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BENEFICIATION AND ANALYSIS OF FELDSPAR SAMPLES for Liberated Minerals Pty. Ltd.
by Warman International Ltd.
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RESEARCH AND DEVELOPMENT DIVISION REPORT

REPORT 77/84715

Beneficiation and Analysis

of

Feldspar Samples

for

Liberated Minerals Pty Ltd

WARMAN INTERNATIONAL LTD.

RESEARCH AND DEVELOPMENT DIVISION

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RESEARCH & DEVELOPMENT DIVISION

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Beneficiation and Analysis

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Feldspar Samples

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Liberated Minerals Pty Ltd

A.I. Bellingham

S.F. Rayner

16th December, 1977

CONTENTS

SUMMARY

1. Six feldspar samples were assayed for conformity to selling specifications. Four met the requirements for potash feldspar. The remaining two met the requirements for soda feldspar except for their calcium contents and in one case, potassium content.

2. Qualitative analysis of five hard rock specimens failed to reveal the prescence of any elements in economic quantity. The colours in the rock were attributed to the iron and manganese contents.

how sampled?

3. An ore composite sample was subjected to a scouting programme of differential flotation to recover products of mica, feldspar, beryl and quartz.

   Based on a series of trial flotation tests one proving test, restricted to single stage or rougher flotation, was performed. Grain counting assessment yielded the following distributions;

Mica Product:	grade	61.4% mica
	recovery	92.2%
	major contaminant	34.8% feldspar
Feldspar Product:	grade	91.1% feldspar
	recovery	90.5%
	major contaminant	7.5% quartz
Quartz Product:	grade	96.1% quartz
	recovery	84.8%
Beryl Product:	grade	27.8% beryl
	recovery	16.5%
	major contaminants	feldspar, beryl, magnetics

The conclusion from this scouting programme is that separation of the ore into the four mineral products listed is likely to be metallurgically viable.

An extended test programme would be required to define the process criterea.

1. INTRODUCTION

Aggreement was reached in August 1977 with Messrs McKenzie and Kempney of Liberated Minerals Pty Ltd on a laboratory programme to examine a suite of ore samples. Full details of the programme are listed in our letter of agreement reproduced in Appendix A and are summarized in Table 1.1. A laboratory identification 1444-1, 1444-2 etc was given to each sample and is used throughout this report.

The 'sample beneficiation' programme referred to in the table constitutes the major effort from a metallurgical point of view, the remaining work being mainly analytical. In brief, the object of this explotatory investigation was to provide data for a preliminary flowsheet design and to show that saleable grade products for mica, feldspar, beryl and quartz could be obtained. The test sample comprised of a 50/50 blend of the Egebek and Triple Chance dump samples.

Table 1.1

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SUMMARY OF PROPOSED TESTWORK

Laboratory Identification Number	Sample Description	Weight (kg)	Action Requested
1444-1	Triple Chance Dump (Be)	31.6	See 'Sample Beneficiation'
1444-2	Egebek Dump (plus previous submission)	22.4 2.0	See 'Sample Beneficiation'
1444-3	Contaminants of No.3 Pit Inca Lease - 5 coloured hard-rock specimens plus one soft white rock	10.5	Six specimens to be sampled for X-ray fluorescence semi-quantitative analysis of elements atomic numbers greater than 22. Quantitative analysis of any significant metallic elements. Identify the mineral of the soft white rock
1444-4	Ice cream container - Inca No.3 Lease - crushed sample plus separate feldspar rock specimen (plus previous submission)	13.1 0.25 3.08	Hold the crushed sample but analyse rock specimen for conformity to feldspar selling specification
1444-5	Beryl chips and sand ex Triple Chance	1.2	Analysis of beryllium content
1444-6	Egebek - Mica schist	1.15	Percent mica
1444-7	Egebek - Book mica	1.66	Hold - no action
1444-8	Triple Chance soda feldspar	1.25	Analysis for conformity to the feldspar selling specifications provided. Choose sample for analysis selectively so as to reject any large free quartz inclusions. Remove any adhering clay.
1444-9	Egebek main pit feldspar	1.37	
1444-10	Egebek second pit feldspar	1.85	
1444-11	Egebek Pierces lode feldspar	0.55	
1444-12	Black Adder Creek - soda feldspar (plus previous sample)	0.72 6.1	

2. BACKGROUND MINERALOGICAL DATA *

The following descriptions relate to minerals discussed in this report and are a basis for subsequent discussions.

Beryl

Beryllium Aluminium Silicate, $Be_3Al_2(Si_6O_{18})$

Composition: BeO 14.0%, Al_2O_3 19.0%, SiO_2 67.0%

Small amounts of cesium are often present. Recognised usually by its hexagonal crystal form; sp.gr. 2.75-2.8

Quartz

Silica SiO_2. Under the microscope it appears transparent to translucent with a glassy luster; sp.gr..2.65

Muscovite Mica

Also termed *white mica, common mica* or *potash mica.* Essentially represented by the formulae $KAl_2(AlSi_3O_{10})(OH)_2$. Frequently contains small amounts of iron, magnesium, calcium, sodium, lithium, fluorine and titanium. Characterized by its highly perfect cleavage allowing the mineral to be split into excessively thin sheets; sp.gr. 2.8-3.1. Transparent and colourless in thin sheets.

