of graphite for use in crucibles is not such an important parameter. However, the type of ash present may be deleterious, because if the ash is too alkaline the crucible life may be foreshortened owing to difficulties in standing up to melt conditions.

The most significant development in crucible manufacture technology is the move to flexibility in the types, flake sizes, and quality of graphites utilised. Another major development is replacement of traditional clay-graphite crucibles by silicon carbide-graphite crucibles. This occurred at the same time as the introduction of isostatic pressing technology for the steel industry in which a smaller flake size could be used. In the clay-graphite crucibles about 45% was made up of large flake graphite which had a carbon content of approximately 90%. After the introduction of carbon-bonded silicon crucible it was found that only 30% of make-up had to be medium to large flake, and the required carbon content of the graphite fell to 80%. The smaller sized flakes also increased the strength of the final product, when graphite was a predominant component in the mix.

Foundries — graphite coatings

Graphite has traditionally been used as a refractory coating in the foundry industry. When mixed with bonding agents such as refractory clays, sand, talc, and mica it provides a smooth finish to the surface of the mould. This prevents the metals from adhering to the mould, thus allowing the castings to be easily removed on cooling, and also reduces subsequent machining and finishing costs. The purity of the graphite used varies considerably and can be anywhere from between 40% to 70% carbon, and is typically 200–300 mesh BSS. As such, amorphous graphite is sometimes used, along with cheaper reground rejected graphites. Sulphur is considered a deleterious material, along with any other fusible minerals, whereas other minerals such as quartz and mica are looked upon as advantageous.

For further reading on the use of graphite in refractories see Graphite drawing on mixed sources, (IM, July '84, p. 37) and Graphite in Refractories (IM, May '86 supplement, p. 19).

Non-refractory applications

High carbon crystalline powders are used in several applications such as brake linings, batteries, brushes, and sintering, and other graphite powders are used in lubricants, conductive coatings, and expandable graphites. Amorphous graphite is mainly used for the manufacture of mechanical engineering components or in the recarburisation of steel particularly in the USA and Japan.

Brake-linings. Beneficiated natural flake and vein graphite are both used in the manufacture of brake linings. With replacement of asbestos over the past few years the graphite component has risen from 1–2% to 15% in some cases eg some semi-metallic linings. However, in some applications such as drum brakes asbestos has been hard to replace and research is still going on to find the best substitute. The brake-linings market for graphite will continue to grow but will reach a peak in the not too distant future as most substitutions possible have already been made. Generally, the amount of graphite used in this end-market follows the economics of its parent, the automotive industry.

World production of graphite *(tonnes)*

Country	*1983*	*1984*	*1985*	*1986*	*1987*
West Germany (b)	12,000	12,400	12,800	13,200	13,600
Austria (a)	40,418	43,789	30,764	36,167	39,391
Czechoslovakia	26,666	27,000	35,000	25,254	—
Norway	8,063	10,067	2,684	—	—
Romania	12,600	12,400	12,000	12,000	12,000
USSR	80,000	80,000	82,000	83,000	84,000
Turkey	4,805	—	—	3,586	11,760
Madagascar	13,496	14,155	14,700	16,188	13,168
Zimbabwe	19,862	12,334	10,450	15,004	13,530
Mexico	44,327	41,529	35,378	37,780	37,000
Brazil (d)	27,636	32,680	43,664	47,000	—
Burma (c)	272	234	200	200	—
China	185,000	185,000	185,000	185,000	185,000
India	42,778	39,106	33,586	40,483	26,864
North Korea	25,000	25,000	25,000	25,000	25,000
South Korea	33,266	58,563	71,479	97,218	99,765
Sri Lanka	5,768	5,768	7,472	7,453	9,400
World total	584,000	605,000	607,000	645,000	643,000

Notes:
(1) This table includes all forms of amorphous and crystalline graphite but excludes synthetic material
(2) In addition to the countries listed, Canada, Egypt and Namibia are also believed to produce graphite
(a) Crude
(b) Including production from imported crude graphite
(c) Years ended 31 March following that stated
(d) Including beneficiated and directly shipped material
Source: British Geological Survey, World Mineral Statistics

Batteries. A move towards rechargeable nickel-cadmium batteries has meant that the use of graphite in batteries has not developed much over the last few years. It is traditionally used in the dry cell zinc/carbon batteries, but these have been superseded to some extent by alkaline-manganese batteries which do contain some but small amounts of graphite. Therefore this is not thought of as being a developing market for graphite with the growth in rechargeable batteries.

Brushes. Various combinations of natural and synthetic graphite are used in the manufacture of carbon-bush grades according to the end use of the brushes.

Sintering. This uses high-purity graphite which is mixed with metal powders in a dry metal form and heated into specific shapes, for example cog-wheels.

World production of graphite

As can be seen from the accompanying table of production of graphite by country, the three countries with the highest output include China, the USSR, and South Korea. However, the country which has brought most influence to bear on the market over the last ten years has been China. Other major producers include Mexico, Brazil, Austria, India, and North Korea with established graphite producing countries such as Madagascar, Sri Lanka, Zimbabwe, and West Germany not far behind. Potential producers include Canada with several deposits currently under evaluation, and in the coming year Norway will be producing again. In addition capacity increases have also been announced for plants in India.

All the graphite producers are net exporters to varying degrees at the present time, with the exception of the Eastern Bloc countries, where almost all graphite production is consumed internally. Japan and the USA are the largest importers of graphite with imports of 94,268 and 43,335 tonnes respectively in 1987.

The producing countries

China

The map on p.35 of China shows the four areas in which graphite production takes place — Inner Mongolia, Heilongjiang, Shandong, and Shanxi.

Shandong Province
This is the oldest and largest producer of flake graphite in china with an annual production of 60,000 tonnes. There are three main mines in the province namely Nan Shu, Bai Shu, and Dong Guan, the largest of which is reportedly Nan Shu. Nan Shu produces approximately 20,000 tpa of flake graphite which grades 85–99.5% carbon. Mining is opencast and reserves have been estimated at 1.5m. tonnes of graphite. Nearby, to the south of Nan Shu, is Bai Shu Mine which has an annual output of around 15,000 tonnes. Besides the principal operation there are a number of smaller mines in the area that work on a joint venture system in several communes. Bai Shu mine purchases graphite from these smaller operations after grinding and some primary flotation has been carried out. Further processing is carried out at Bai Shu plant. Bai Shu is also China's main source of exfoliated flake graphite, which is now increasingly being used in sealing rings and brake linings. The third mine, Dong Gaun, is much smaller with quarrying being carried out in a number of small pits in the area.

NGS
Buying Graphite is a Matter of Confidence...
Good Graphite
is graphite at a good price, constant quality level, precise delivery performance, with properties fitting best to the products...

Graphite Consumers
producing professional products don't just want to buy graphite but expect more from their supplier. We offer consultant service supported by our graphite labs to graphite consumers and producers, as well as to machine suppliers to graphite industry.

