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Use of Oxide Assays to Determine Mineral Composition at Mina do Barroso Lithium Project, Portugal.

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Prepared for Savannah Lithium Lda
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Executive Summary

Substantial lithium Mineral Resources have been defined by Savannah Resources Plc ("SAV") at its Mina do Barroso Lithium Project ("MBLP") which is located approximately 60km ENE of the city of Braga in northern Portugal.

Economic evaluation of the MBLP completed as part of a feasibility study has identified that gangue minerals associated with the spodumene pegmatite deposits have the potential to generate saleable by-products from the processing of the lithium bearing pegmatite rocks. The by-products include feldspar, quartz and muscovite. A program of quantitative XRD analysis comprising 14 samples was completed by SAV and confirmed the observations from drilling and surface samples of the pegmatite that the pegmatite rock mass is composed almost entirely of feldspar (albite and microcline), quartz, spodumene and muscovite. The average composition based on XRD of all 14 samples showed the mineral content to be albite 38%, quartz 27%, spodumene 12%, muscovite 12% and microcline 10%. Undetermined minerals accounted for 1.5% of the rock mass.

SAV has conducted two programs of multi-element analysis of drilling samples using XRF analysis to quantify oxide concentrations within the pegmatite. A total of 127 individual drilling samples were re-assayed using XRF. In addition, 141 sample composites (representing 2,020m of drilling) were prepared and analysed to provide multi-element data throughout the pegmatite. The results of these various samples have been used by PayneGeo to prepare normative mineralogy calculations to determine the mineral composition of the samples.

The results from the quantitative XRD work was used to calibrate the results from the normative calculations using regression formulas and correction factors. The methodology for deriving mineral compositions from assay data for the main pegmatite minerals is summarised as follows:

- Spodumene – excellent correlation of spodumene with assayed Li_2O allows the proportion of spodumene to be accurately determined by normative mineralogy based on Li_2O analysis;
- Albite – good correlation of albite with assayed Na_2O although the normative calculation underestimates albite content (likely due to presence of Ca or Mg in feldspar lattice) so a positive correction factor (+17%) has been derived from XRD comparisons;
- Microcline – Regression of XRD results shows good correlation of microcline with K_2O assay. Regression formula can be applied to K_2O analyses to determine microcline content;
- Muscovite – reasonable correlation between muscovite and microcline in XRD has allowed a ratio of microcline to muscovite to be determined;
- Muscovite and microcline – factor applied to limit total microcline+muscovite content to match available K_2O in assays so a small negative correction factor (-4%) has been applied;
- Other minerals – XRD shows 1.5% of rock mass to be other undetermined minerals;
- Quartz – the proportion of the rock mass calculated by subtracting the other elements from the total mass.

The results of QEMSCAN analysis were available for five samples. These were used as a further check on the normative mineralogy and were found to support the calculated data reasonably well.

There is some uncertainty in the results due to the reliance on a small number of XRD analyses. The XRD results also show a degree of inconsistency with the multi-element assay results from those samples (for example the poor correlation of assayed Na_2O with measured albite content). However,

the general consistency of mineralogy in the pegmatites and the abundance of a small number of minerals suggest that the results will provide a reasonable estimate of the by-product minerals in large scale parcels.

A methodology for the estimation of mineral composition in the Mineral Resource block models has been derived. Where sufficient oxide assay data is available (currently only the Grandao deposit), this involves interpolation of values using the oxide data and is considered to give a reliable estimate of the mineralogy.

Where oxide data is not available, mineral composition can be assumed using the reliably estimated Li_2O grades and assumed parameters for the other minerals. The resulting mineralogy is suitable for preliminary evaluation only. Additional oxide analyses using composited exploration samples should be conducted on deposits where the mineralogy is important to the overall project evaluation.

The reliability of the calculations could be improved with a larger database of quantitative XRD analyses.

Any mineral separation test work conducted during the study should be compared to the predicted mineralogy as a further test on the reliability of the normative and regression-based mineralogy.

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Principal Geologist

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Appendix 1: Mineral and Chemical Results from Samples Analysed by XRD

1. Introduction and Project Summary

The Mina do "Barroso Lithium Project ("MBLP") project lies on the mining licence *Mina do Barroso project C-100* located in northern Portugal (Table 1-1). Previous mining work at the MBLP has focused on production for the ceramics industry.

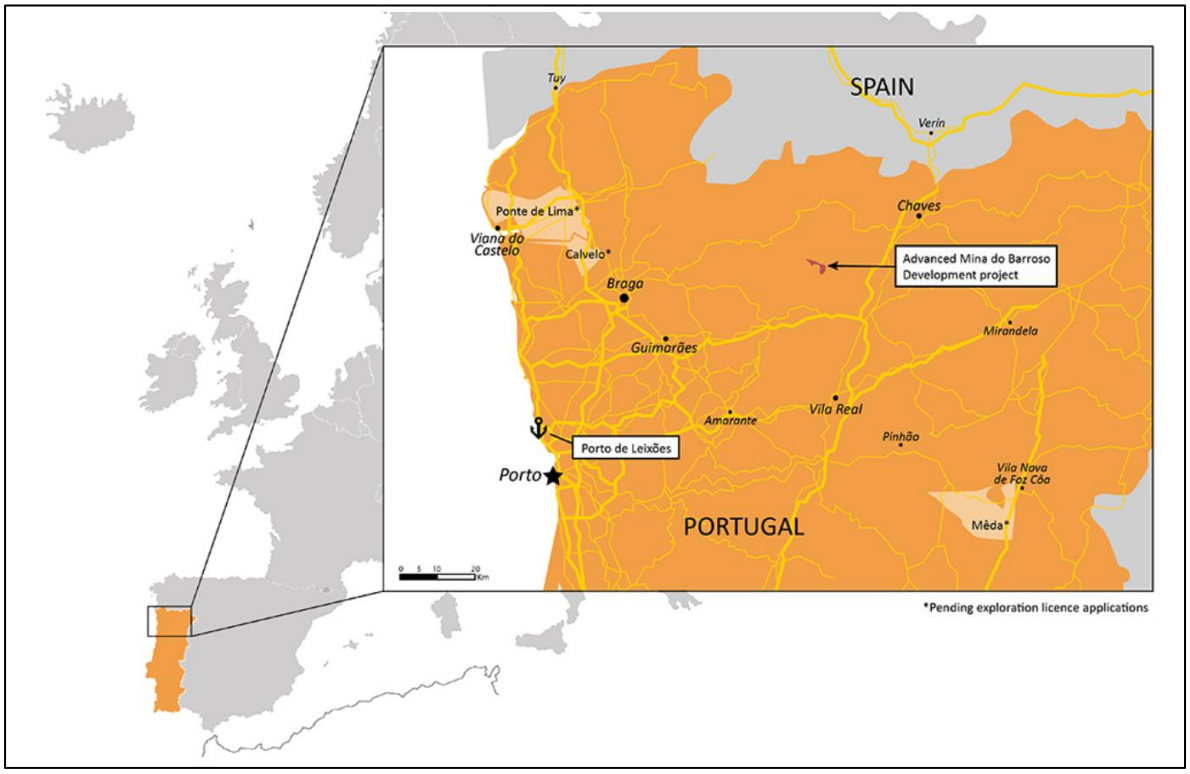


Table 1-1: Project Location Plan (from Savannah Resources Plc)

Since acquisition of the project in May 2017, SAV has completed exploration work including reconnaissance geological mapping and trenching to define areas prospective for lithium mineralisation. Several programs of drilling and detailed metallurgical test work have now been completed with Mineral Resources estimated for four of the prospect areas – Reservatorio, Grandao, Pinheiro and NOA. Following completion of a positive Scoping Study in June 2018, a Feasibility Study has commenced to determine the economic potential of the project.