Feldspars

The pure feldspars are silicates of aluminium with either potassium, sodium or calcium.

a) Potash Feldspar

Orthoclase - together with microcline which has an identical composition known as potash feldspar

Potassium aluminium silicate $K(AlSi_3O_8)$

Composition: K_2O 16.9%, Al_2O_3 18.4%, SiO_2 64.7%

Sodium may replace potassium. Colourless, white gray or flesh red; sp.gr. 2.6.

b) Plagioclase (soda-lime) Feldspars

Albite - $NaAlSi_3O_8$

Anorthite - $CaAl_2Si_2O_8$

Together these two minerals known as the plagioclase feldspars form a complete solid solution series from pure albite to pure anorthite with calcium substituting for sodium with a contaminant substitution of aluminium and silicon in all proportions. sp.gr. 2.6-2.7. Transparent to translucent. Colourless, white, gray, less frequently greenish, yellowish, flash red.

* Reference Dana's 'Manual of Mineralogy'

3. CHEMICAL ANALYSIS

3.1 Feldspar Samples

Six samples were analysed for conformity to the selling specifications listed in Table 3.1 for potash and soda feldspar.

The results given in Table 3.2 indicate that samples 4, 9, 10 and 11 are essentially orthoclase with a small sodium content and meet the selling specifications for potash feldspar.

Samples 8 and 12 are plagioclase with sodium predominating over calcium i.e. albite with some anorthite. These two samples meet the selling specifications for soda feldspar except for their calcium contents and in the case of sample 12, the potassium content.

3.2 Beryllium Assays

Chemical analysis of the three beryllium containing samples yielded the following results.

3.3 Mica Determination

The sample, 1444-6 , Egebek - mica schist contained 71% mica as determined by sizing and grain count procedure.

Table 3.3

Sample No.	Description	Assay % BeO	Calculated Beryl Content
1444-1	Triple Chance Dump	0.31	2.2
1444-2	Egebeck Dump	0.007	0.05
1444-5	Beryl chips and sand	8.6	61.4

Table 3.1

Feldspar selling specifications*

	Potash Feldspar %	Soda Feldspar %
SiO_2	67.6	67.6
Al_2O_3	18.44	19.6
Na_2O	3.22 max	10.68 min
K_2O	10.5 min	0.17 max
CaO	0.52 max	0.93 max
MgO	0.06 max	0.42 max
Fe_2O_3	0.08 max	0.13 max
TiO_2	trace	trace

* supplied by Liberated Minerals.

Selected from existing pits — NOT dump material after comparison

Table 3.2

Analysis of feldspar rock specimens

	Inca No.3 Lease	Triple Chance Soda	Egebek Main Pit	Egebek Second Pit	Egebek Pierce's Lode	Black Adder Soda
Lab No. 1444-	4	8	9	10	11	12
SiO_2	65.5	67.2	65.1	65.3	65.1	65.2
Al_2O_3	19.3	20.0	19.4	19.5	19.5	21.7
Na_2O	3.4	10.7	2.9	3.4	3.4	10.7
K_2O	12.2	0.10	12.1	11.7	11.4	0.55
CaO	0.04	1.5	0.06	0.07	0.03	1.7
MgO	0.01	0.01	0.01	0.01	0.01	0.03
Fe_2O_3	0.069	0.077	0.080	0.060	0.092	0.12
TiO_2	0.01	0.03	0.01	0.01	0.01	0.05

4. QUALITATIVE ANALYSIS OF ROCK SPECIMENS FROM No.3 PIT

a) Hard Rock Samples

The samples were sorted into five groups on the basis of similar appearance. The groups were designated A to E. Selected chips were then taken from each group, crushed and analysed by X-ray fluorescence (XRF) scanning. This is a technique which identifies the presence and the approximate concentration of all elements between atomic number 22 and 92.

Full results of the XRF scans appear in Appendix B and are summarized in Table 4.1. No element in economic quantity was identified. The colours in the rock would be due to the iron and manganese contents.

b) Soft Rock Sample

The mineral in the soft rock, sample F, has a specific gravity of 2.33. It is a clay, probably kaolin, a hydrous aluminium silicate which is derived from the alteration of aluminium silicates, particularly feldspar.

Table 4.1

Summary of semi-quantitative X-ray scan analysis

	Detected but less than 100 ppm	100-1000 ppm	1000 - 10,000 ppm	greater 10,000
Iron			F	A,B,C,D,E,
Manganese		A,C,E	D	
Zirconium	D			
Rubidium		A		
Strontium	C	A,B,D		
Zinc	D			
Niobium		D		

Note : 1% ≡ 10,000 ppm

5. SAMPLE BENEFICIATION

5.1 Equipment

Testwork was conducted in a laboratory Wemco Fagergren Mineral Master Cell with a cell charge of approximately 780 g. Conditioning was fixed at 50% solids and flotation at 25% solids. During the float, make-up water was added to compensate for the float overflow. Reagent additions quoted in kilograms per metric tonne are on the basis of dry solids feed to the float cell.

5.2 Reagents

Acids

Laboratory grade hydrofluoric acid and sulphuric acid were prepared as 10% solutions for control of pH during conditioning and flotation stages.

Armac T

A cationic amine acetate reagent. It is recommended for the flotation of mica, feldspar and iron bearing minerals from silica sand. Up to 5% solutions are prepared by dissolving the reagent in hot water. Australian distributors are Steetly Chemicals Ltd. Prepared as a 1% solution for testwork.

Promoter 308 (PSL)

Supplied by Steetly Chemicals and referred to as either 308 or PSL, the imported name. An anionic petroleum sulphonate, it acts as a collector for iron bearing minerals such as magnetite, ilmenite, garnet and haematite. Prepared in warm water as a 10% solution for testwork.

Aerofroth 65

Supplied by Cyanamid Australia this is a water soluble poly-propylene glycol frother for metallic and non-metallic flotation. It produces a closely-knit persistent froth. Soluble in all proportions with water it was prepared as a 2½% solution for testwork.