TAMIL NADU MINERALS LIMITED
Graphite
Tamin proposes to market flaky graphite concentrate with fixed carbon ranging from 85% to 96% from the year 1990.
The size range of graphite flakes will be from -28 mesh to +400 mesh.
The capacity of the beneficiation plant will be ABP+ about 9,000 tonnes per annum.
Granite
Tamin exploits world famous black granite comparable to ebony black of Sweden.
For further particulars, please contact:
The Managing Director,
Tamil Nadu Minerals Limited, 31 Kamarajar Salai

Selected imports of graphite *(tonnes)*

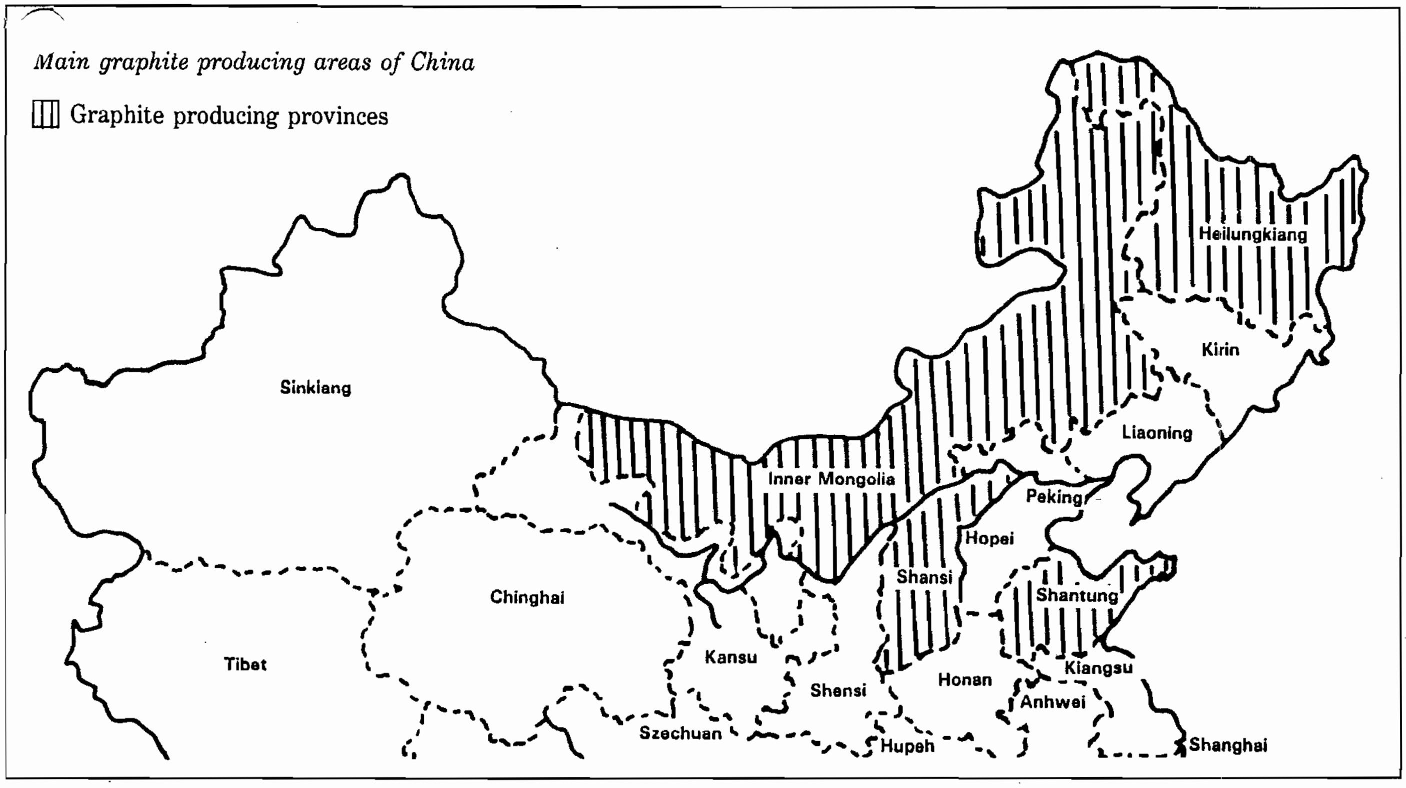
Country	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
United Kingdom	17,862	28,352	19,540	23,460	23,101	19,729
France	4,677	3,662	4,578	5,277	5,572	5,864
West Germany	32,432	28,869	31,983	33,998	37,793	30,504
Italy	5,137	4,104	6,280	5,955	6,867	. . .
Netherlands	863	564	954	636	1,204	1,726
Spain	2,446	1,905	2,004	2,519	3,993	. . .
Austria	2,653	3,738	7,134	3,280	4,966	2,083
East Germany	7,945	6,359	5,712	6,634	5,289	. . .
Poland	6,775	6.688	7,445	6,082	3,929	. . .
Yugoslavia	1,854	2,996	2,220	2,267	2,234	2,415
South Africa	1,630	2,129	4,122	3,834	2,751	. . .
Mexico	363	196	14	46	—	. . .
USA	48,217	39,540	52,840	47,842	38,817	43,335
Venezuela	737	594	701	927	681	. . .
Hong Kong	549	494	1,545	1,499	3,685	4,104
India (b)	130	—	—	—	—	—
Indonesia	231	161	98	150	968	. . .
Japan	53,138	54,195	85,009	78,857	58,645	94,268
Korea, Republic of	414	443	1,260	1,084	3,180	. . .
Malaysia	531	834	1,183	908	510	. . .
Pakistan (a)	986	1,418	1,777	1,566	845	2,630
Taiwan	7,942	10,957	6,574	8,428	8,513	8,390
Australia	1,429	796	979	1,199	1,460	. . .

Note: This table excludes synthetic graphite.
(a) Years ended 30 June of that stated
(b) Years ended 31 March following that stated
. . . Figures currently unavailable
Source: British Geological Survey, World Mineral Statistics

Selected exports of graphite *(tonnes)*

Country	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
UK	2,956	3,123	3,862	2,563	3,739	3,184
West Germany	10,030	9,978	12,210	11,522	9,844	10,287
Austria	13,384	11,406	11,552	11,826	10,284	8,330
Czechoslovakia (a)	2,000	3,000	2,800	3,100	2,800	. . .
Norway	8,244	7,311	8,888	6,161	954	56
USSR (a)	400	600	—	—	—	. . .
Madagascar	14,875	11,685	14,527	16,125	13,595	. . .
Zimbabwe	—	9,720	11,989	15,440	14,700	12,503
Mexico	28,428	19,420	21,323	19,298	—	. . .
USA	9,528	8,729	6,667	9,240	13,089	15,000
Brazil	5,395	5,578	5,082	8,725	9,890	. . .
China (a)	59,000	55,200	78,800	71,800	80,100	. . .
Hong Kong (Re-exports)	188	53	856	508	3,036	3,781
India (b)	2,069	1.187	1,871	1,043	—	. . .
Japan	2,084	2,515	2,927	2,553	2,666	2,019
North Korea (a)	7,000	2,200	11,000	5,800	4,600	. . .
South Korea	21,757	32,694	39,864	48,353	30,969	. . .
Sri Lanka	2,903	4,223	7,215	9,170	9,824	10,388
Taiwan	352	100	237	188	204	178

Note: This table excludes synthetic graphite. . . . Figures currently unavailable.
(a) BGS estimates, based on known imports into certain countries
(b) Years ended 31 March following that stated
Source: British Geological Survey, World Mineral Statistics



Main graphite producing areas of China

Source: W. B. Hill – China, a source of flake graphite for the refractories industry, Proceedings of the 7th Industrial Minerals International Congress, Monte Carlo, 1986.