Initial findings from the Feasibility Study suggest that by-products from the processing of spodumene pegmatites may be saleable to the local ceramics industry. The by-products include feldspar, quartz and muscovite. To allow the by-product evaluation to be assessed, it is necessary to quantify the mineralogy of the deposits. SAV has carried out a range of analyses to assist with this including quantitative XRD analysis, multi-element XRF analysis of drill samples and multi-element analysis of composites samples collected from pulverised drill samples.

The by-product assessment has been focussed largely on the Grandao deposit which currently represents approximately 75% of the total Mineral Resource inventory at the MBLP.

2. Geology and Mineralisation

2.1. Overview

The following information was sourced from a technical geological report (CGMSL, 2017) and Savannah stock exchange releases (Savannah, 2017).

At the Mina Do Barroso project ("MBLP"), lithium mineralisation occurs predominantly in the form of spodumene-bearing pegmatites which are hosted in metapelitic and mica schists, and occasionally carbonate schists of upper Ordovician to lower Devonian age. Lithium is present in most pegmatite compositions and laboratory test work confirms that the lithium is almost exclusively within spodumene. Distinct lithium grade zonation occurs within the pegmatites, with weakly mineralised zones often evident at the margins of the intrusions. Minor xenoliths and inliers of schist are observed on occasions.

Geological logging and quantitative XRD analysis has demonstrated that the pegmatite bodies are comprised largely of silicate minerals. The average composition of the 14 samples analysed by XRD was albite 38%, quartz 27%, spodumene 12%, muscovite 12% and microcline 10%. Undetermined minerals accounted for 1.5% of the rock mass.

2.2. Mineral Geochemistry and Normative Mineralogy

The chemical formulae and atomic weights for the main mineral components of the pegmatites are shown in Table 2-1.

Table 2-1: Mineral Geochemistry

Mineral	Formula	Atomic Weight	Element (Oxide) Multiplier
Albite	$NaAlSi_3O_8$	262.2	Na*11.4 (Na_2O*8.46)
Quartz	SiO_2	60.08	Si*2.14 (SiO_2*1)
Spodumene	$LiAlSi_2O_6$	186.08	Li*26.65 (Li_2O*12.36)
Muscovite	$KAl_3Si_3O_{10}(OH)_2$	398.28	K*10.19 (K_2O*8.45)
Microcline	$KAlSi_3O_8$	278.32	K*7.12 (K_2O*5.91)

In certain circumstances it is possible to calculate mineral content in a sample from the elemental or oxide analyses ("normative mineralogy"). The element or oxide multipliers shown in Table 2-1 are simple formulae to show how the element value could be used to calculate the mineral content if that element were present only in that particular mineral.

In the case of the spodumene pegmatites, Na occurs only in albite and Li occurs only in spodumene so the elemental assays can be used to calculate those minerals. Muscovite and microcline have similar chemical composition but are the only minerals that have K in the composition so the K assay can provide a limit to the total muscovite and microcline assemblage, but is only of limited use in defining the proportion of each of those minerals. All minerals in the pegmatite contain Si, so the SiO_2 assay can not be used to define quartz content.

The formulae in Table 2-1 represent pure end-member composition for the minerals. The feldspar minerals albite and microcline can have chemical variations due to solid solution series between end-members with substitution of Ca in albite and Na in microcline. Hence the derived multipliers may not be precise in determining mineral composition based on individual element (or oxide) assays.

3. Data Sets

3.1. Overview

Three data sets were provided by SAV to PayneGeo to be compiled and analysed for this study. The data sets are summarised in Table 3-1

Table 3-1: Summary of Data Used in Mineralogy Study

Name of Data Set	Sample Type	Count	Assay Method
Metallurgical Samples	Composites	14	XRF and XRD
Metallurgical Samples	Composites	5	QEMSCAN
Drilling Samples	Individual samples	127	ICP (Li_2O), XRF (oxides)
Drilling Composites	Composited Drilling Samples	141	Li_2O from original samples, XRF (oxides)

The 14 metallurgical samples were the only samples to be analysed using quantitative XRD to determine mineral composition. Some of those were included in the 5 samples for which QEMSCAN data was available. The drilling data sets were analysed by ICP for Li_2O or by XRF for oxide analysis.

3.2. XRD and XRF Analysis of Metallurgical Samples

SAV completed quantitative XRD analysis of 12 metallurgical samples and two bulk composite samples. Each of the samples was also analysed by XRF to determine elemental components measured in oxide form. Results for the main oxides and for the mineral assemblages determined by XRD are shown in Table 3-2. Full results are included in Appendix 1.

To assess the compositional trends in the different mineral species, the proportion of each mineral was plotted against the other minerals. Selected charts are shown in Figure 3-1 and all charts are included in Appendix 1.

Strong trends were observed between albite and spodumene (negative), microcline and muscovite (positive) and between microcline and quartz (negative).

