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BENEFICIATION TESTING OF THREE SAMPLES OF GRAPHITE-BEARING ROCK FROM ANCUABE, MOZAMBIQUE

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BENEFICIATION TESTING OF THREE SAMPLES OF GRAPHITE-BEARING ROCK FROM ANCUABE, MOZAMBIQUE

D A Briggs and C J Mitchell

INTRODUCTION

Three samples of graphite-bearing rock were received in April 1989 from Dr Alastair Brown, exploration manager of Kenmare Resources PLC, Dublin. The testwork requested involved an investigation into the feasibilty of the separation of graphite flakes from the samples by means of air classification and froth flotation. Analysis of the products would then provide data on the grades and recoveries obtained over an appropriate range of flake sizes.

The three samples were as follows:

(i) CORE (3.2 kg)

This consisted of broken lumps of around 2 inch diameter of a granular quartz-feldspar-graphite metamorphic rock. Magnetite was also present, and the graphite content apppeared to be of the order of 10 %. Graphite occured as coarse flakes, mainly around 0.5 - 2.0 mm in diameter.

(ii) WEATHERED (3.0 kg)

This sample was similar to the core, but was obviously obtained from the surface-weathered material. It was extensively iron-stained, and much more friable in character. Much free graphite had been liberated as coarse flakes, and the overall graphite content was at least as good as the core sample.

(iii) ELUVIAL (3.8 kg)

This appeared to be less promising material than the other two samples. The overall graphite content was somewhat lower, due to the presence of abundant reddish-brown dispersed iron oxide soil material. Although graphite flakes were clearly visible, it was anticipated that these would be less easy to recover and purify due to the presence of the abundant soil material.

PREPARATION OF SAMPLES

The core sample was jaw-crushed so that it was all finer than 4 mm; it was noted that the sample was particularly hard. The other two samples were considerably more friable and as they already contained much - 4 mm material, this was screened off first and then the oversize was crushed as before and added to the feedstocks.

Each sample was then screened on 2 mm, and the respective - 4 + 2 mm fractions carefully ground through 2 mm. The machine used was a laboratory agate cone and collar grinder, as past experience had shown that this type of machine was effective in grinding gangue into the fine sizes while also retaining maximum graphite flake size. In large-scale plant practice, similar results would be effected by the use of a high-speed impact swing-hammer machine. The presence of tough quartz was again noted, particularly in the core sample. It was important that the grinding was carried out in stages, otherwise a too vigorous treatment would result in over grinding of the graphite flakes.

When all the material had been ground finer than 2 mm the samples were screened on 1 mm, and the - 2 + 1 mm material was in turn stage-ground to pass 1 mm. In the course of this treatment, it had become apparent that free graphite flakes were becoming liberated and were beginning to concentrate on the 1 mm screen. Grinding was therefore stopped, and the small (around 1 % of the total weight) graphite-rich oversize products were retained.

The bulk of the samples were then screened in turn on 30, 60 and 120 BS mesh sieves, which correspond to apertures of 500, 250 and 125 microns respectively. All sized products were recovered and weighed, and small representative splits were analysed for graphite content using the standard loss-on-ignition method. A weighed sample was air dried at 105 °C, and then fired for two hours in a muffle furnace at 400 °C to drive off any volatiles.

Finally the samples were again fired for a further two hours at 1000 °C to burn off the graphitic carbon. The weight loss between 400 and 1000 °C gives a sufficiently accurate measure of the graphite content of each sample, and good consistency was obtained on different splits. All the results are recorded below in the tables; the volatiles present were insignificant, usually well below 1 %, so are not given.

Table 1: Distribution of graphite in Core sample

Size Fraction	Weight %	% Assay	Distribution %
+ 16	0.5	79.0	3.6
- 16 + 30	45.0	13.3	54.1
- 30 + 60	29.4	9.8	26.1
- 60 + 120	13.8	6.4	8.1
- 120	11.3	8.1	8.1
Total	100.0		100.0
Head Assay		(11.1)	

Table 2: Distribution of graphite in Weathered sample

Size Fraction	Weight %	% Assay	Distribution %
+ 16	3.2	68.1	15.9
-16 + 30	38.4	17.3	50.0
- 30 + 60	35.7	8.1	22.0
- 60 + 120	13.4	5.6	6.1
- 120	9.3	8.1	6.0
Total	100.0		100.0
Head Assay		(13.2)	