Heilongjiang Province
In this province the main production mines are located close to the Sino-Soviet border, to the east of the provincial capital of Harbin and near to the town of Jixxi. There are three major producing mines — Liu Mao, Lin Mine, and Moshuan Mine — which produce a total of 30–35,000 tpa of graphite and carbon black products. Liu Mao Mine produces 10–12,000 tpa of 70–90% carbon flake graphite and reserves at the mine are estimated to be some 12m. tonnes.

Shanxi Province
Total production from Shanxi Province is 5–6,000 tpa from two mines, Guodian and Deisheng, located in the north of the province near the town of Datong. Production capacity is approximately 5–6,000 tpa of graphite grading 80%, 85%, and 90% carbon.

Inner Mongolia
Annual production from the province is in the region of 8–10,000 tonnes and is derived mainly from the Xing Ho Mine. Graphite is produced grading 85–95% carbon and reserves at the mine have been put at 1.4m. tonnes. During the winter months production is sometimes curtailed owing to the harsh conditions.

With roughly a 30% share of world production China has a dominating influence on the world graphite market, particularly in supply of flake graphite to the refractory industry. When China first came into the world market its low production costs undercut existing suppliers of flake graphite and Chinese material soon carved a sizeable market niche. However, over the last year various factors have come into play which mean that exports have been reduced and prices have risen. World demand and increased internal consumption are two factors, others include recent droughts and infrastructure problems. Output of Chinese iron and steel was 55.5m. tonnes in 1987, up from 46.7m. tonnes in 1985, and some 49.6% since 1980. Consequently refractory production has increased in line with this, and thus more graphite has been consumed domestically. China currently has its own internal problems with high inflation, and as such the price of graphite for domestic consumers has risen accordingly. This has had a knock-on effect to the prices of exported graphite, which have also incorporated increases in freight costs.

The Chinese are also in the process of implementing a centralisation policy for the sale of graphite. This will mean that customers will not be able to buy graphite from a particular mine source, but from a central agency which will supply the various grades and mesh sizes. However, this policy is not finding too much favour with the refractory buyers as often graphite from one deposit will differ in shape, chemical impurities, and other parameters that are unique to the one location. However, with the increased use of blended grades in much refractory manufacture this will not present so great a problem as in years past when particular recipes for refractory manufacture were based on graphites from one source.

India

Production from India has declined over the last five years from a total in 1983 of 42,778 tonnes to around 26,864 tonnes in 1987, although the country is still one of the major producers of graphite. Reserves in India have been estimated to be approximately 180m. tonnes of mostly amorphous graphite. The two most important producing states are Rajasthan and Orissa, but graphite is also produced in the states of Andhra Pradesh, Bihar, Gujarat, and Tamil Nadu. Currently there are approximately 20 producing mines in Orissa State, largely located in the Bolangir district.

The most significant producing companies in India include *Agrawal Graphite Industries, Sri J. M. Graphites Mining and Manufacturing Co.,* and *TP Minerals Pvt Ltd.* Agrawal Graphite operates several mines at various locations at Ganjaudar and Temrimal, Orissa State, which have a total capacity of approximately 16,000 tonnes run-of-mine ore. The company runs a processing plant at Chacherbeng in the Belpara district, Bolangir. It also operates another processing plant through an associated company, *Gandhamardan Graphite Udyog,* at Menkamunda in Sambalpur district. At the latter plant there are facilities for crushing, grinding, and flotation and the company produces a range of crystalline flakes and powders in various mesh sizes. Total combined capacity from the plants is 4,800 tonnes and current output is in the order of 350 tpm. The graphite is then mainly sold for use in crucibles, mag-carbon bricks, founddry fluxes, steel production, batteries, lubricants, and brake linings. Agrawal Graphite is currently planning to expand both its graphite processing facilities so that it will have a total capacity of 6,000 tpa.

TP Minerals Pvt Ltd also operates mines in Orissa State located at Madagudarf, Phulbani, and Sargipali, along with three processing plants at the same sites. Total mine production is an estimated 12,500 tpa of graphite ore, from which the company produces approximately 3,000 tpa flake and powdered graphite. Main market outlets include refractories, fluxes, crucibles, carbon rods, and pencils. TP Minerals is also planning to expand through the opening of a new mine and the addition of further processing equipment, although further details are currently unavailable.

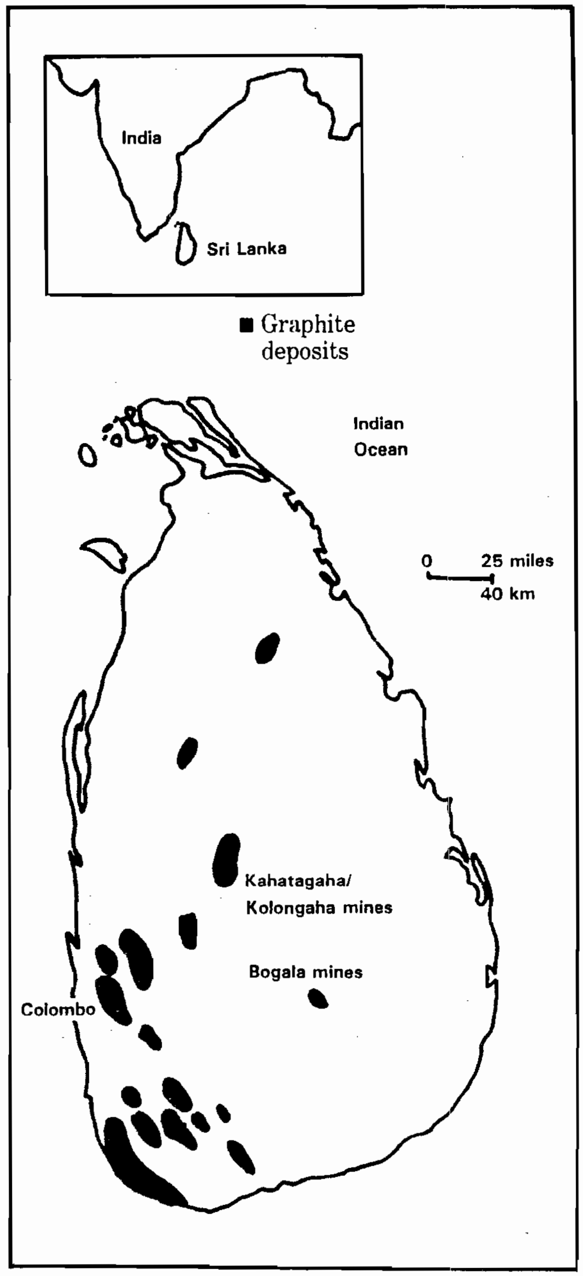
J. M. Graphites Mining and Manufacturing mainly supplies the domestic foundry industry in the Punjab, refractory crucible requirements in Andhra Pradesh, pencil manufacturers, and the steel industry. The company operates a number of mines in various locations in Bolangir, Kalahandi, and Koraput in Orissa as well as numerous mining leases. The company controls around 150 leases with the mines operating between 20 and 25 leases at a time. The graphite is surface mined often by labour intensive hand-picking methods.