Table 3-2: Chemistry and Mineralogy of XRD Samples

Sample	XRF Analysis							Quantitative XRD					
	Li_2O	Fe_2O_3	Al_2O_3	SiO_2	Na_2O	CaO	K_2O	Alb	Qtz	Mcl	Musc	Spod	Total
	%	%	%	%	%	%	%	%	%	%	%	%	%
M00111	0.62	0.34	16.30	73.19	3.17	0.08	3.28	45.8	25.7	9.7	8.5	8.1	97.8
M00116	1.25	0.34	16.50	73.03	3.13	0.17	2.60	33.0	21.6	11.5	16.8	15.5	98.6
M00125	0.77	0.35	16.34	73.54	4.61	0.15	2.31	46.3	25.5	6.9	8.0	10.0	96.6
M00133	0.85	0.58	16.48	71.78	3.85	0.42	3.19	39.9	29.0	8.2	10.7	11.4	99.2
M00139	1.06	0.40	16.32	73.44	4.03	0.18	2.64	36.9	26.4	10.8	10.2	13.4	97.7
M00147	0.53	0.53	16.18	73.72	4.54	0.27	2.89	35.4	29.0	8.2	19.1	7.3	99.0
M00158	1.30	0.45	16.44	73.99	3.34	0.27	3.04	36.9	25.0	12.1	8.7	16.4	99.2
M00176	0.99	0.50	16.22	73.51	3.99	0.34	2.70	36.9	26.9	10.9	12.4	12.1	99.3
M00225	0.98	0.35	16.13	73.75	3.65	0.30	3.09	36.2	25.2	10.2	15.5	11.6	98.7
M00235	0.06	0.22	16.28	72.45	4.69	0.24	4.08	43.6	22.7	11.3	20.1	1.1	98.9
M00242	0.80	0.35	16.92	73.00	3.53	0.29	3.66	37.0	21.5	12.5	17.4	10.3	98.7
M00248	1.69	0.45	15.49	74.83	3.34	0.35	1.71	26.9	34.0	6.7	9.9	21.0	98.5
Stage 1 Bulk Comp	0.97	0.47	16.17	73.77	3.69	0.29	2.92	41.5	26.1	9.3	9.7	11.5	98.0
Stage 2 Bulk Comp	1.26	0.48	16.42	73.29	3.76	0.26	2.61	31.5	42.4	4.9	3.7	15.7	98.2
Average	**0.94**	**0.41**	**16.30**	**73.38**	**3.81**	**0.26**	**2.91**	**37.7**	**27.2**	**9.5**	**12.2**	**11.8**	**98.5**

(Alb-albite, Qtz – quartz, Mcl – microcline, Musc – muscovite, Spod – spodumene)

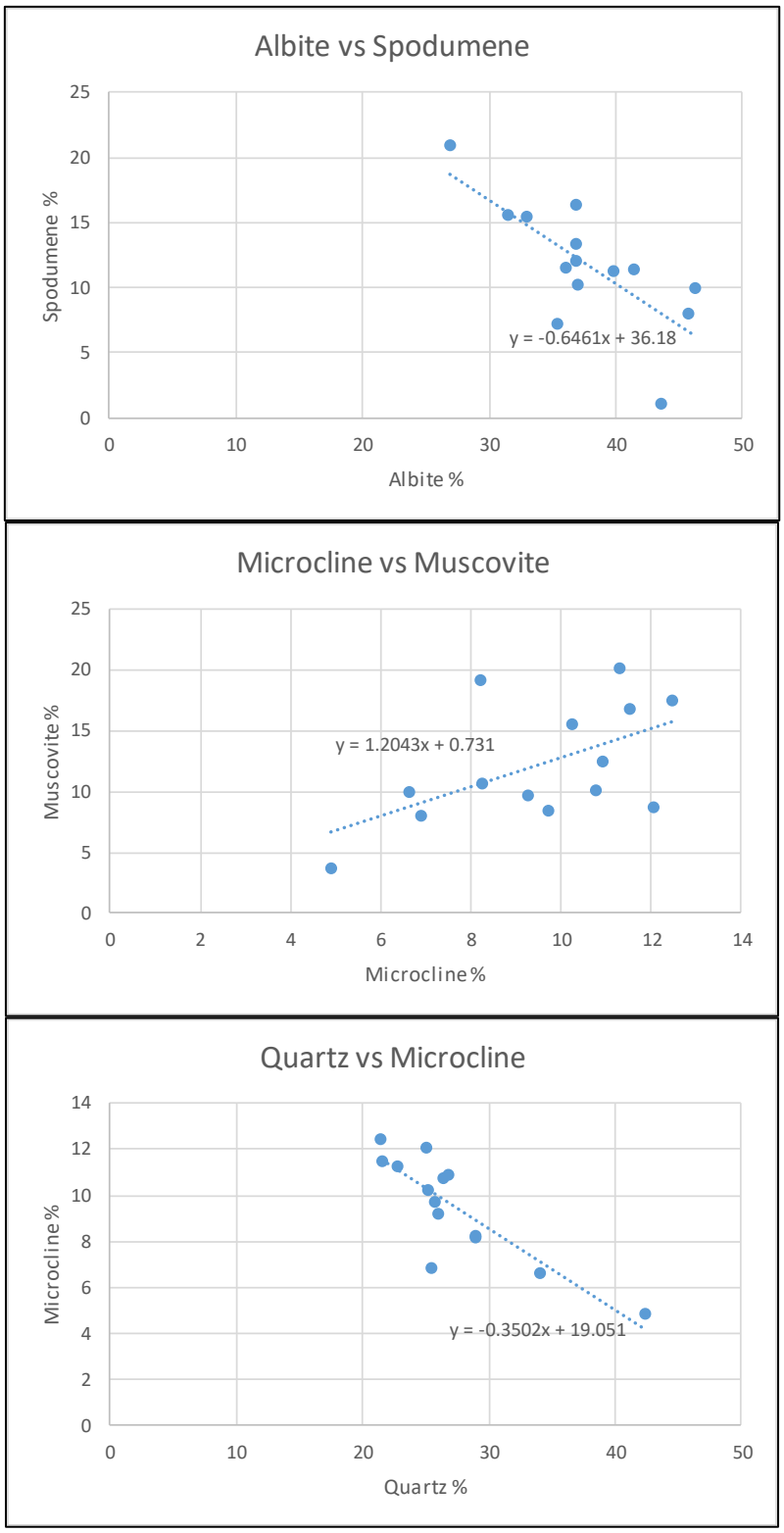


Figure 3-1: Selected Correlation Plots of Results from XRD Analysis

The oxide assays determined using XRF analysis for each of the samples for which XRD determinations were available were used to generate charts of the main oxides against the main mineral species. These are shown in Figure 3-2 to Figure 3-4. Plots for Al_2O_3 and SiO_2 are included in Appendix 1.

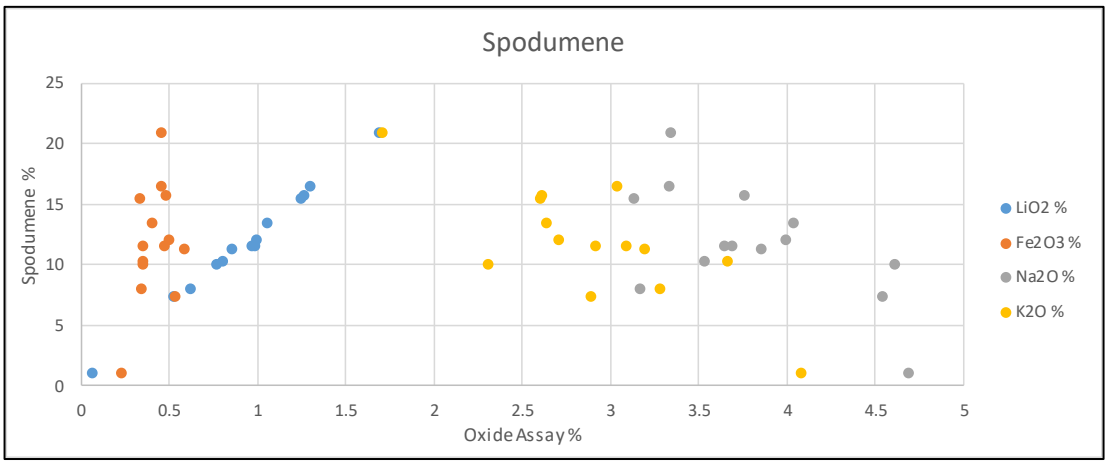


Figure 3-2: Oxide Assays vs Mineral Content for Spodumene

It is clear from Figure 3-2 that a strong correlation exists between Li_2O and the spodumene content measured by XRD. A moderate negative correlation is observed between Na_2O and spodumene, but no other correlation was noted.