Table 3: Distribution of graphite in Eluvial sample

Size Fraction	Weight %	% Assay	Distribution %
+ 16	1.9	45.0	9.1
- 16 + 30	44.3	9.4	47.7
- 30 + 60	29.4	6.7	22.7
- 60 + 120	12.1	6.4	9.1
- 120	12.3	7.8	11.4
Total	100.0		100.0
Head Assay		(8.8)	

Discussion of results

The results were used to calculate the overall head assays of the original samples and these confirmed the initial impressions of their grade. The weathered sample was the richest, containing 13.2 % graphite, the core sample contained 11.1 % and the eluvial material was of the lowest grade, 8.8 % graphite. The tables also show that the - 16 + 30 mesh fractions contain around 50 % of the total graphite in each sample at slightly enhanced grades and that a further 22 - 26 % of the total graphite is contained in the - 30 + 60 mesh fractions. These two size fractions (corresponding to the coarse and medium flake sizes of graphite) taken together with the + 16 mm oversize material, contain over 80 % of the total graphite in each sample. This is highly satisfactory as the current market demand is for coarse and medium flake. Although there is some need for fine flake (- 60 + 120 mesh) this commands a much lower price, and the - 120 mesh fines are comparatively much less valuable as there is currently a glut on the market.

The above results are encouraging in that over 80 % of the total graphite is available in the most valuable sizes, and the next step in the investigation was to see whether this material would respond to upgrading treatment. The screening operations have provided ideal feedstock for treatment of sized fractions by air classification. The method has been shown in previous work by the British Geological Survey to work very well for coarse and medium flake graphite, but somewhat less well for fine flake. The - 120 mesh fines are not treatable by air classification, but as they only contain 8 % (core sample), 6 % (weathered sample) and 11 % (eluvial sample), of the total graphite in each rock at grades lower than the overall head value, they can be neglected without any significant loss in recovery.

AIR CLASSIFICATION TESTS

Description of Alpine zig-zag separator

The machine used was the Multi-Plex Laboratory Classifier Type 1-40 MZM, which is the smalest version available. However, it is capable of throughputs up to 100 kg/hour, and the results can be matched on the scaled-up pilot and full-size production classifiers. The laboratory machine can rapidly handle batch samples of 1 kg; attachments for continuous running are available.

Essentially, the classifier consists of a long zig-zag column through which is passed a current of air which can be controlled by means of a throttle (Fig. 1). Material fed into the upper part of the zig-zag tube is then separated into two fractions by the upward current of air. The fraction passing downwards through the airstream is coarse, granular and of higher density, and that carried up - and discharged through a cyclone - is finer in particle size, of lower specific gravity, and also tends to include any flatter, platy particles. The movement of the particles in the classifying tube can be directly observed through the plexiglass cover and adjustments made to achieve the separation by simply varying the setting of the air throttle, while the machine is running. The two fractions are collected separately in 1-litre glass bottles, these can be combined and repassed in a continuous run when the optimum conditions have been established by visual inspection of the products recovered at different settings of the throttle.

The classifier is capable of handling material in the size range 0.1 - 6 mm, and if presented with an unsized feed would simply separate coarse from fine particles. Repeated running at different settings would produce a series of fractions separated on the basis of particle size. However, it provides a method for the concentration of minerals from their ground host-rocks on the basis of differences in specific gravity and particle shape, provided that it fed with individual fractions that have first been closely sized by screening. This mode of gravity separation thus has high potential for the separation of graphite (density 2.3) which tends to occur as flat, flaky particles, from granular quartz and feldspar (density 2.7) which form the bulk of the host rocks.

Separation procedure

Each size fraction, except the + 16 mesh oversize and the - 120 mesh fines, was processed in turn on the air classifier. The amount of air passing through the classifier was gradually increased by adjusting the throttle until a good separation of graphite flakes from the granular waste material was being achieved. A graphite concentrate was then obtained at the optimum setting of the flow of air, which was read off directly from the flow meter in M^3/hour. Such a setting aimed at maximum recovery of clean graphite flakes passing up the tube, but also at the exclusion of granular waste which would reduce the grade of the concentrate. The reject material which had passed down the airstream was then reclassified at a slightly increased flow rate. The objective of this re-pass was to recover the rest of the graphite in the fraction in a 'middling' product, and thus leave the final reject or 'tailing' as free of graphite as possible. It is not possible in any form of commercial mineral separation to produce a clean concentrate and a clean tailing in a single pass, hence the usefulness of producing a middling. In practice, middlings products are usually recalculated, often after regrinding as they may contain composite particles of intermediate density. Such was the case for the present samples.