Tamil Nadu Minerals Ltd of Madras is proposing to establish a graphite beneficiation plant for its mine located in Sivanganga Taluk, Pasumpon Murthuramalingam District of Tamil Nadu State. The company intends the plant to be on line by 1990. Currently the mine produces 28 tpd of graphite concentrate, approximately 10,000 tpa, which has a carbon content of between 96–99%.

Sri Lanka

Sri Lanka is one of the long established producers of high quality, microcrystalline vein material with a history of graphite production stretching back 160 years. Over the last five years production has increased gradually from 5,768 tonnes in 1983 to 9,400 tonnes in 1987. This is because former problems with equipment failure, worn machinery, and also rationed hydroelectric power, have largely been overcome. Exports of graphite also rose to a total of 10,398 tonnes exported in 1987 compared with 9,824 tonnes in 1986. This was despite internal difficulties in 1987 caused by drought and ethnic conflicts which slowed down economic development and damaged transport and communications infrastructure.

Location of State Mining and Mineral Development Corporation's graphite mines in Sri Lanka



Source: Dissanayake 1981, adapted from Geology of the Non-Metallics by Peter W. Harben and Robert L. Bates

ASBURY

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Carbon: *Up to 99.9+%*

Nearly all mining is carried out by the *State Mining and Mi— Development Corporation (MMDC)* which operates two mine ne locations of which are indicated on the accompanying map. The company formerly operated three mines, but two of these have been merged to form one concern. MMDC was established in 1971 as part of the government's policy of nationalising all basic industries. The largest of the two mines is located at Bogala at Aruggammana, Kegalle District, about 50 miles from Columbo, and has a production of some 5,000 tpa accounting for nearly 60% of total production. The other mine, Kahatagaha/Kolongaha, is situated in Kurunegala District at Dodangaslanda and has a production of around 3,600 tonnes.

The company produces various grades of graphite with 80% to 99% carbon. Flakes (−10 mesh +60 mesh) and flake type (−40 +100 mesh) are manufactured artificially using natural graphite to be aimed at the mag-carbon bricks industry, particularly in Japan and the USA. Other major export markets include the UK, Australia, West Germany, Poland, and France. For future developments the company is looking at modernising and expanding its existing facilities to increase production to meet the currently continuing growth in demand. The Asian Development Bank has been reported to be looking at the possibility of granting assistance to the MMDC to develop new mines and for modernisation.

istan

T only company reported to be producing graphite in Pakistan *lack Mountain Mineral (Pvl) Ltd* which operates a mine in bon, Mansehra, NWFP. The operation has an annual output of ome 3,500 tonnes of graphite of 92% carbon.

Reserves have been delineated by the *Azad Kashmir Mineral and Industrial Development Corp.* about 100 miles north-east of the city of Muzaffarabad. Proven reserves are in the order of 1m. tonnes with another 8m. tonnes inferred containing 10–12% carbon. The company has carried out some testwork and pilot plant studies suggest that flotation would produce an 84% concentrate.

Korea

Korea has traditionally been an important supplier of graphite. However, in recent years exorts from North Korea have declined drastically from an estimated 23,700 tonnes in 1979 to 4,600 tonnes in 1986. This again will have been due in part to an increase in internal consumption of graphite for steel. South Korea has always been a major producer and in the last four years production had risen from 33,266 tonnes in 1983 to 99,765 tonnes in 1987, and is now back at levels last recorded in the 1950s.

Exports, on the other hand, have varied from 39,864 tonnes in 1984 to 48,353 tonnes in 1985 and down to 30,969 tonnes in 1986 Graphite is mainly exported to countries in the Far East, particularly Japan, Taiwan, and Indonesia. Export levels for 1987 are also expected to be low as production of steel in South Korea was up 15.3% in 1987 from the previous year owing to domestic economic growth, and therefore more graphite will have been used internally. Japanese manufacturers have also started to produce Mag-carbon bricks in South Korea because of lower production costs there, and this too will result in lower apparent exports of graphite.

The main reserves of graphite in South Korea are amorphous, although some work has been carried out on minor deposits of crystalline flake graphite. This has led to the existence of a number of short lived operations of marginal viability. Principal deposits of graphite are located in the provinces of Shung Chong Puk Do, Kiong Sang Puk Co, and Kang Won Do. Reserves of flake graphite are estimated to be between 1m. and 1.5m. tonnes averaging 80% carbon, and those of amorphous graphite to be between 2.5m. and 3m. tonnes with an average grade of 75% carbon. Amorphous graphite occurs as irregular lenses parallel to the structure of enclosing schists and phyllites of sedimentary origin and are mostly located near to anthracite coal deposits.

Austria

Nearly all the graphite produced in Austria is amorphous with production in Austria in 1987 standing at 39,391 tonnes of crude graphite. This places Austria as the leading producer of graphite in Western Europe, followed by West Germany. Most of the production is carried out in two different mineralogical regions, Steiermark (Styria) and Neiderösterreich (Lower Austria).

Grafitbergbau Kaiserberg Franz Mayr-Meinhof & Co. produces some 14,000 tpa, and expects the same level in 1988, from its mine at Kaiserberg-Leims, near St Michael. Processing facilities consist of drying, classification, milling, flotation and fine grinding and the product is mostly amorphous graphite. The company sells graphite for many different uses including iron and steel, blackening, coal reclamation, covering material for acid, fire retardent applications, and paint and lacquering industries. Some graphite is also sold for use in lubricants, the replacement of asbestos in brakes, the plastics industry, offshore engineering, and in anti-static floor coverings. Around 90% of the company's products are exported, mostly to EEC and COMECON countries. However, some highly refined products are exported to third world countries. Besides traditional iron and steel applications Grafitbergbau is now promoting graphite as an additive for high technology products. The company is also planning an expansion of its fine grinding and flotation facilities and the construction of a new laboratory.