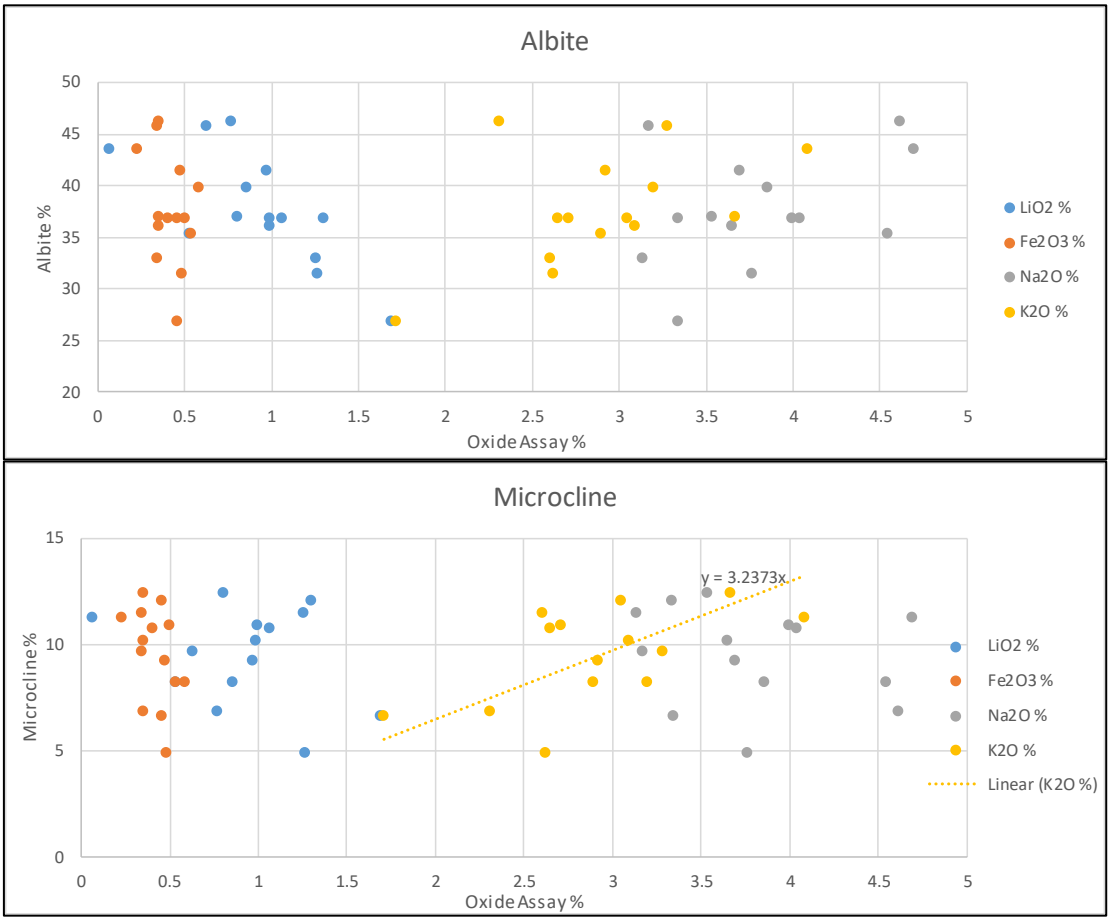


Figure 3-3: Oxide Assays vs Mineral Content for Albite and Microcline

Figure 3-3 plots the oxide assays against the content of the feldspar minerals. A weak positive correlation is demonstrated between albite and Na_2O. A moderate correlation is shown between microcline and K_2O.