All products were recovered, weighed and analysed for graphite content as before. The distributions of weight and graphite were calculated for each size fraction, and also as related to overall recovery from each original head sample. The results are given in tables 4, 5 and 6.

Discusion of results

Inspection of tables 4, 5 and 6 shows that air classification has been successful in recovering the bulk of the graphite in each size fraction into the concentrate and middlings products. In general the air classified tailings contain only around 2 - 3 % graphite, the best results being those obtained from the eluvial material. Examination of the tailings showed that their graphite content was accounted for by the presence of small graphite particles contained in intergrowths. Such graphite would not be recoverable unless the material was very finely ground, which would be an expensive procedure, and not economic in view of the low value of fine graphite.

The air classified middlings contain much more potentially recoverable graphite, generally at around the original grade of the size fraction from which they were derived. Some free graphite is present together with mica and some composite particles, and this is certainly worthy of further treatment, possibly after additional light grinding. At this stage, however, it is best to regard the middlings products as reserve materials for further studies to increase overall recovery.

TABLE 4 Air classification of core sample

Classifier setting (m^3/hr)	Size fraction	WEIGHT		GRAPHITE		
		% fraction	% head	Assay %	Distribution % fraction	Distribution % head
	> 16	unseparated	0.5	79.0	100.0	3.6
	16-30	100.0	45.0	(13.3)	100.0	54.1
12	conc	13.8	6.2	65.5	68.9	37.3
15	midl	16.3	7.3	10.1	12.1	6.6
15	tail	69.9	31.5	3.5	19.0	10.2
	30-60	100.0	29.4	(9.8)	100.0	26.1
5	conc	22.6	6.6	43.1	73.7	19.2
9	midl	26.6	7.8	7.9	15.8	4.1
9	tail	50.8	15.0	2.7	10.5	2.8
	60-120	100.0	13.8	(6.4)	100.0	8.1
3	conc	8.2	1.1	39.8	44.6	3.6
5	midl	22.9	3.2	8.4	25.7	2.1
5	tail	68.9	9.5	3.2	29.7	2.4
	<120	unseparated	11.3	8.1	100.0	8.1
	TOTAL		100.0			100.0
	Head assay			(11.1)		
	Combined concentrates					
	>30		6.7	(66.5)		40.9
	>60		13.3	(54.9)		60.1
	>120		14.4	(53.7)		63.7
	Combined concentrates + middlings					
	>30		14.0	37.1		47.5
	>60		28.4	(30.5)		70.8
	>120		32.7	(28.6)		75.5
			Y	G		R

TABLE 5 Air classification of weathered sample

Classifier setting (m^3/hr)	Size fraction	WEIGHT % fraction	WEIGHT % head	GRAPHITE Assay %	GRAPHITE Distribution % fraction	GRAPHITE Distribution % head
	> 16	unseparated	3.2	68.1	100.0	15.9
	16-30	100.0	38.4	(17.3)	100.0	50.0
13	conc	17.6	6.8	82.5	79.2	39.6
17	midl	19.7	7.6	11.5	12.6	6.3
17	tail	62.7	24.0	2.4	8.2	4.1
	30-60	100.0	35.7	(8.1)	100.0	22.0
7	conc	8.5	3.0	64.2	62.5	13.8
9	midl	16.3	5.8	11.7	21.6	4.8
9	tail	75.2	26.9	1.9	15.9	3.4
	60-120	100.0	13.4	(5.6)	100.0	6.1
4	conc	5.0	0.7	44.0	30.1	1.8
5	midl	19.1	2.6	15.1	39.7	2.4
5	tail	75.9	10.1	2.9	30.2	1.9
	<120	unseparated	9.3	8.1	100.0	6.0
	TOTAL		100.0			100.0
	Head assay			(13.2)		
	Combined concentrates					
	>30		10.0	(77.9)		55.5
	>60		13.0	(74.7)		69.3
	>120		13.7	(73.2)		71.1
	Combined concentrates + middlings					
	>30		17.6	(49.2)		61.8
	>60		26.4	(42.7)		80.4
	>120		29.7	(40.3)		84.6
			Y	G		R