Pine Oil

Largely replaced by 'chemical' type collectors it produces a tough, persistent froth and was considered applicable to beryl flotation.

Distillate Oil

Used as a promoter for coarse feldspar flotation. Distillate oil was used in this case but generally a heavy hydrocarbon oil such as fuel oil is recommended.

5.3 Experimental Procedure

a) Sample Preparation

As a preliminary both the Egebek and Triple Chance Dump samples were crushed to minus 3 mm in a laboratory jaw crusher. The composite sample, on which the testwork in this programme was to be performed, was prepared by combining equal portions of the two samples. From this, further samples were split as required. The remaining individual samples were set aside for any future work.

Grinding was conducted in a stainless steel rod mill, 300 mm long by 210 mm diameter on 1-kg batch charges of -3 mm ore. Trial grinding tests established that a retention time in the mill of 10 minutes with 12.1 kg of rods at 60% solids and a rotation speed of 60 r.p.m. reduced 95% of the sample to minus 600 μm (25 mesh B.S.). Further grinding to reduce the percent of oversize produced an equivalent percent of -75 μm (200 mesh B.S.) slimes. For the trial tests the oversize was set aside. Where more than 1 kg of ore was being prepared the oversize from each grind was combined with the feed to the next batch grind. Slimes which amounted to approximately 20% were removed by a two stage pulp/decant operation in a five litre beaker designed to remove minus 75 μm material.

b) General Float Procedure (-600+75)μm

From an assessment point of view the 600 x 75 μm fraction from the grinding operation constituted the test feed upon which all flotation performance and distributions were based.

For the trial tests each of the differential flotation stages was treated as a separate study i.e. the mica float conditions were examined fully as listed in the test proposal with the tailings being combined and set aside for the feldspar/beryl trial float tests.

Having established a set of reference conditions upon which to base a differential float scheme then a complete test was conducted sequentially.

c) Mica Flotation

The sample of approximately 780 g was pulped with fresh water to 50% solids in the conditioning vessel and agitated just sufficiently to keep all the material in suspension. Sulphuric acid as a 10% solution was added until the nominated pH was obtained. Amine acetate reagent was added as a 1% solution indicating the start of the 3 minute conditioning period. Frother was added during this time.

After transferring the sample to the float cell at 25% solids the pH was again noted and in some cases adjusted with further aliquots of acid. Flotation was continued until all the action had ceased and the time (usually 3 minutes) noted. The mica concentrate was dried and weighed with the tailings progressing to feldspar/beryl recovery.

d) Bulk Feldspar/Beryl Flotation

The tailings from the mica flotation were decanted to remove any slimes produced and repulped at 50% solids in the conditioning vessel with fresh water. Hydrofluoric acid as a 10% solution was added to produce the required pH. In a few tests a brief condition period was allowed before adding the float promoters and frother at the start of the conditioning proper (3 mins).

The sample was floated at 25% solids for 3-4 minutes until the action ceased. Initially the cell speed was 1500 r.p.m. but because such a large percentage of the sample was being floated (70% of float feed) the agitation was reduced to 1000 r.p.m. after the first two minutes. The silica tail was dried and weighed. The feldspar/beryl concentrate was further processed to float the beryl.

e) Beryl Flotation

As a preliminary to the beryl flotation the reagents from the previous stage were removed by

i) agitation for five minutes with 0.75 kg/t of commercial calcium hypochlorite

ii) two stage dilution/decant operation in a five litre beaker

The washed solids were repulped in the conditioning vessel at 50% solids and the pH adjusted with sulphuric acid prior to adding a petroleum sulphonate (P.S.L.) promoter for beryl flotation. In the latter tests the Aerofroth 65 frother was coupled with a few drops of pine oil to produce a stronger froth.

Flotation was again carried out at 25% solids and since only a small weight of concentrate was expected (some 3½ grams of beryl) the float was rapid but was allowed to proceed for 3 minutes. Products were dried and weighed.

5.4 Evaluation of Products

Time commitments prevented the complete analysis of each float fraction from the sequence of trial tests. However sufficient information on which to base the further successive tests was obtained by visual examination, sizing of products and microscopic examination. The results of these endeavours are not reported in detail but relevant comments are made in Tables 5.1 to 5.3.

A more detailed quantitative approach was adopted for the reference tests where each fraction was assessed by;

i) Removal of a magnetic fraction (except in the case of the mica concentrate)

ii) Screening into five size fractions (420, 300, 212, 150 and -150 μm) and grain counting each fraction for mica, feldspar, quartz, beryl and others.

5.5 Results of Trial Tests

a) Mica Flotation

The results of eight tests are summarized in Table 5.1 with best results achieved in Tests 3 & 6.

The following comments are relevant;

i) The amount of amine acetate promoter required is apparently proportional to the amount of mica.

ii) Higher conditioning and flotation pH values resulted in an increasingly unselective float. A maximum critical pH value of 2.5 is indicated.

iii) Stage flotation at pH 2 did not improve the selectivity of the float with fine feldspar adhering to the mica in both stages. The first stage floated fine mica and the second coarse mica.

iv) Insufficient promoter results in incomplete flotation of mica.

b) Feldspar/Beryl Flotation

Seven tests are reported in Table 5.2 with best results obtained in Tests 13 and 15. As with the mica tests some controlling factors became obvious.

i) A pH value of less than 3 is necessary to achieve selective flotation.

ii) Mica not floated in the previous stage follows the feldspar

iii) The feldspar/beryl fraction always appeared free of quartz the problem being to float all the feldspar from the quartz tail.

iv) Unfloated feldspar was always in the coarse fractions, much of it in the plus 500 µm (30 mesh) size range.

v) Addition of a hydrocarbon oil (distillate or fuel oil) promoted the flotation of coarse feldspar.

vi) Provided the pH was below 3 the quantity of hydrofluoric acid rather than pH became the significant variable as amounts of acid were required to give any measureable difference to pH i.e. the acid was being consumed in reaction with the pulp.

vii) A short conditioning period in acid only, prior to adding reagents, appeared to give a better separation.

c) Beryl Flotation

Four tests are reported in Table 5.3 but the conclusions that could be drawn were far from complete with only 2-4% of the float feed reporting in a very weak froth. Best results were obtained for Test 19.