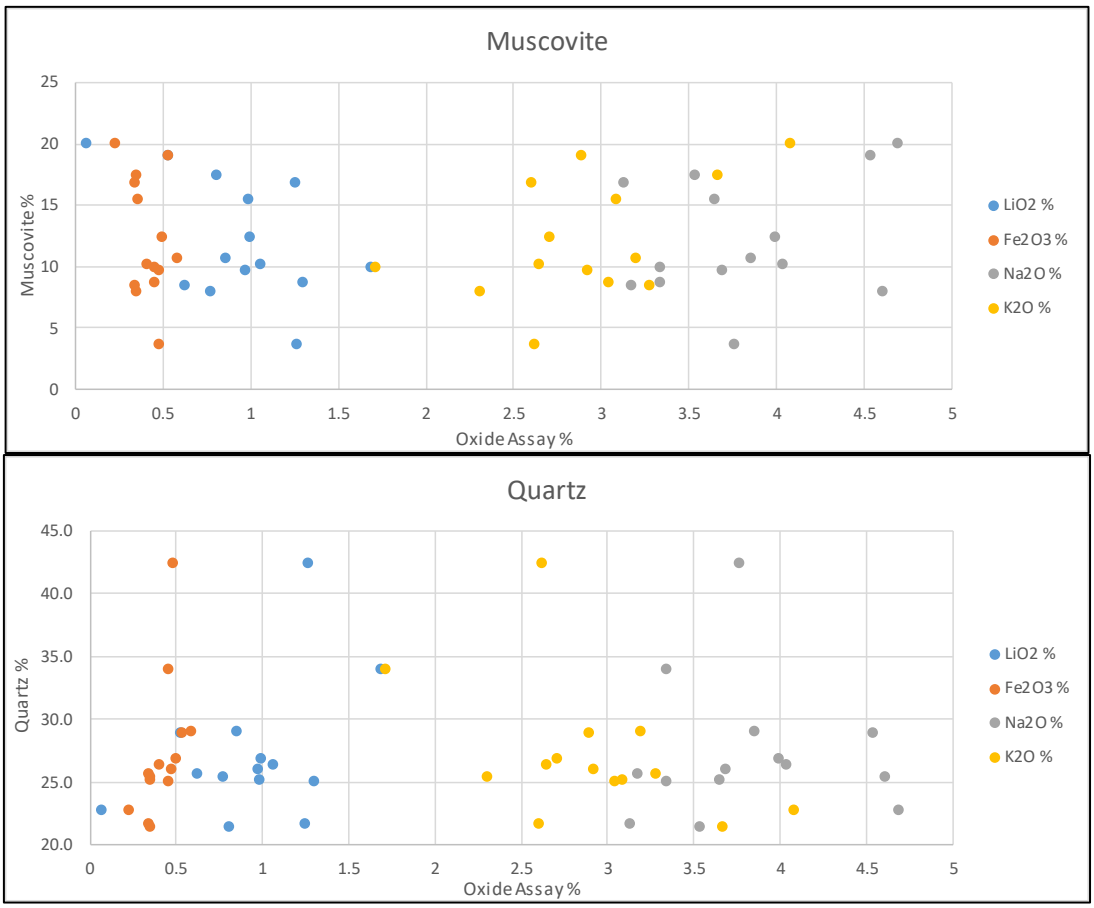


Figure 3-4: Oxide Assays vs Mineral Content for Muscovite and Quartz

In Figure 3-4, the oxide assays are plotted against muscovite and quartz. A weak correlation was observed between K_2O and muscovite.

3.3. XRF Analysis of Individual Drilling Samples

To allow an initial understanding of the distribution of the multi-element data in the deposit, SAV completed XRF analysis of 127 samples, largely sourced from four RC holes. The location of the samples is shown in Figure 3-5.

Summary statistics from the data set are shown in Table 3-3. Correlation analysis was also completed which showed that there was little correlation between the main oxides. However the strong negative correlation observed between Li_2O and Na_2O in the XRD samples was also present in the drilling samples (Figure 3-6).

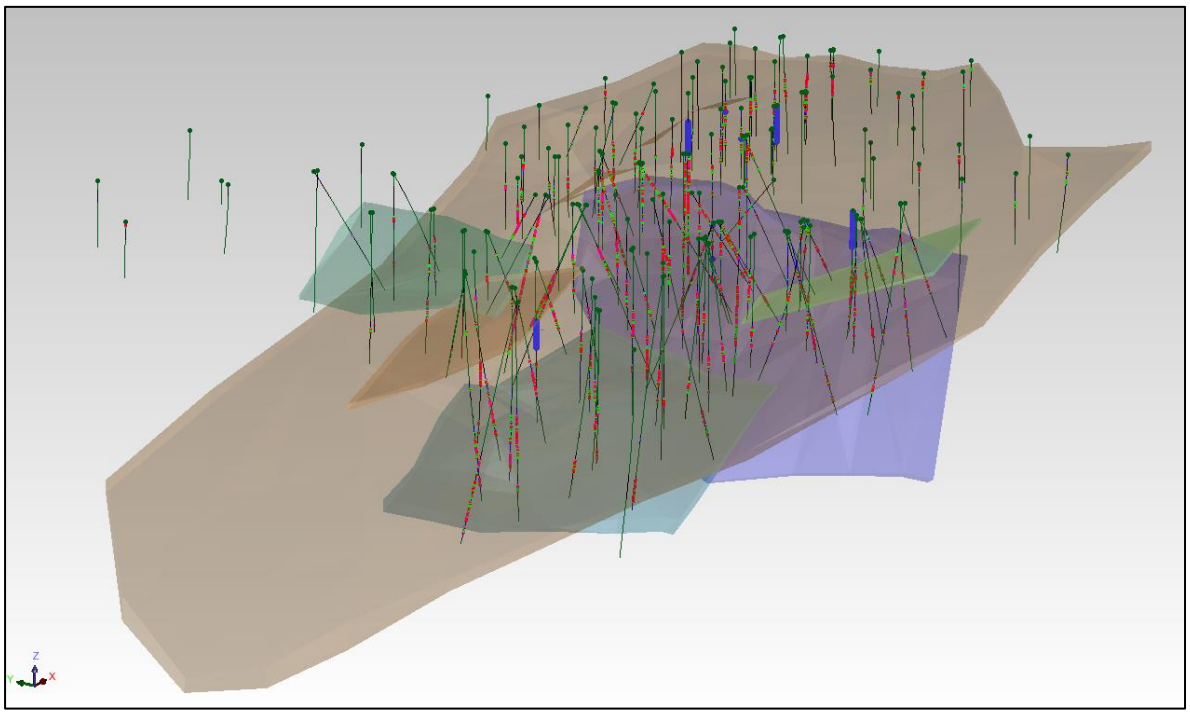


Figure 3-5: Distribution of 1m Samples With Multi-element Analysis (blue dots)

Table 3-3: Oxide Assays (XRF) of 1m Drilling Samples

Oxide	***Li2O_pct***	***Na2O_pct***	***K2O_pct***	***Fe2O3_pct***	***Al2O3_pct***	***SiO2_pct***
Parameter						
Mean	1.11	3.45	2.57	1.32	16.04	73.59
Median	1.11	3.62	2.61	1.10	16.19	73.64
Std Devn	0.55	1.17	0.50	1.12	1.61	2.67
Variance	0.30	1.36	0.25	1.25	2.59	7.11
Minimum	0.04	0.07	0.94	0.359	4.6	60.23
Maximum	3.13	5.61	4.89	7.6	21.07	90.63
Count	126	127	127	127	127	127
Percentiles						
0.1	0.32	2.03	2.03	0.77	15.85	72.59
0.2	0.64	2.73	2.20	0.90	15.99	73.05
0.3	0.91	3.28	2.41	0.96	16.09	73.23
0.4	1.04	3.49	2.48	1.00	16.14	73.51
0.5	1.11	3.62	2.61	1.10	16.19	73.64
0.6	1.24	3.77	2.68	1.16	16.22	73.77
0.7	1.34	4.05	2.78	1.20	16.32	73.93
0.8	1.51	4.25	2.84	1.31	16.42	74.10
0.9	1.82	4.72	3.03	1.55	16.72	74.32
1	3.13	5.61	4.89	7.60	21.07	90.63