TABLE 6 Air classification of eluvial sample

Classifier setting (m^3/hr)	Size fraction	WEIGHT % fraction	WEIGHT % head	GRAPHITE Assay %	GRAPHITE Distribution % fraction	GRAPHITE Distribution % head
	> 16	unseparated	1.9	45.0	100.0	9.1
	16-30	100.0	44.3	(9.4)	100.0	47.7
14	conc	6.6	2.9	73.7	45.0	21.5
18	midl	15.1	6.7	23.0	32.1	15.3
18	tail	78.3	34.7	3.2	22.9	10.9
	30-60	100.0	29.4	(6.7)	100.0	22.7
7	conc	4.3	1.3	38.4	22.2	5.0
9	midl	19.1	5.6	14.2	37.5	8.5
9	tail	76.6	22.5	3.8	40.3	9.2
	60-120	100.0	12.1	(6.4)	100.0	9.1
4	conc	3.2	0.4	25.8	11.4	1.1
5	midl	17.8	2.2	10.1	25.7	2.3
5	tail	79.0	9.5	5.5	62.9	5.7
	<120	unseparated	12.3	7.8	100.0	11.4
	TOTAL		100.0			100.0
	Head assay			(8.8)		
	Combined concentrates					
	>30		4.8	(62.3)		30.6
	>60		6.1	(57.2)		35.6
	>120		6.5	(55.3)		36.7
	Combined concentrates + middlings					
	>30		11.5	(39.4)		45.9
	>60		18.4	(31.7)		59.4
	>120		21.0	(29.3)		62.8
			Y	G		R

The air classified concentrates are of excellent quality, particularly those obtained from the coarse - 16 + 30 mm mesh size fractions. A particularly good result was obtained from the weathered material, where the concentrate contained 82.5 % graphite, and this represented a recovery of 79.2 % of the graphite in the size fraction, and 39.6 % of the total graphite in the head sample. Some mica, often vermiculite, was noted in the concentrates as it had been in the middlings fractions. This has been concentrated with the graphite because of its similar flaky habit, but past experience has shown that this can be removed by froth flotation.

The bottom sections of tables 4, 5 and 6 show the effects of notional combination of firstly all the air classified concentrates, taken together with the enhanced grade + 16 mm mesh oversize, and secondly, the combined concentrates and middlings. Y, G and R denote overall weight yields, graphite grades and graphite recoveries respectively.

For the weathered sample, an overall recovery of 71.1 % of the total graphite in the head has been obtained at a combined grade of 73.2 % graphite, and this is contained in only 13.7 % of the total weight. This is an excellent result as it shows that pre-concentration by air classification would enable the rejection of 86.3 % of the weight to be achieved in producing a greatly upgraded product to be taken to water for purification by froth flotation. If the air classified middlings are taken into account, the overall recovery would be increased to 84.6 %, but the grade would drop to 40 .3 % graphite. This, however, could still be a feasible procedure if high recovery of graphite from the middlings could be achieved, but this is beyond the result of the present investigation.

The overall results for the other two samples are less good, but still show that air classification could 'cream-off' graphite concentrates of around 55 %, at a useful recovery of 63.7 % for the core sample, but only at 36.7 % for the eluvial material.

The final stage in the investigation was to determine what further upgradings could be accomplished by froth flotation of the air classified concentrates.

FROTH FLOTATION

Introduction

The normal method of processing graphite used in the mining industry is that of froth flotation, which involves the selective coating of graphite particles by a light oil in an aqueous pulp, and recovering them in a froth which rises the top of the flotation cell and is scooped off. Although graphite is relatively easy to separate from its host rock by this method, it is more difficult to purify to high grades. The reason for this is that graphite often occurs intergrown with other minerals such as mica in composite particles. As graphite floats very readily, these composite particles also tend to appear in the flotation concentrates, particularly as they, and also gangue particles of very fine size can also become smeared with a thin coating of soft graphite. These can only be eliminated by repeated cleaning in the flotation cell, but this method requires the use of large quantities of water, and hence is not an appropriate technology for water-short areas.

These difficulties were minimised in the case of the Mozambique samples in a number of ways. As already emphasized, some considerable care was taken to grind and size the feed prior to the concentration process so that high-value coarse flakes were released at their natural size and not over-ground. Also, the - 120 mesh fine material was eliminated from further treatment simply by being screened out and rejected. Advantage was also taken of the pre-concentration afforded by air classification so that tailings of low graphite content could also be eliminated and thus the amount of material which had to be treated in water was vastly reduced. It was easier to float material which had been sized, and of course upgraded by the air classification.