Observations;

i) An extremely thin, weak looking froth was obtained. In latter tests addition of a few drops of pine oil improved the froth strength.

ii) Much of the beryl concentrate was ironstone of some form. Petroleum sulphates are employed in the glass industry to float ironstone from glass sand.

Unsuccessful!

iii) The significance of pH and reagent quantities was impossible to assess.

Summary of Trial Mica Flotation Testing

Table 5.1

TEST CONSTANTS :
- pH adjusted with sulphuric acid
- * wt.% is relative to float feed
- 0.03 kg/t of Aerofroth 65 added to each conditioning stage
- conditioning @ 50% solids - float @ 25% solids

TEST No.	VARIABLE	CONDITIONING pH	CONDITIONING Armac T kg/t	FLOAT pH	FLOAT wt.% float	DIAGNOSTIC FEATURES
	TRIAL RUN					Both float products of reasonable grade but need cleaning for a high grade concentrate. First float is fine mica and second coarse mica. Final tail contains some mica
1	1st stage float	2.0	0.08	2.9	5.8	
	2nd stage float	2.0	0.12	2.9	7.3	
			0.20		13.1	
2	1st stage float	2.0	0.08	2.0	6.7	+600 µm (25 mesh) grind oversize rejected. General comments as for Test 1. Less coarse mica in tail.
	2nd stage float	2.0	0.12	2.1	6.4	
			0.20		13.1	
3	Single stage float	2.0	0.16	2.0	12.7	Float characterised by a strong though thin froth with rapid and almost complete flotation of mica present. Contaminant in mica concentrate is mainly fine feldspar often adhering to mica flakes
4	pH	3.0	0.16	3.0	43.7	Very strong froth obtained which carried over almost half the float feed producing a low grade mica concentrate
5	pH	2.5	0.16	2.5	13.4	Slightly more feldspar in mica concentrate compared to Test 3
6	Uncontrolled pH during float	2.0	0.16	2.5	10.5	Marginally more mica in float tail compared to Test 3
7	Promoter	2.0	0.12	2.6	9.6	Better grade mica concentrate but slightly more mica in float tail than in Test 3
8		2.0	0.16	2.0	7.0	

Summary of Trial Feldspar/Beryl Flotation Testing — Table 5.2

TEST CONSTANTS	
	pH adjusted with hydrofluoric acid * wt. % relative to float feed 0.03 kg/t Aerofroth 65 used in each test conditioning @ 50% solids - float @ 25% solids

TEST No.	VARIABLE	CONDITIONING pH	CONDITIONING Armac T kg/t	FLOAT pH	FLOAT wt.%* float	DIAGNOSTIC FEATURES
9		3.5	0.4	3.5	75.5	Poor separation of feldspar/quartz with particle size being dominant factor i.e. most fine minus 212 μm material in float conc. and coarse plus 212 μm material in tail
10	pH	2.5	0.4	2.7	67.5	Visually feldspar concentrate was free of quartz. Quartz tail contains 50 ±% feldspar in the coarse plus 420 μm fraction, much less in other fractions
11	pH conditioning step introduced	2.5	0.4	2.7	69.5	Only slight reduction in entrained coarse feldspar in float tail
12	1 kg/t distillate oil promoter	2.5	0.4	3.5	71.5	Marked improvement in separation with hydrocarbon oil aiding flotation of coarse feldspar, maybe 1% in silica tail. A 500 μm (30 mesh) grind may improve this
13	2 kg/t distillate	2.4	0.4	3.0	76.1	Excellent results with feldspar and quartz fractions visually 90±% free of contamination from the other fraction
14	promoter	2.6	0.3	3.2	64.1	Equivalent result to Test 12
15	pH conditioning step	2.9	0.4	3.2	74.9	Better results than Test 13

Summary of Trial Beryl Flotation Testing

Table 5.3

TEST CONSTANTS	
	pH adjusted with sulphuric acid * relative to float feed 0.03 kg/t Aerofroth 65 used in each test 4 drops pine oil added to tests 18 & 19 conditioning @ 50% solids - float @ 25% solids

TEST No.	VARIABLE	CONDITIONING		FLOAT		DIAGNOSTIC FEATURES
		pH	P.S.L. kg/t*	pH	wt.%* float	
16		3.0	1.5	3.2	2.7	Very weak, thin froth. Concentrate contains magnetic fraction
17	pH	2.0	1.5	2.0	2.2	No noticeable difference in float performance
18	reagent	2.8	0.5	3.0	2.7	Froth improved by addition of 4 drops pine oil
19	pH	2.0	0.5	2.3	1.3	As above

5.6 Proving Test

Based on the results of the trial flotation work one proving test was carried out under the optimum conditions (listed in Figure 5.1) p.27 achieved. Each of the test products was dried, weighed and grain counted for mineral content.

5.7 Results of Proving Test

The results are presented in the following tables.

Table 5.4 summarizes the distribution of each mineral to the flotation products.