Another Austrian company with graphite interests is *Industrie und Bergbaugesellschaft, Pryssok & Co. KG* which operates opencast mines at Muehldorf, Spitz, and Donnau. Production is approximately 30,000 tpa of microcrystalline graphite grading 50% carbon. All production is sold to the Austrian steel industry,

Production · Import · Export · Stockpile

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with the only processing carried out being crushing and screening at nine site. Currently the market is small owing to very low prices of oil and coal, whereas otherwise graphite is used as a carbon substitute in the blast furnace. This also means that prices charged for the graphite tend to be parallel to oil and coal prices.

West Germany

The only producing graphite mine in West Germany is located in Bavaria, east of Passau, and close to the Austrian and Czechoslovakian border. *Graphitwerk Kropfmühl AG,* the owning company operates the oldest graphite mine in the world. The deposit was being mined by the Celtic people around 800 BC. It wasn't, however, until the Middle Ages that graphite mining was restarted when Passau was the centre of the crucible industry. Grafitwerk Kropfmühl was established in 1916 and today sells a full range of flaky graphites from cheap powders of 60% carbon to high purity grades of 99.99% carbon and also micronised grades. The company now has total annual sales in the region of 16,000 tonnes, half of which goes into the refractory industry mostly to Europe. Apart from the mines and processing plant at Kropfmühl the company also operates a processing plant at Werk Wedol in Holstein.

An associate company of Grafitwerke Kropfmühl producing graphite products in West Germany is *Richard Anton KG* of Graefelfing, Munich. The company is 50% owned by Kropfmühl and operates three production plants in Obernzell, Mannheim, and Hagen. Total capacity of the plants is 40,000 tonnes and graphite is sold to steel works, foundries, refractories, lubrication and friction material industries, as well as into the dyeing and chemical industries.

Norway

A/S Skaland Grafitwerk is the only producer of graphite in Norway, and one of only two producers of flake crystalline graphite in Europe. The company mines a deposit located on the island of Senja, in the far north of the country and just south of the town of Tromso. Reserves of the deposit are estimated to be over 1m. tonnes of crude flake ore that contains 25–30% carbon. Until April 1985 mine capacity was in the region of 40,000 tpa, and plant capacity was 10,000 tpa of an 88–90% concentrate. However, production was halted in April 1985 because of a fire which burnt down the processing plant, although warehousing and the mine area remained intact.

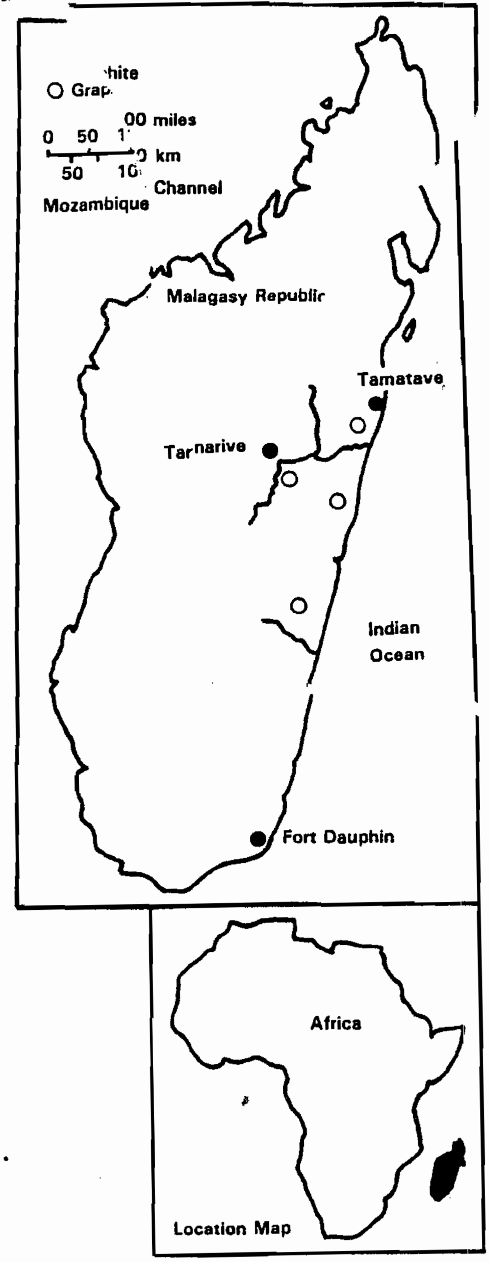
After this incident Skaland continued with its geological exploration and drilling programme which looked at surface deposits within a few kilometres of the old mine. In July 1986 the go-ahead was granted for a new processing plant and this is currently under reconstruction. The new plant will operate with a total output of 10,000 tpa, 60% of which is expected to have a 98% carbon content and is expected to be on stream in the next year.

Madagascar

Madagascar, the Republic of Malagasy, produces graphite of a high quality crystalline flake. Although tonnages produced and exported are small the importance of the graphite is its crystalline flake form. The graphite produced is noted for its uniform thickness, toughness, and cleanness, and is only produced in sizes of approximately 0.25 inch and smaller. Production in 1987 was 13,168 tonnes, down on the previous year's total of 16,188 tonnes, although demand for Madagascan graphite remained strong and until the beginning of 1988 prices had remained steady. Some of the decline in production is reported to be due to increased maintenance on ageing plant.

Five companies are currently producing graphite in Madagascar, with the main production area situated between

Graphite dep)sits of the Malagasy Republic.
From Murd(ch, 1963.



Source: Geology of the Non-metallics by Peter W. Harben and Robert L. Bates
Reference: Murdoch, M. T., 1967, "Mineral Resources of the Malagasy Republic", US Bureau of Mines Inf. Circular 8196

Tamatave and Marovintsy. All the companies are headquartered in Tananarive, the capital of Madagascar. The largest of the five is *Société Minière de la Grande Ile,* and the other four are *Etablissements Gallois, Société Louys, Etablissements Izouard* and *Etablissments Rostaing.*

Zimbabwe

The Lynx mine in Zimbabwe is located between the capital Harare and Lake Kariba and is operated by *Zimbabwe German Graphite Mines (Pvt) Ltd.* The graphite occurs in a medium hard rock and has an average carbon content of 35%. The deposit stretches over 3km but presently only one part is mined, and mining is carried out on four different levels. The monthly capacity of the plant is 1,500 tonnes of concentrate which has a carbon content of between 85% and 94%. Some 50% of the production is flake graphite and the rest is sold in powder form. All sales by the company are through the *Minerals Marketing Corporation of Zimbabwe.* Two companies hold a 50% interest in Zimbabwe German Graphite Mines and these are Graphitwerk Kropfmühl AG and the *Zimbabwe Mining Development Corp.*

Brazil

In 1986 an estimated 47,000 tonnes of graphite was produced in Brazil (including beneficiated and directly shipped material) of which by far the largest producer of crystalline flake was *Nacional de Grafite.* The company operates surface mines in two areas of the country, Itapecerica and Pedra Azul, both in Minas Gerais State. Pedra Azul is located approximately 10 miles from the border with Bahia State, and almost all remaining production in Brazil is from the southern area of Bahia State.