Separation procedure

The air classified concentrates from the sized fractions of each rock were therefore treated in a Denver laboratory flotation cell. A drop of kerosene was added to each sample in an aqueous pulp as flotation collector, together with a drop of methyl isobutyl carbinol (MIBC) as frothing

TABLE 7 Core sample: Flotation of air classified concentrates

Product	WEIGHT % fraction	WEIGHT % head	GRAPHITE Assay %	GRAPHITE Distribution % fraction	GRAPHITE Distribution % head
+16 (unclassified)	insufficient material for flotation				
conc					
midl					
tail					
TOTAL	100.0	0.5	79.0	100.0	3.6
Head assay			79.0		
-16+30					
conc	75.8	4.7	86.3	99.4	37.1
midl	3.7		1.7	0.2	
tail	20.5		1.2	0.4	
TOTAL	100.0	6.2	(65.8)	100.0	37.3
Head assay			65.5		
-30+60					
conc	52.7	3.5	91.9	98.8	19.0
midl	0.9		-	-	
tail	46.4		1.3	1.2	
TOTAL	100.0	6.6	(49.0)	100.0	19.2
Head assay			43.1		
-60+120					
conc	17.9	0.8	91.0	94.2	5.4
midl	1.5		10.1	1.2	
tail	80.6		1.0	4.6	
TOTAL	100.0	4.3	(17.3)	100.0	5.7
Head assay			16.7		
Combined flotation concentrates					
>30		5.2	(85.6)		40.7
>60		8.7	(88.1)		59.7
>120		9.5	(88.4)		65.1
		Y	G		R

TABLE 8 Weathered sample: Flotation of air classified concentrates

Product	WEIGHT % fraction	WEIGHT % head	GRAPHITE Assay %	GRAPHITE Distribution % fraction	GRAPHITE Distribution % head
+16 (unclassified)					
conc	86.4	2.8	85.6	97.2	15.5
midl	3.8		34.9	1.7	
tail	9.8		8.5	1.1	
TOTAL	100.0	3.2	(76.1)	100.0	15.9
Head assay			68.1		
-16+30					
conc	90.2	6.1	90.9	99.5	39.4
midl	0.4		-	-	
tail	9.4		4.7	0.5	
TOTAL	100.0	6.8	(82.4)	100.0	39.6
Head assay			82.5		
-30+60					
conc	69.0	2.1	93.6	97.3	13.4
midl	0.8		-	-	
tail	30.2		5.8	2.7	
TOTAL	100.0	3.0	(66.4)	100.0	13.8
Head assay			64.2		
-60+120 (A/C conc + mid)					
conc	15.4	0.5	92.3	92.8	3.9
midl	1.2		-	-	
tail	83.4		1.3	7.2	
TOTAL	100.0	3.3	(15.3)	100.0	4.2
Head assay			21.1		
Combined flotation concentrates & middlings					
>30		8.9	(89.2)		54.0
>60		11.0	(90.1)		68.3
>120		11.5	(90.2)		72.2
		Y	G		R

TABLE 9 Eluvial sample: Flotation of air classified concentrates

Product	WEIGHT % fraction	WEIGHT % head	GRAPHITE Assay %	GRAPHITE Distribution % fraction	GRAPHITE Distribution % head
+16 (unclassified)					
conc	44.7	0.9	91.7	94.7	8.6
midl	0.5		-	-	
tail	54.8		4.1	5.3	
TOTAL	100.0	1.9	(43.3)	100.0	9.1
Head assay			45.0		
-16+30					
conc	61.7	1.8	89.7	75.2	16.2
midl	-		-	-	
tail	38.3		47.7	24.8	
TOTAL	100.0	2.9	(73.7)	100.0	21.5
Head assay			73.7		
-30+60					
conc	35.9	0.5	91.1	77.3	3.9
midl	7.0		67.4	11.1	
tail	57.1		8.5	11.6	
TOTAL	100.0	1.3	(42.3)	100.0	5.0
Head assay			38.4		
-60+120 (A/C conc + mid)					
conc	6.8	0.03	87.8	52.6	0.6
midl	2.0		22.4	4.4	
tail	91.2		5.4	43.0	
TOTAL	100.0	0.4	(11.4)	100.0	1.1
Head assay			12.5		
Combined flotation concentrates					
>30		2.7	(90.3)		24.8
>60		3.2	(90.5)		28.7
>120		3.23	(90.5)		29.3
		Y	G		R

agent. The contents of the cell were allowed to condition for 2 minutes, then air was admitted and the resultant graphite-rich froth scooped off to form a rougher concentrate. Flotation was allowed to continue for about a further 2 minutes until all the graphite had been floated off, leaving a clean tailing in the bottom of the cell. As already indicated in the introductory remarks to this section, some graphite-coated gangue particles floated with the concentrate. The rougher concentrates were returned to a second cell, and re-floated without any further addition of reagents. This had the effect of reducing the impurities, which dropped out and were recovered as flotation middlings. It was noted that a little mica was present, but this was only a minor impurity and did not seriously affect the flotation.