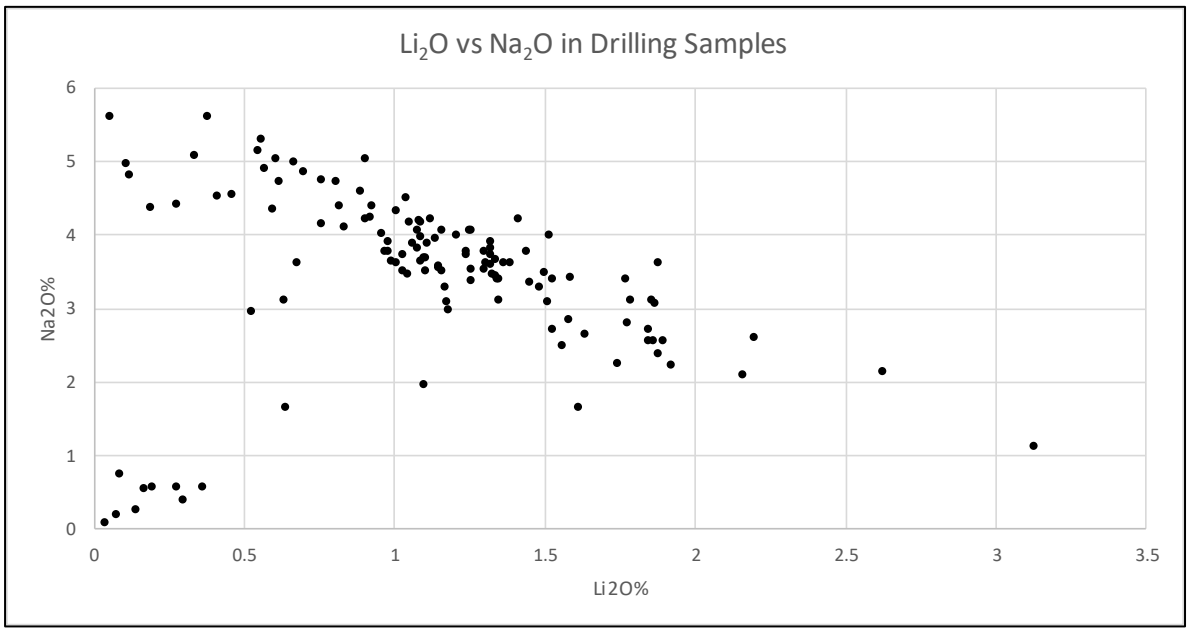


Figure 3-6: Scatterplot of Li_2O and Na_2O in Drilling Samples

3.4. XRF Analysis of Composite Drilling Samples

To provide representative data to be obtained throughout the Grandao deposit, SAV prepared 141 composite samples from 79 holes. The composite length varied from 4m to 28m with an average length of 14m. The composites were assayed for a multi-element suite using XRF. The composites were not analysed for Li_2O, so PayneGeo assigned the Li_2O value to the composites by preparing length-weighted averages of Li_2O in the individual drilling samples that made up each composite. The location of the composite samples is shown in Figure 3-7.

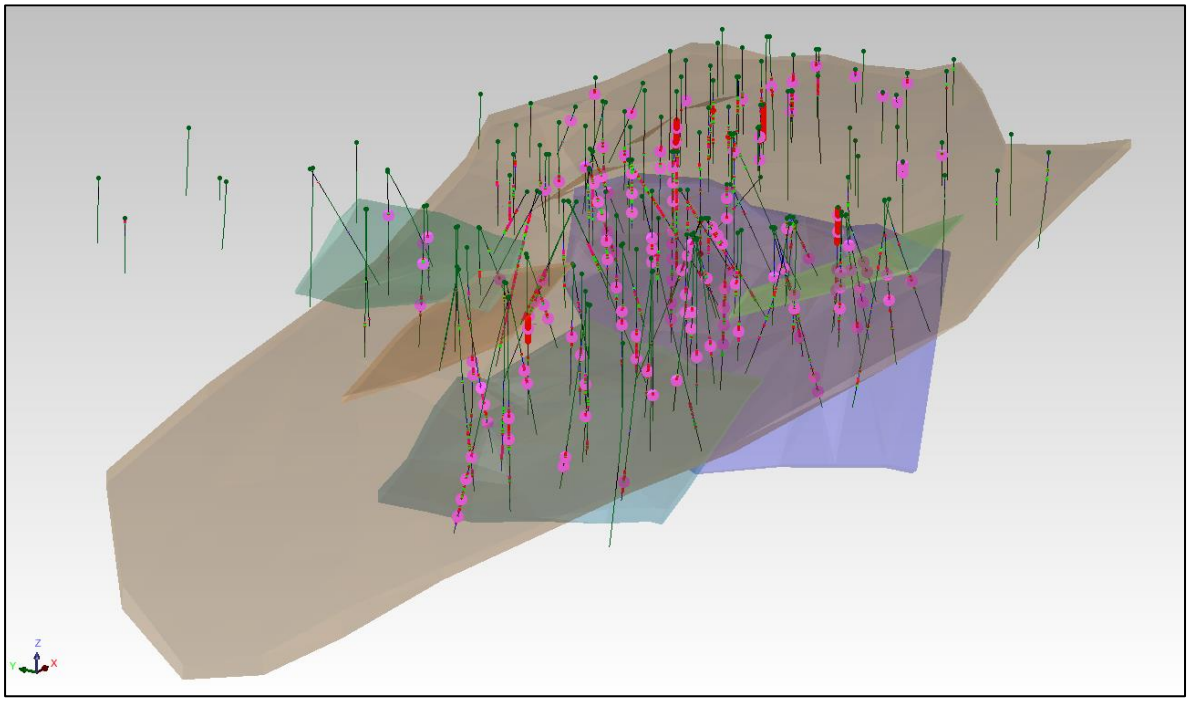


Figure 3-7: Distribution of Composite Samples With Multi-element Analysis (pink dots)

Summary statistics from the data set are shown in Table 3-4. Correlation analysis was also completed which showed that there was little correlation between the main oxides. However the strong negative correlation observed between Li_2O and Na_2O in the XRD samples was also present in the drilling samples (Figure 3-6)

Table 3-4: Oxide Assays (XRF) of Drilling Composites

Oxide	*Li2O_pct*	*Na2O_pct*	*K2O_pct*	*Fe2O3_pct*	*Al2O3_pct*	*SiO2_pct*
Parameter						
Mean	1.05	3.47	2.66	1.29	16.04	73.27
Median	1.14	3.56	2.60	1.16	16.14	73.36
Std Devn	0.37	0.53	0.33	0.51	0.69	1.44
Variance	0.14	0.28	0.11	0.26	0.48	2.07
Minimum	0.07	2.06	1.88	0.74	13.14	66.68
Maximum	1.75	5.68	4.08	4.12	17.96	77.69
Count	141	141	141	141	141	141
Percentiles						
0.1	0.45	2.84	2.34	0.96	15.5	72.2
0.2	0.79	3.12	2.45	1.01	15.74	72.85
0.3	0.95	3.35	2.5	1.04	15.94	73.06
0.4	1.04	3.44	2.55	1.1	16.06	73.17
0.5	1.14	3.56	2.6	1.16	16.14	73.36
0.6	1.19	3.63	2.65	1.21	16.2	73.53
0.7	1.24	3.72	2.72	1.26	16.27	73.7
0.8	1.32	3.83	2.82	1.42	16.37	73.9
0.9	1.45	3.94	3.02	1.62	16.59	74.21
1	1.75	5.68	4.08	4.12	17.96	77.69