Nacional de Grafita is head-quartered in Itapecerica, which is the location of the older mine. The ore is located in pockets spread over an area of approximately 50 square miles. The pockets have an average grade of 20% carbon and are sufficient to yield the necessary annual tonnages of ore in approximately three to four months, since it requires no blasting and is removed by front end loader. From this mine a variety of natural flake and powder grades are produced, and the company planned to have a 6,600 tpa capacity leaching plant on stream by the beginning of 1987 to produce a high purity carbon graphite of 99.6% C. The company's other mine, Pedra Azul, is newer and larger than Itapecerica and produces some 660,000 tpa of crude ore. Here too the company is carrying out an expansion programme to produce a further 56,000 tpa of ore which is scheduled to begin in mid-1991. In addition to known reserves, a new deposit of graphite has been delineated about 30 miles south-east of the present operations.

Around 95% of Brazilian production originates in Minais Gerais State, with the balance made up from Bahia State. However, the graphite produced from Bahia State was almost all consumed as foundry facings without prior beneficiation. Of the rest of the country's production, about 21% was exported in 1986 and a large proportion was consumed in the iron and steel industry and refractory industry. Brazil also manufactures mag-carbon bricks, expanded graphite, and continuous casting ware.

Mexico

Mexico is one of the most important sources of amorphous graphite in the Western Hemisphere and also has a significant deposit of crystalline graphite in the State of Oaxaca in the south of the country. Annual production has declined over the last four years, from a total of 44,327 tonnes produced in 1983 to a level of 37,000 tonnes recorded in 1987. Production of graphite in Mexico is very much influenced by the USA, as approximately 50% of the amorphous graphite imported into the USA is from Mexico, as can be seen from the table.

These exports represented some 55–60% of the total graphite production in Mexico in 1987. US influence is also felt at the producing end as several of the companies are either owned by or associated with US companies. However, with the upturn in the steel industry in the USA the market for the Mexican amorphous graphite is improving after the decline suffered during periods of rationalisation and production cutbacks in the USA.

Internal consumption of graphite is also growing in the domestic steel industry, with an estimated output of 7.4m. tonnes of raw steel in 1987, up some 3.4% on 1986. The demand for graphite last year in the steel and foundry industries was reckoned to be in the region of 20,000 tonnes.

Amorphous deposits of graphite have been recorded in the state of Sonora for over 100 years, and the area is still the main source of the material. Recently the discovery of a new deposit in an area up to 60 miles east and 100 miles south of the original

US imports of graphite *(short tons, %)*

	Imports of natural graphite			
Country	*1985*	*%*	*1987*	*%*
Brazil	5,092	11	4,763	12
Canada	340	1	548	1
China	11,054	23	9,837	24
West Germany	907	2	269	1
Madagascar	1,819	4	1,325	3
Mexico	21,354	47	20,713	50
Sri Lanka	1,654	4	1,402	3
Other	3,237		1,733	
Total	46,838		41,194	

* Excludes crystalline flake, but includes lump graphite, amorphous graphite, and fine crystalline flake

Source: US Bureau of Mines

Several mining companies are active in the region the largest of which is *Grafitos Mexicanos SA* which produces from various mines in the area and has proven reserves in excess of 0.76m. tonnes. Associated with Grafitos Mexicanos is *Grafitera de Sonora SA de CV* which operates San Francisco Mine located approximately 56 miles north-east of Guayamos in Sonora. Currently the conmpany is extracting approximately 1,000 tpa of crude graphite. Grafitos Mexicanos also acquired the rights and assets of *Cia Minera Moraguirre SA de CV,* a company that was closed down in 1983, but now is operating again under the name *Cia Minera Moradillas SA de CV.*

Both Grafitos Mexicanos and Grafitera de Sonora are 49% owned by *Asbury Carbons Inc.* of the USA. Asbury Carbons also operates a processing plant at Torres through another subsidiary company, *Grafitos Industrializados Mexicanos SA de CV (Gravimex).* Recently upgraded to meet growing domestic and export demand, the plant has a capacity of 30,000 tpa and treats the ouput from all the mining operations. Most of the output from Torres is destined for refractories and the recarburising industry, although some is subsequently transported to other Asbury Carbon's subsidiary companies in the USA, namely *Asbury Graphite Mills Inc.* and *Cummings & Moore Graphite Company.* The Grafitos and Grafimex interests together account for almost 80% of Mexico's amorphous graphite output in 1987, of which the company exported approximately 45%.

Grafito Superior SA, 49% subsidiary of Chicago-based US company *Superior Grapite Co.,* also operates in the Sonora area. The company has two underground mines, with a combined production total of 7–10,000 tonnes of crude graphite, which are located at Hermosillo and Navajoa. Ore from these two operations is processed at Torres and a variety of grades produced for the domestic and US markets. Two underground mines are also operated by *Explotadora Sonorense de Grafito Srl* at Tonichi and Las Trincheras. These two mines have an annual production in the region of 7,000 tonnes.

Crystalline graphite is produced by *Grafito de Mexico SA* from its Telixtlahuaca mine in the state of Oaxaca. The company produces approximately 50,000 tpa of crude ore and from that around 2,000 tpa of crystalline flake concentrate. However the company is currently expanding its flotation and milling facilities and is aiming to double the plant's output to 4,000 tpa of crystalline graphite by the end of 1988. The expansion has the joint objective of reducing Mexico's dependence on imports of flake graphite and should also generate foreign exchange. At present the company produces four grades — A (+48 mesh) for refractories and crucibles, B (−48 mesh) for pencils, lubricants, brushes and paints, blend AB, and O grade (−325 mesh) for pencils. All the grades have an average of 93.76% carbon, and O

The other company involved in Oaxaca State is *Minerales No Metalicos SA* which has conducted a pre-feasibility study on a 10,000 tpa capacity plant. The proposed plant will have three products large flake (98%C), large flake (92%C), and medium and small flake (88%C) and is intended predominantly for export to the USA. To date proven reserves of 8.3m. tonnes of 3.9–4.5% C have been delineated. Smaller pockets of 6.8–10% C have also been recorded and these will be used to enrich the ore. The project represents a total investment of some $4.7m. from three companies that are as yet unidentified. If the project receives a green light then it is expected to begin production at the end of 1989.

North America

The only producing graphite mine at the time of writing in Canada and the USA is operated by *Graphite Asbury Quebec Inc.*, a subsidiary of *Asbury Carbons Inc.* The flake graphite mine is in Notre Dame du Laus, Quebec, and has been operational for the last six years. In recent years Asbury Carbons has modernised the facility and cut the work force by 30% whilst increasing production, and also increasing the flake quality to over 90% carbon. Additionally the company has increased the production of +100 mesh flakes from the plant.