The cleaned concentrate, middlings and tailings were recovered, weighed and analysed for graphite content as before. Yields, grades and recoveries were calculated and the results are given in Tables 7, 8 and 9. The unclassified + 16 mesh oversize fractions from the weathered and eluvial samples were also floated, but that from the core sample was not, due to shortage of material. There was insufficient material in the - 60 + 120 mesh air classified concentrates for froth flotation, so in all three cases these were combined with the air classified middlings for flotation purposes. This provided enough material to carry out viable tests and thus complete the overall recovery calculations.

Discussion of results

The flotation tests were very successful in recovering most of the graphite which had already been pre-concentrated by the air classifying operations. Grades of around 90 % graphite were obtained at high recoveries in almost every case. These results were obtained by means of a primary rough float followed by one repeat float to clean the concentrate and eliminate middlings. In large-scale plant practice, several re-cleaning floats are usually carried out to increase purity. Thus the grades of 90 % could probably be improved in this way, but are already highly satisfactory, and eminently saleable.

At the bottom of each table overall yield, grade and recovery figures are given. The weathered material is clearly the best; 68.3 % of all the graphite in the sample has been recovered as coarse and medium flake (+ 60 mesh) at a grade of 90.1 % graphite in only 11.0 % of the total weight. Recovery of all the graphite coarser than 120 mesh increases to 72.2 %, again at a grade just over 90 %. Recovery of + 120 mesh graphite from the core sample is 65.1 % at a grade of 88.4 % graphite - this being a considerable improvement on the somewhat low grades obtained by air classification alone. Even the least good eluvial material can produce graphite concentrates at over 90 % grade, but this is at a very low recovery of only 29.3 %.

SUMMARY OF RESULTS

(i) The graphite contents of the three samples were as follows : -

Core	11.1 %
Weathered	13.2 %
Eluvial	8.8 %

(ii) Controlled grinding is necessary to ensure that graphite flakes are released as cleanly as possible without any undue reduction in their size. The use of a laboratory cone and collar mill produced a satisfactory grind which distributed around 80 % of the total graphite in each sample into the most valuable coarse and medium flake sizes. Similar results could be achieved by the use of high-speed impact swing hammer mills.

(iii) Close sizes of the ground material was required for feeding to the first stage of the concentration process, air classification. Screening down to 120 mesh would recover the bulk of the graphite; the minus 120 mesh fines contained such a small proportion of the total graphite that they can be eliminated from further processing, particularly as they would lower the grade of the flake produced.

(iv) Air classification provides a method for pre-concentrating the graphite without the use of water, which is a great advantage for on-site treatment in arid terrain. This produces graphite concentrates of around 60 - 80 % grade for the coarsest size fractions. Results are given in detail in Tables 4, 5 and 6, but taken for all the graphite coarser than 120 mesh, the air classified concentrates for each sample compare as follows: -

	% Weight	% Grade	% Recovery
Core	14.4	53.7	63.7
Weathered	13.7	73.2	71.1
Eluvial	6.5	55.3	36.7

The results are clearly good for the weathered material and poor for the eluvial, but in general air classification has allowed the rejection of a high proportion of the weight of the original material with minimal loss of overall graphite content for two of the samples. Results from the laboratory air classification tests can be 'scaled-up' to those which can be expected from the corresponding pilot-scale and full-scale production classifiers. Recoveries could be increased by taking the air classified middlings into account, but this would involve re-treatment including further grinding, and this is beyond the remit of the present investigation.

(v) The air classified concentrates provided excellent feeds for final purification by froth flotation. This produced graphite concentrates of around 90 % grade at recoveries little lower than those obtained from air classification alone. The detailed results are given in Tables 7, 8 and 9, and the comparative overall figures areas below: -

	% Weight	% Grade	% Recovery
Core	9.5	88.4	65.1
Weathered	11.5	90.2	72.2
Eluvial	3.2	90.5	29.3

The figures for the core and weathered samples are excellent, and even in the case of the eluvial sample, high-grade graphite concentrates can be produced, although admittedly at a low recovery.

(vi) Further work should involve the maximising of recovery, and it is suggested that some attention is given to flotation of the air classified middlings, and whether some re-grinding is required.

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