Tables 5.5 to 5.8 list the grain count analysis of each flotation product.

Fig. 5.1 shows a schematic representation of the processing sequence.

Summary of Mineral Distribution to Float Products

Table 5.4

	wt.%	MICA %	MICA dist. %	FELDSPAR %	FELDSPAR dist. %	QUARTZ %	QUARTZ dist. %	BERYL + %	BERYL + dist. %	MAGS + OTHERS %	MAGS + OTHERS dist. %
MICA CONCENTRATE	13.5	61.4	92.2	34.8	8.5	3.6	1.6	0.2	1.6		
QUARTZ CONCENTRATE	28.8	1.0	3.4	0.9	0.5	95.9	88.6	0.2	3.6	2.0	50.0
FELDSPAR CONCENTRATE	55.0	0.7	4.4	91.1	90.5	5.3	9.3	2.2	78.3	0.7	33.3
BERYL CONCENTRATE	0.9	0		33.6	0.5	17.5	0.5	27.8	16.5	21.1	16.7
CALCULATED FEED ANALYSIS	98.2*	9.0		55.4		31.0		1.6		1.2	

* 1.8% losses as slimes

dist% distribution % = Recovery.

\+ beryl assessment by assaying product for their Be content. Assay feed analysis 1.9% beryl.

Table 5.5

Summary of grain count analysis of Mica Concentrate

Mica	61.4%
Feldspar	34.8%
Quartz	3.8%
Beryl	not counted
Magnetics	not removed
Others	-

Breakdown Analysis of Each Size Fraction

FRACTION (μm)	wt.%	Mica %	Feldspar %	Quartz %	Beryl %	Others %
mags	-					
+420	4.5	97.2	2.3	0.5		-
-420 +300	13.1	89.3	8.2	2.2		-
-300 +212	22.9	73.0	25.8	1.2		-
-212 +150	9.5	57.6	39.1	3.0		0.3
-150	50.0	46.3	47.9	5.8		-

Table 5.6

Summary of grain count analysis of Feldspar Concentrate

Mica	0.7%
Feldspar	91.1%
Quartz	7.5%
Beryl	not counted
Magnetics	0.7%
Others	-

Breakdown Analysis of Each Size Fraction

FRACTION (μm)	wt.%	Mica %	Feldspar %	Quartz %	Beryl %	Others %
mags	0.7					
+420	9.0	0.2	95.6	4.2		
-420 +300	19.2	0.3	95.3	4.4		
-300 +212	27.8	0.3	93.3	6.4		
-212 +150	17.2	1.1	89.0	9.9		
-150	26.1	1.0	88.2	10.8		

Table 5.7

Summary of grain count analysis of Quartz Concentrate

Mica	1.0%
Feldspar	0.9%
Quartz	96.1%
Beryl	not counted
Magnetics	1.8%
Others	0.2%

Breakdown Analysis of Each Size Fraction

FRACTION (µm)	wt.%	Mica %	Feldspar %	Quartz %	Beryl %	Others %
mags	1.8					
+420	10.6	-	1.0	98.6		-
-420 +300	21.2	-	1.0	98.7		0.3
-300 +212	28.4	0.6	0.8	98.6		-
-212 +150	17.0	0.4	0.7	98.9		-
-150	21.0	3.5	1.6	94.9		-

Table 5.8

Summary of grain count analysis of Beryl Concentrate

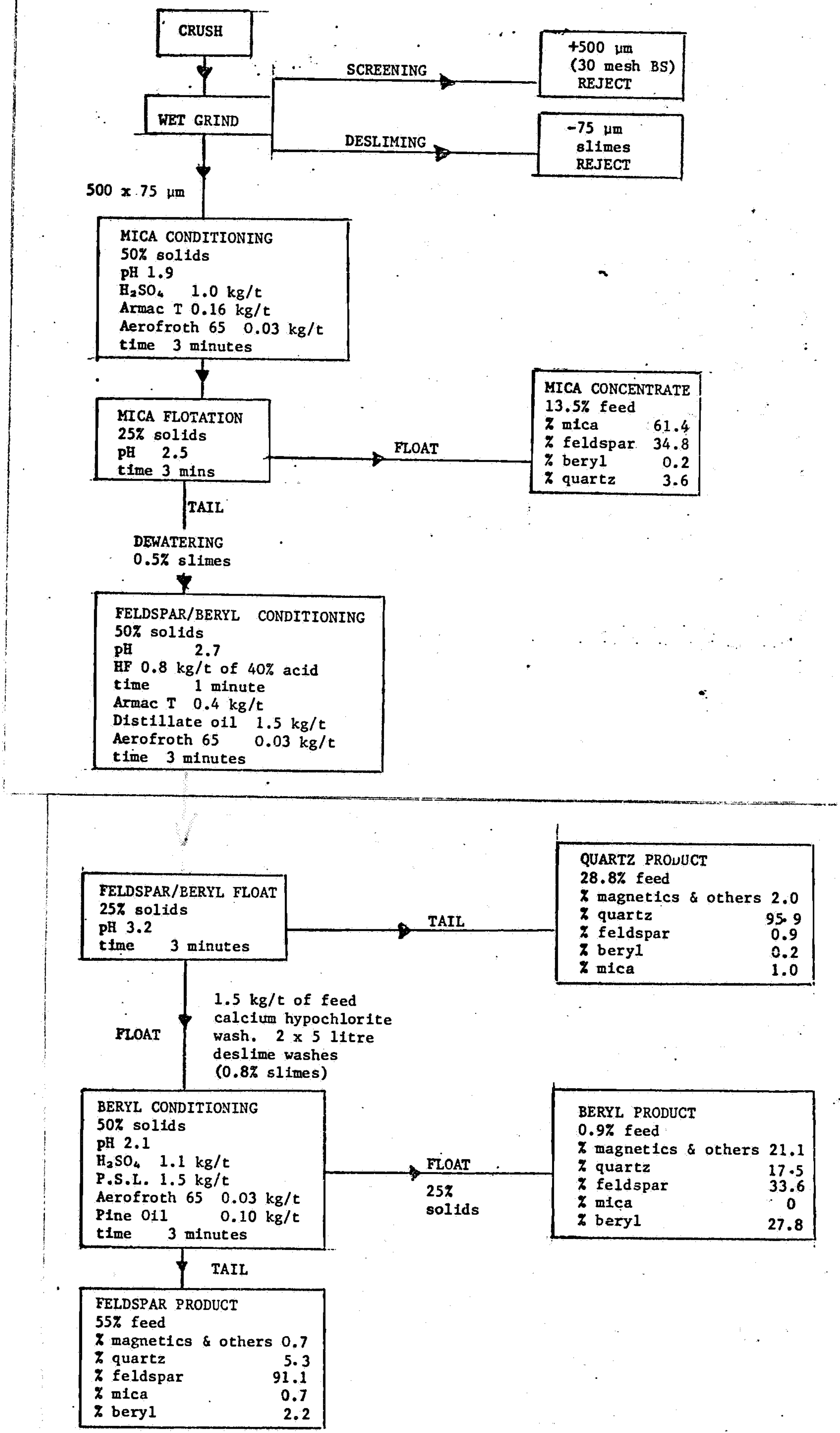
Mica	–
Feldspar	33.6%
Quartz	45.3%
Beryl	not counted
Magnetics	19.7%
Others	1.4%