Asbury Carbons Inc. is the holding company not only for graphite mining operations in Canada and Mexico but also several graphite processing and manufacturing companies based in the USA. *Asbury Graphite Mills Inc.* includes processing plants at Asbury, New Jersey, and Bethlehem, Pennsylvania. However, the company's most modern and largest facility is at Kittanning, Pennsylvania, which was completed two years ago. Kittanning has processing facilities for screening, blending, drying, and grinding of graphite and cokes, along with other speciality carbon types. It also has its own barge loading facilities at the plant, which are on the Mississipi River system. The company recently invested in a new laboratory for quality control at the Asbury plant and has adopted computerised statistical process control systems at all three plants.

Another subsidiary of Asbury Carbons is *Cummings & Moore Graphite Company,* which is located in Detroit, Michigan, and again operates processing facilities for raw materials and finished graphites. On the west coast, Asbury Carbons has consolidated all its operations into one plant at Rodeo, California, operated by *Asbury Graphite of California Inc.* At this plant the company has increased capacity of crushing, screening, and grinding operations for both graphite and petroleum cokes.

Superior Graphite Co., based in Chicago, also imports graphite from its associate company in Mexico and is a major processor of graphite in the USA. The company operates plants in Chicago and Hopkinsville, Illinois, and has interests in the development of engineered graphite materials and advanced ceramic products. It originally patented a high temperature continuous processing system in 1977, and since then has developed high purity carbons and graphites with modified or improved properties which are now finding use in the manufacture of structural ceramics and advanced refractories.

There is still considerable interest in the development of several potential deposits in Canada in Nova Scotia, Ontario, and Quebec. *Cal Graphite Corp.* is undertaking a C$1.1m. exploration programme and mining project at Graphite Lake, Ontario which, at time of writing, is nearing completion. To date approximately 29m. tonnes of coarse flake graphite ore have been delineated with a carbon content of between 2.5% and 3.5%. However, a new report prepared by the consulting geologists has recorded proven and probable reserves that are nearly double those initially proven. Public access roads and internal mine roads are now in place and construction work has begun on the mill building. This work is due to be completed by the end of December 1988 and equipment installation, including the 5,000 tpd mill, will be put in place over the winter months. This is slightly later than originally planned because engineering design changes had to be incorporated into the process flowsheet to satisfy enviromental concerns. Start up of the plant is now aimed for early spring 1989. According to the company's mining plan, the outcrop orebody will be mined down to lake elevation during the first five years, after which the company will proceed with opencast mining using an independent contractor. Production rates will start at an initial 1,000 short tons and be increased until eventually the plant is operating at a full production rate of 5,000 tpd.

In July 1988 Cal-Graphite purchased 71 acres of land in Walden, near Sudbury, Ontario. Construction of the company's head offices and research facilities has already begun on the site and the research facilities will be used to further develop refining processes to upgrade the graphitic carbon content for speciality markets. The company is represented in the market place by *Amalgamet Canada*, a division of *Premetalco Inc.* and a subsidiary of *Preussag AG* of West Germany.

Another graphite project is being carried out by joint venture partners *Princetown Resources Corp.* and *North Coast Industries Ltd* at Bissett Creek, where another crystalline flake graphite deposit exists. The deposit is located approximately 300 km north-east of Toronto and has an ore reserve base calculated to be in excess of 34m. tonnes of ore grading 3.3% graphite with a 2% cut-off. A positive pre-feasibilty report has been prepared by *KHD Canada Inc.*, on a process developed to give a high grade product. Concentrate analyses by KHD indicate that over 50% of the material will have a grain size between 16 and 48 mesh and carbon content will be in the 90–92% range. there may be further upgrading through acid leaching to a carbon grade of 98–99%. It is proposed that the mine will be opencast, and is projected to produce 16,900 tonnes of marketable flake graphite which will require a mill throughput of 600,000 tonnes. North Coast Industries and Princetown Resources Corp. are expecting to begin production in 1989 and at the estimated throughput the mine life is projected to be 25 years.

Still in Ontario *Stewart Lake Resources* has been evaluating its Desert Lake deposit, north of Kingston at Kirkham and is currently carrying out diamond drilling to convert probable reserves to proven. Reserves at present stand at an estimated 1m. tons of 11% graphite. The results of the feasibility studies, which the company has been conducting, are due out in January 1989. If favourable the mine could be on stream in 1990. The study is thought to be based on a low tonnage, high grade operation with an output of 12,700 tpa of concentrate. Capital costs of the mine are estimated to be C$13m. Another deposit, Timmons near Renfrew, is also currently under evaluation and was previously last worked during the war years. A joint venture company called *Lodi-Black Hawk Inc.* is carrying out trenching surface work on Timmons, but has not, as yet, carried out any bulk sampling.

Carbontec Industries Ltd is also actively investigating another graphite deposit, located on Cape Breton Island, Nova Scotia. The schistose deposit is mainly amorphous graphite although some crystalline flake could be produced. Carbontec was first formed in December 1985 by a group of private investors. Prior to the company's formation the investors had carried out a considerable amount of exploration and process research and had filed claims on the island. The graphite content of the body is said to range from 25% to 70% carbon, although in reality it probably averages 40–45%C. The company is aiming to produce a high quality 90% plus carbon material.

In Quebec another project that is currently under way is an agreement between *Stratmin Inc.* of Montreal and Asbury Graphite Mills Inc. Initially Stratmin is to produce some 67,000 tpa of mine ore to give a concentrate of approximately 5,000 tpa from its Mount Laurier deposit. The concentrate will then be custom milled by Asbury Graphite at its facilities at Notre Dame du Laus, around 45km from Mount Laurier. To begin with the agreement is to run for five years depending on the results of feasibility studies currently being carried out by Stratmin, and is also conditional upon Stratmin starting full production before

April 1989. Subject to Stratmin constructing its own milling facilitie—Asbury will have the option to purchase any production in exce of 5,000 tpa of concentrate. Under the agreement Asbury is also recognised by Stratmin to be the sole purchaser of its graphite destined for North American and Mexican projects.

Mazarin Inc. is also planning to spend some C$1.1m. in the next five months exploring for graphite in the Fermont area in Quebec, north of Sept Isles. The project is being financed in part by an exploration grant from the province of Quebec.

As with all new projects reticence of investors and price instability may well have adverse consequences for projects of marginal viability. It remains to be seen one or two years hence just how many of these potential suppliers have begun production; as always with several contenders only the fittest survive.