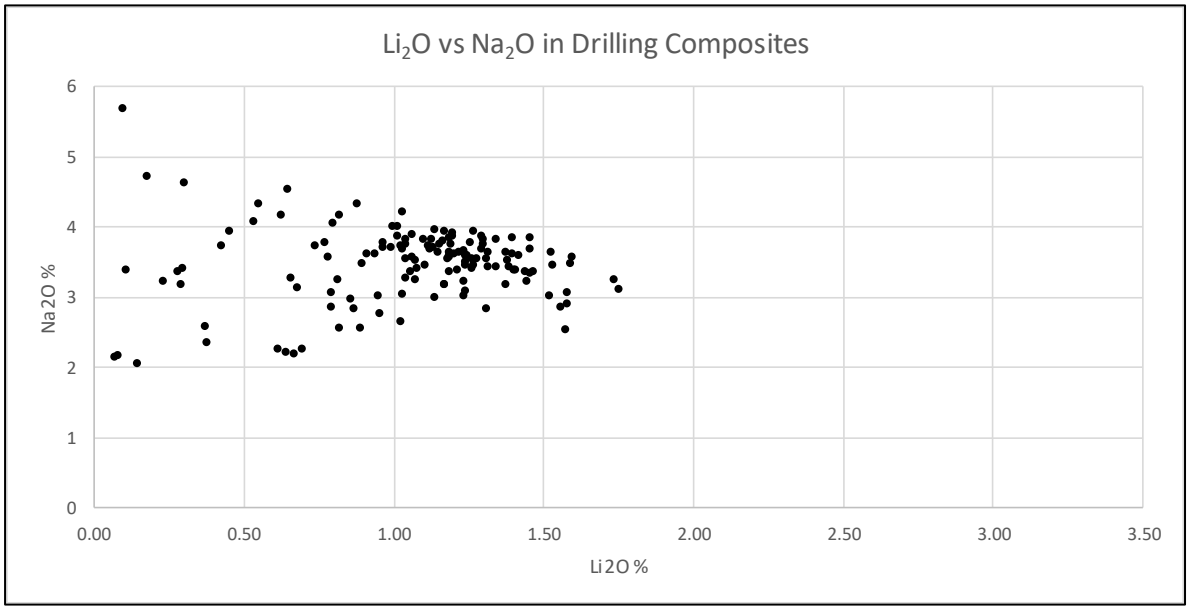


Figure 3-8: Scatterplot of Li_2O and Na_2O in Drilling Composites

4. Mineralogy Calculations

4.1. Overview

The primary data set used for determining an appropriate method of calculating mineralogy from the XRF oxide analyses was the 14 metallurgical samples. This was due to that data set having both quantitative XRD to show mineralogy, and comprehensive oxide analyses by XRF analysis.

To allow the mineralogy to be estimated throughout the Mineral Resource model, the mineralogy calculations were applied to the drilling composites data set comprising 141 samples. These composites were distributed relatively evenly through the Grandao deposit.

4.2. Mineralogy

4.2.1. Spodumene

The calculation for spodumene was based on the normative mineralogy using the Li_2O assay data with the formula *spodumene=Li_2O*12.36*. This was then applied to the metallurgical assay data and it was found that it matched very well with the XRD results (Figure 4-1).

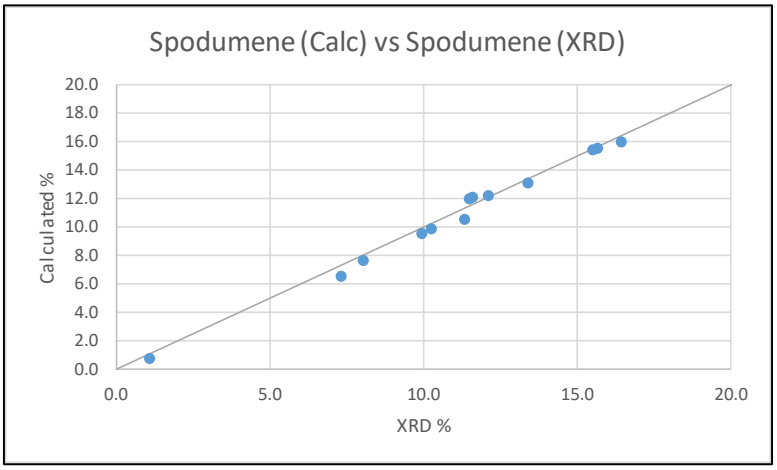


Figure 4-1: Calculated vs XRD Spodumene Metallurgical Samples

The normative calculation for spodumene based on Li_2O content is considered to be very reliable at all grade ranges.

4.2.2. Albite

The calculation for albite was based on the normative mineralogy using the Na_2O assay data with the formula *albite=Na_2O*8.46*. This was then applied to the metallurgical sample data and it was found the it underestimated the albite content relative to the XRD results. The underestimation occurred in most samples and resulted in calculated mean albite content of 32.3% compared to 37.7% by XRD. It also resulted in the calculated quartz being overestimated compared to the XRD value for quartz.

It was determined that a correction factor of 1.17 (increase of 17%) was required for the mean calculated albite to match the mean XRD albite. It is possible that this could be a result of calcium substitution of sodium in the albite crystal lattice adding to the atomic weight of the albite and not being correctly calculated using Na alone. The derived formula applied to the XRD data was determined to be:

$$albite=Na_2O*8.46*1.17$$

Plots of the calculated albite against the XRD albite and calculated quartz against the XRD quartz for all samples is shown in Figure 4-2. Plots with the correction factor applied are shown in Figure 4-3.

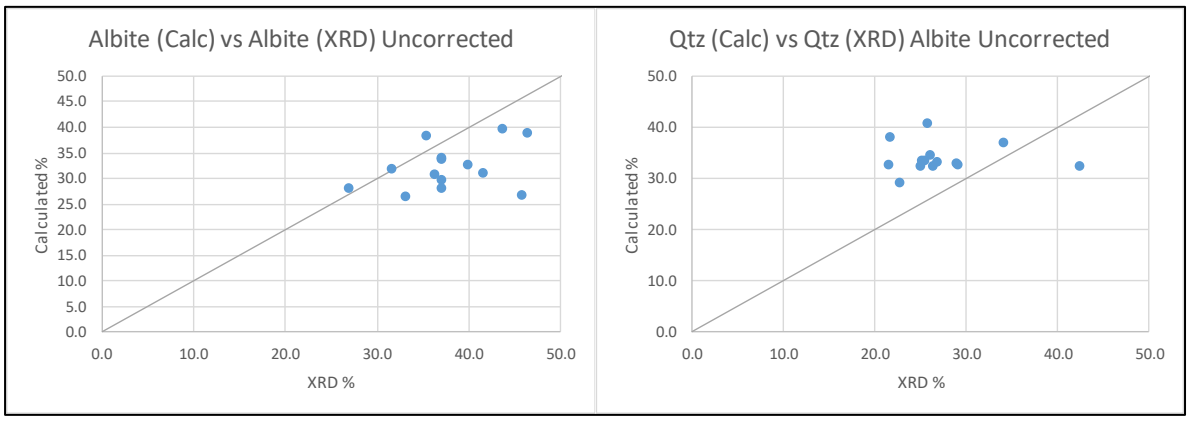


Figure 4-2: Calculated vs XRD Albite and Quartz in Metallurgical Samples (Uncorrected)