Breakdown Analysis of Each Size Fraction

FRACTION (µm)	wt.%	Mica %	Feldspar %	Quartz %	Beryl %	Others %
mags	19.7					
+420	0.4	1.6	46.6	48.3		3.5
-420 +300	1.7	–	40.2	53.1		6.6
-300 +212	8.4	–	41.2	55.2		3.6
-212 +150	9.2	–	39.5	56.0		4.5
-150	60.6	–	42.2	56.7		1.1

Schematic summary of proving float test — Figure 5.1

(Note: reagent additions refer to solids feed to each stage)



5.8 Discussion

As an exploratory test programme the results were encouraging and indicate that a successful separation of each of the minerals mica, feldspar and quartz can be achieved by a differential float sequence. For each of the above minerals more than 90% reported to the respective flotation product. The separation of beryl was not as positive as the mica and feldspar separations but to some extent this was probably due to the small amount of beryl to be floated. Based on the assays of section 3.2 the total weight of beryl concentrate that could have been recovered in each test was 3.5 grams. In addition the reagents used for beryl flotation are also those used in the glass sand industry for general flotation iron bearing minerals (hence the 21.1% magnetics). This would indicate that some further processing would be required to obtain a high grade beryl product. The importance of removal of reagents used in the bulk feldspar/beryl float was not fully investigated. Distillate oil, necessary for flotation of coarse feldspar is difficult to remove and so should be used only sparingly.

The product grades produced by the single stage of flotation were not high enough for selling and several stages of flotation cleaning are indicated for each rougher product.

The mica concentrate contained only 61.4% mica with the major contaminant being fine feldspar (34.8%) and quartz (3.6%). Feldspar is activated by the same reagent as mica and separation revolves around close control over float conditions. In the rougher float performed the object was to remove all the mica and so it was inevitable that some feldspar was floated. The quartz which was mainly in the fine fractions was probably carried over with the sheer volume of material reporting to the concentrate. Further stage flotation is required to upgrade the product.

The feldspar concentrate contained 91.1% feldspar with the main contaminant being quartz. Again the quartz was probably carried over with the volume of material reporting to the feldspar/beryl float concentrate. A second stage of flotation at reduced solids concentration prior to the beryl float seems a logical step. This might also reduce the quartz reporting with the beryl product.

The quartz product, already 95.9% quartz can be readily upgraded by removal of the magnetic fraction. An alternative would be to conduct an additional mixed cationic/anionic float stage to float iron bearing minerals, mica and feldspar.

The beryl concentrate contained 16.5% of the beryl at a grade of 27.8%. The bulk of the remaining beryl remained with the feldspar concentrate. It is envisaged that further work on the beryl might be preceded by trial flotation tests on feldspar samples spiked with greater amounts of beryl.

Grain counting for beryl proved inconclusive and so assessment was made by assaying for Be and calculating the beryl content using the formulae of page 6. In the grain count analysis beryl would be counted as quartz.

6. PRELIMINARY FLOWSHEET RECOMMENDATIONS

The results of this test programme have shown that ore, as it is represented by the sample submitted, responds well to the flotation processes usually used to beneficiated pegmatite minerals. At this stage it is our opinion that with further testing it would be possible to define a commercial process for this ore similar to those processes now in operation overseas.

Typical plant design criteria which could apply to this ore are

(1) crushing, wet grinding and classifying to 100% passing 600 μm and minimum percentages passing 75 μm.

(2) desliming at 75 μm; note that this incurrs a loss of 15 to 20% of as-mined ore.

(3) conditioning with reagents for mica flotation at 50% solids for x minutes.

(4) flotation comprising one rougher stage, one scavenger stage and 3 or 4 cleaning stages. The rougher and scavenger floats would typically be at 30 to 40% solids for 5 minutes each. The cleaning floats would be say 5 minutes per stage.