Other potential deposits

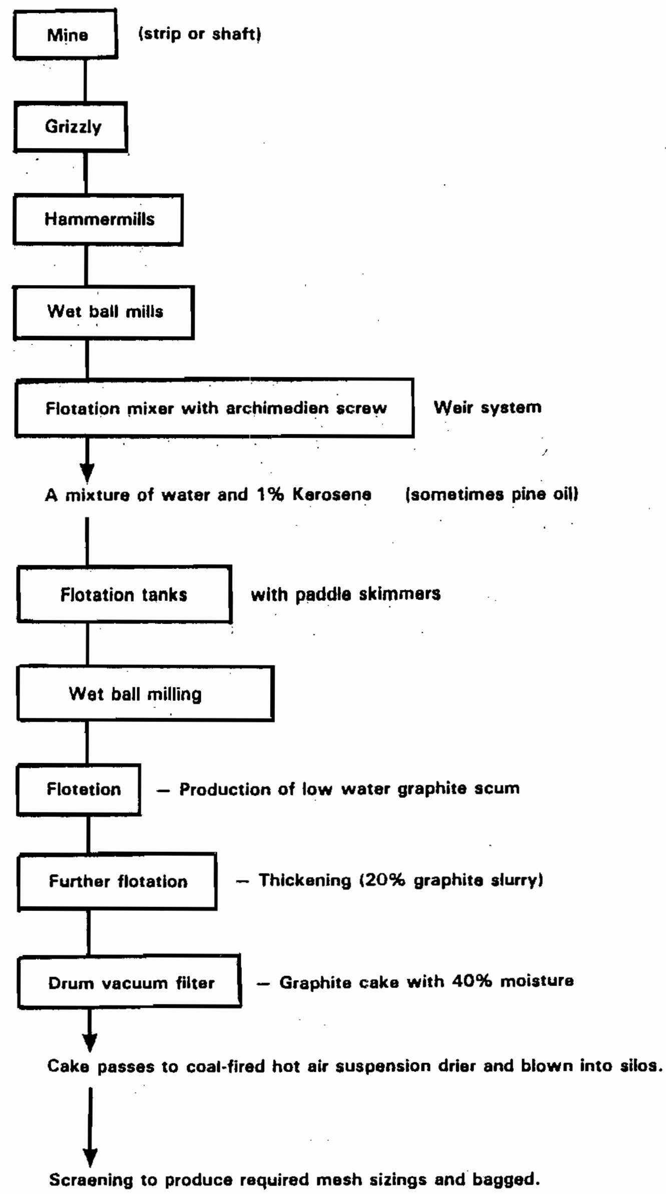
Australia

Gwalia Minerals NL, minerals arm of the *Gwalia Group,* has carried out some initial exploration work in on its 100% held Munglinup deposit located 80km east of Ravensthorpe in Western Australia. Diamond drilling has confirmed good continuity of the graphitic horizons of over 600 metres of strike and at at least 50 metres depth within part of the known mineralisation. A significant resource of 1.6m. tonnes averaging 13% carbon has been indicated by costeaning and drilling. This represents a substantial increase on previous estimates. The company reports that the graphite horizons are soft and friable to at least 50 metres and would be amenable to open pit mining techniques. Earlier efforts by other companies to produce a high grade medium to coarse flake graphite product had been shown to be uneconomic. However, Gwalia Minerals has negotiated a 12 month option period, during which it will carry out further metallurgical testwork and exploration in order to cost the operation and produce a feasibility report. Market studies will also be carried out and will include distribution of the final product to potential customers.

Processing of graphite

As every graphite deposit is unique, processing flowsheets are adapted to suit the individual characteristics of the ore. Graphite floats readily and does not require a collector and thus froth flotation has become the standard beneficiation route, particularly for disseminated ores. Flotation usually consists of a series of rougher, cleaner, and scavenger cells, along with a scalp float. Prior to flotation the graphite is normally coated with a light oil such as kerosene or pine oil in an aqueous pulp. After flotation a concentration table is sometimes used to produce higher carbon grades. Throughout the circuit great care is taken to maintain the size of the flake particles ■

A basic flow sheet of a typical Chinese processing operation to produce flake graphite.



Source: W. B. Hill — China, a source of flake graphite for the refractories industry, Proceedings of the 7th Industrial Minerals International Congress, Monte Carlo, 1986.

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APPENDIX 6

PHASE II EXPLORATION PROGRAM - DETAILED BUDGET

PHASE II EXPLORATION PROGRAM - DETAILED BUDGET

DIAMOND DRILLING

	#	Rate		
PREFIELD PLANNING				
Project Geologist	5	$260 /day	$1,300	
Sr. Geologist	1	$350 /day	$350	$1,650
MOBILIZATION				
Project Geologist	1	$260 /day	$260	
Assistant	1	$210 /day	$210	
Sr. Geologist	1	$350 /day	$350	
Truck Rental	1	$70 /day	$70	$890
DIAMOND DRILLING				
Project Geologist	20	$260 /day	$5,200	
Assistant	20	$210 /day	$4,200	
Sr. Geologist	2	$350 /day	$700	
Accomodation	42	$25 /manday	$1,050	
Meals	42	$25 /manday	$1,050	
Truck Rental	22	$70 /day	$1,540	
Drill Mob/Demob			$1,500	
Drill Coring	2625	$20 /ft	$52,500	
Core Boxes	2625	0.25 /ft	$656	
Additional Drill Expenses			$1,000	
Drill Kit	1	$250 /3 weeks	$250	
Field Supplies				
Field Office Kit	1	$50 /3 weeks	$50	
Computer Rental	1	$250 /3 weeks	$250	
Rock Analyses	250	$18 /sample	$4,500	$74,446
DEMOBILIZATION				
Project Geologist	1	$260 /day	$260	
Assistant	1	$210 /day	$210	
Sr. Geologist	1	$350 /day	$350	
Truck Rental	2	$70 /day	$140	$960
DATA COMPILATION & REPORT				
Project Geologist	10	$260 /day	$2,600	
Sr. Geologist	2	$350 /day	$700	
Drafting	40	$30 /hr	$1,200	
Wordprocessing	30	$30 /hr	$900	
CADD Peripherals	25	$50 /hr	$1,250	
Printing & Reproduction			$200	$6,850
		DIAMOND DRILLING SUBTOTAL		$84,796

PHASE II EXPLORATION PROGRAM - DETAILED BUDGET

BENCH SCALE BULK SAMPLE TESTING

One Bulk Sample Test		$3,000
	PROGRAM TOTAL	$87,796
	10% CONTINGENCY	$8,780
	GRAND TOTAL	$96,576

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THIS SUBMITTAL CONSISTED OF VARIOUS REPORTS, SOME OF WHICH HAVE BEEN CULLED FROM THIS FILE. THE CULLED MATERIAL HAD BEEN PREVIOUSLY SUBMITTED UNDER THE FOLLOWING RECORD SERIES (THE DOCUMENTS CAN BE VIEWED IN THESE SERIES):

Report on the 1988 Spring Exploration Program Laurier twp Graphite Prospect, Trout Creek Ont., T. Dickson and P.A. Hartwick, Aug. 5, 1988 → see 2.11563, Report of Work W8809-63, W8909-41