(5) the mica float tailing would then be conditioned and floated for a feldspar/beryl concentrate in a circuit essentailly similar to described for the mica float, i.e. roughing, scavenging and 3 or 4 cleaning stages.

(6) the feldspar/beryl float tail would become a quartz product.

(7) a beryl flotation stage would require a washing circuit to remove previous reagents prior to flotation. Typically this would involve a calcium hypochlorite wash dewatering followed by a two stage water wash.

(8) for beryl the conditioning would be as for the mica float but with a reduced number of flotation stages i.e. one rougher float and one or two cleaner floats.

(9) each mineral concentrate would be dried and separated magnetically.

Certified plant and process criteria similar to those listed above would be the end product of a further test programme.

APPENDIX A

Letter of Agreement

WARMAN INTERNATIONAL LTD.

(INCORPORATED IN VIC.)

TELEGRAMS & CABLES:
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439 8311 (6 LINES)
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ARTARMON
N.S.W. 2064
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18-26 DICKSON AVENUE
ARTARMON
SYDNEY
NEW SOUTH WALES

AIB/SFR/EH
77/4918

RESEARCH & DEVELOPMENT DIVISION

19th August, 1977

Liberated Minerals Pty Ltd
34 Hygeia Parade
Ringwood, Vic. 3134

Attention : Mr. D. Kempney
Mr. J. McKenzie

Dear Sirs

Examination and Testwork on Pegmatite Samples

We refer to your meeting with us in our office on August 16. This letter is a record of the agreed action on the samples you submitted and also we present for your approval the estimated cost of the total programme of testwork.

Samples Submitted

The samples you provided were sorted under your direction into 12 groups each of which we have now designated with a laboratory number. The attached table shows our laboratory number and your description of each group together with the action proposed for each group of samples.

Sample Beneficiation

Samples 1 & 2 from the Triple Chance and Egebek dumps are for beneficiation testwork. Initially a composite of approx. 30 kg will be prepared by blending equal portions of each sample. The composite will then be processed as described in our previous letter of 31st May, 1977 (ref. No. SFR/EH - 77/3206). Analysis of the individual samples submitted and the process products will be conducted by microscopic grain staining techniques, i.e. % beryl, % feldspar etc. Samples of products will be retained.

Rock Specimens for Feldspar Analysis

Six samples as listed in the table were nominated for analysis to conform with the specifications for saleable feldspar. This involves analysis for Si, Al, Fe, K, Ca, Mg, Na and Ti on each sample.

Rock Specimens for Identification Analysis

Six samples identified as contaminants of No.3 pit are each to be analysed on a semi-quantitative basis followed by quantitative analysis of any significant metallic elements. The samples will be given an alphabetic identification A, B, C, D, ... etc.

Cost of Testwork

We estimate that the cost of the testwork we have outlined will be as follows.

(i) beneficiation work according to our letter of May 31 2670

(ii) additional analytical and identification work as defined herein 1400

Timing

The testwork will take an estimated six weeks to complete. In accordance with your verbal instructions, work has already commenced but it is necessary for us to receive your official order on a formal letter of authorisation as soon as possible.

We trust that this proposal meets with your approval. If you would like to discuss any aspect in further detail, please phone or write.

Yours faithfully

WARMAN INTERNATIONAL LTD.

A.I. Bellingham

Manager, Research and Development Division

LIBERATED MINERALS PTY LTD

SUMMARY OF PROPOSED TESTWORK

Laboratory Identification Number	Sample Description	Weight (kg)	Action Requested
1444-1	Triple Chance Dump (Be)	31.6	See 'Sample Beneficiation'
1444-2	Egebek Dump (plus previous submission)	22.4 2.0	See 'Sample Beneficiation'
1444-3	Contaminants of No.3 Pit Inca Lease - 5 coloured hard-rock specimens plus one soft white rock	10.5	Six specimens to be sampled for X-ray fluorescence semi-quantitative analysis of elements atomic numbers greater than 22. Quantitative analysis of any significant metallic elements. Identify the mineral of the soft white rock
1444-4	Ice cream container - Inca No.3 Lease - crushed sample plus separate feldspar rock specimen (plus previous submission)	13.1 0.25 3.08	Hold the crushed sample but analyse rock specimen for conformity to feldspar selling specification
1444-5	Beryl chips and sand ex Triple Chance	1.2	Analysis of beryllium content
1444-6	Egebek - Mica schist	1.15	Percent mica
1444-7	Egebek - Book mica	1.66	Hold - no action
1444-8	Triple Chance soda feldspar	1.25	Analysis for conformity to the feldspar selling specifications provided. Choose sample for analysis selectively so as to reject any large free quartz inclusions. Remove any adhering clay.
1444-9	Egebek main pit feldspar.	1.37	
1444-10	Egebek second pit feldspar	1.85	
1444-11	Egebek Pierces lode feldspar	0.55	
1444-12	Black Adder Creek - soda feldspar (plus previous sample)	0.72 6.1	

APPENDIX B

Semi-quantitative X-ray Fluorescence Scans

- APPLICATION ADVICE -

1. The report covers a search for all elements having atomic numbers from 22 to 92 inclusive.

2. Unless the element is indicated in one of the ranges shown it can only be present in amount less than the limit of detection of the technique.

3. The ranges shown are semi-quantitative estimates only and are recorded in parts per million (10,000 ppm = 1%)

4. In silicate-type samples the limit of detection will vary between 5 to 100 ppm depending on the element. A characteristic limit may be increased by mineralisation with other metals.

Sample A

LABORATORY REPORT 77/84715

QUALITATIVE ANALYSIS BY X-RAY FLUORESCENCE

Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 pm	Greater than 10,000 ppm	Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm
Ti					Ce				
V					Pr				
Cr					Nd				
Mn		**			Pm				
Fe				**	Sm				
Co					Eu				
Ni					Gd				
Cu					Tb				
Zn					Dy				
Ga					Ho				
Ge					Er				
As					Tm				
Se					Yb				
Br					Lu				
Kr					Hf				
Rb		**			Ta				
Sr		**			W				
Y					Re				
Zr					Os				
Nb					Ir				
Mo					Pt				
Tc					Au				
Ru					Hg				
Rh					Tl				
Pd					Pb				
Ag					Bi				
Cd					Po				
In					At				
Sn					Rn				
Sb					Fr				
Te					Ra				
I					Ac				
Xe					Th				
Cs					Pa				
Ba					U				
La									

WARMAN EQUIPMENT (INTERNATIONAL) LTD.

Sample B

000040

LABORATORY REPORT 77/84715

QUALITATIVE ANALYSIS BY X-RAY FLUORESCENCE

PAGE B2

Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm	Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm
Ti					Ce				
V					Pr				
Cr					Nd				
Mn					Pm				
Fe				**	Sm				
Co					Eu				
Ni					Gd				
Cu					Tb				
Zn					Dy				
Ga					Ho				
Ge					Er				
As					Tm				
Se					Yb				
Br					Lu				
Kr					Hf				
Rb					Ta				
Sr		**			W				
Y					Re				
Zr					Os				
Nb					Ir				
Mo					Pt				
Tc					Au				
Ru					Hg				
Rh					Tl				
Pd					Pb				
Ag					Bi				
Cd					Po				
In					At				
Sn					Rn				
Sb					Fr				
Te					Ra				
I					Ac				
Xe					Th				
Cs					Pa				
Ba					U				
La									

Sample C

000041

LABORATORY REPORT 77/84715

QUALITATIVE ANALYSIS BY X-RAY FLUORESCENCE

Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 pm	Greater than 10,000 ppm	Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm
Ti					Ce				
V					Pr				
Cr					Nd				
Mn		**			Pm				
Fe				**	Sm				
Co					Eu				
Ni					Gd				
Cu					Tb				
Zn	**				Dy				
Ga					Ho				
Ge					Er				
As					Tm				
Se					Yb				
Br					Lu				
Kr					Hf				
Rb					Ta				
Sr					W				
Y					Re				
Zr					Os				
Nb					Ir				
Mo					Pt				
Tc					Au				
Ru					Hg				
Rh					Tl				
Pd					Pb				
Ag					Bi				
Cd					Po				
In					At				
Sn					Rn				
Sb					Fr				
Te					Ra				
I					Ac				
Xe					Th				
Cs					Pa				
Ba					U				
La									

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Sample D

LABORATORY REPORT 77/84715 QUALITATIVE ANALYSIS BY X-RAY FLUORESCENCE **PAGE** B4

Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm	Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm
Ti					Ce				
V					Pr				
Cr					Nd				
Mn			**	**	Pm				
Fe				**	Sm				
Co					Eu				
Ni					Gd				
Cu					Tb				
Zn					Dy				
Ga					Ho				
Ge					Er				
As					Tm				
Se					Yb				
Br					Lu				
Kr					Hf				
Rb					Ta				
Sr		**			W				
Y	**				Re				
Zr	**				Os				
Nb		**			Ir				
Mo					Pt				
Tc					Au				
Ru					Hg				
Rh					Tl				
Pd					Pb				
Ag					Bi				
Cd					Po				
In					At				
Sn					Rn				
Sb					Fr				
Te					Ra				
I					Ac				
Xe					Th				
Cs					Pa				
Ba					U				
La									

WARMAN EQUIPMENT (INTERNATIONAL) LTD.

LABORATORY REPORT 77/84715

Sample E

QUALITATIVE ANALYSIS BY X-RAY FLUORESCENCE

Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm	Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm
Ti					Ce				
V					Pr				
Cr					Nd				
Mn		**			Pm				
Fe				**	Sm				
Co					Eu				
Ni					Gd				
Cu					Tb				
Zn					Dy				
Ga					Ho				
Ge					Er				
As					Tm				
Se					Yb				
Br					Lu				
Kr					Hf				
Rb					Ta				
Sr					W				
Y					Re				
Zr					Os				
Nb					Ir				
Mo					Pt				
Tc					Au				
Ru					Hg				
Rh					Tl				
Pd					Pb				
Ag					Bi				
Cd					Po				
In					At				
Sn					Rn				
Sb					Fr				
Te					Ra				
I					Ac				
Xe					Th				
Cs					Pa				
Ba					U				
La									

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Sample F

000044

LABORATORY REPORT 77/84715

QUALITATIVE ANALYSIS BY X-RAY FLUORESCENCE

PAGE B6

Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm	Element	Detd Less than 100 ppm	100 - 1000 ppm	1000 - 10,000 ppm	Greater than 10,000 ppm
Ti					Ce				
V					Pr				
Cr					Nd				
Mn					Pm				
Fe			**		Sm				
Co					Eu				
Ni					Gd				
Cu					Tb				
Zn					Dy				
Ga					Ho				
Ge					Er				
As					Tm				
Se					Yb				
Br					Lu				
Kr					Hf				
Rb					Ta				
Sr					W				
Y					Re				
Zr					Os				
Nb					Ir				
Mo					Pt				
Tc					Au				
Ru					Hg				
Rh					Tl				
Pd					Pb				
Ag					Bi				
Cd					Po				
In					At				
Sn					Rn				
Sb					Fr				
Te					Ra				
I					Ac				
Xe					Th				
Cs					Pa				
Ba					U				
La									