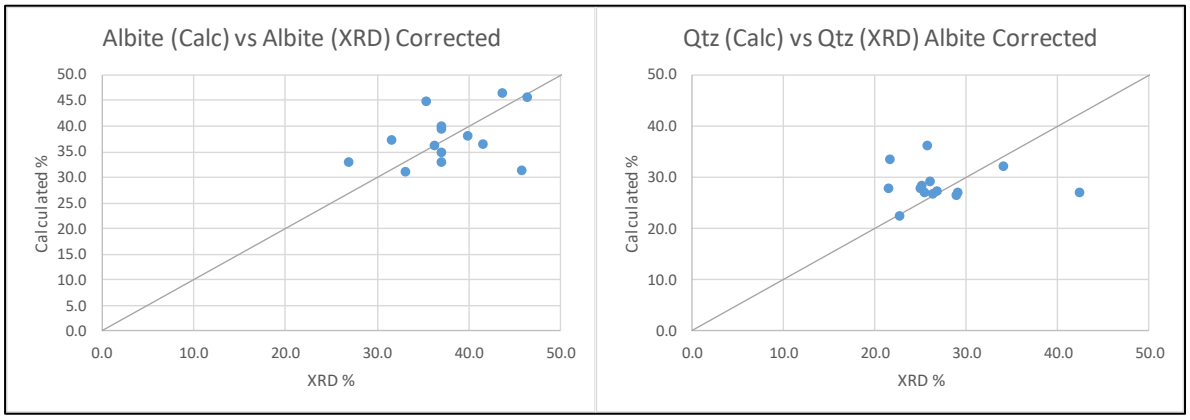


Figure 4-3: Calculated vs XRD Albite and Quartz in Metallurgical Samples (Corrected)

4.2.3. Microcline and Muscovite

A simple normative calculation could not be used to determine the microcline content, as its chemical composition was similar to that of muscovite. The differentiating molecular component of each mineral is potassium. If all of the potassium occurred in microcline, the microcline content could be calculated as *microcline=K_2O*5.91*. If all of the potassium was in muscovite, the calculation would be *muscovite=K_2O*8.45*. As both minerals occurred in similar abundance, the multipliers would be substantially less than shown.

Review of the correlation plot of K_2O with microcline showed a reasonable correlation (Figure 4-4). The calculated regression formula from this was *microcline=K_2O*3.237* which was reasonable relative to the theoretical formula with no muscovite.

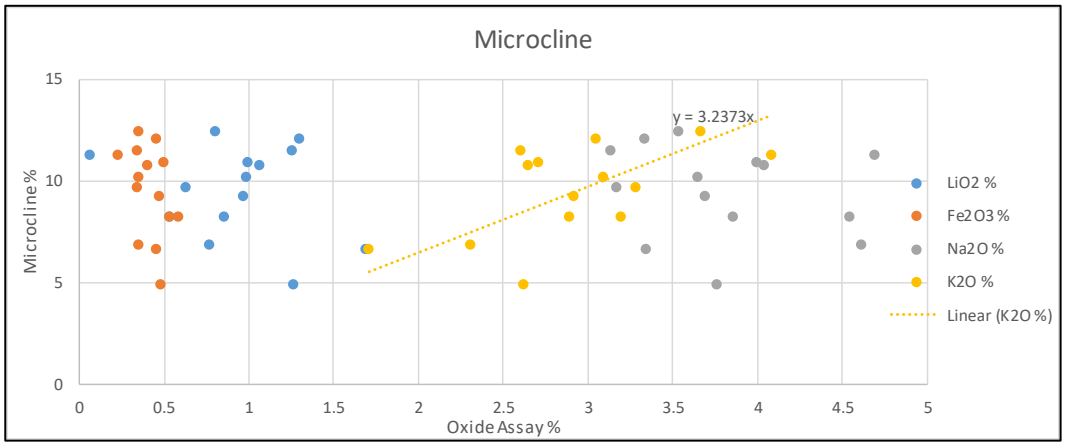


Figure 4-4: Correlation of K_2O and Microcline in Metallurgical Samples

Review of the correlation plot of muscovite with microcline from the XRD data showed a reasonably consistent correlation between the two minerals (Figure 4-4). The derived formula was: muscovite=1.2043*microcline + 0.73.

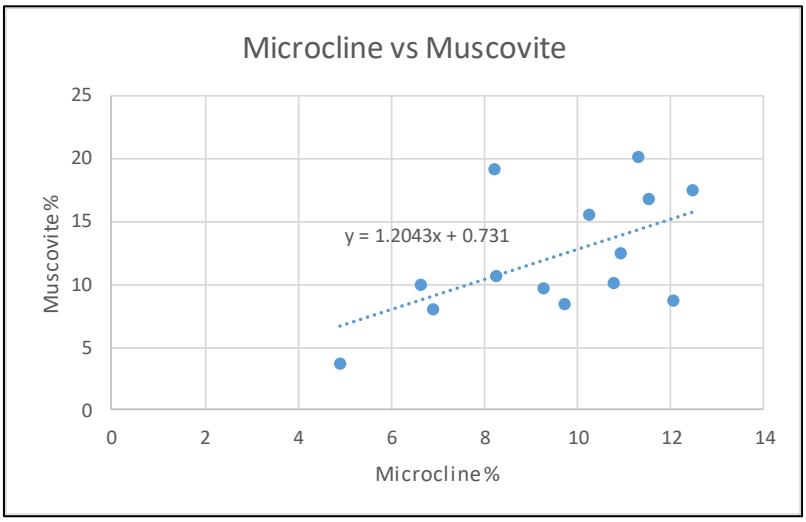


Figure 4-5: Correlation of Muscovite and Microcline in Metallurgical Samples

As all of the potassium was assumed to be contained in microcline and muscovite minerals, the total assayed K_2O set an upper limit for the abundance of those minerals. Using the derived formulas (Figure 4-4 and Figure 4-5) it was found that the contained K_2O exceeded the assayed K_2O by a minor amount. The formula for microcline was therefore adjusted (reduced) until the mean K_2O content of the samples matched the K_2O content of the calculated minerals (the muscovite:microcline ratio did not change). The resulting final formulas were:

$$microcline=K_2O*3.12$$

$$muscovite=1.2043*microcline + 0.73$$

The derived calculations for muscovite and microcline are considered to have a reasonable level of reliability. The formulas ensure that total potassium content is not exceeded in individual samples

4.2.4. Other Minerals

The XRD analysis determined that the typical content of the 5 main minerals represented 98.5% of the rock mass (with a range of 97.7% to 99.3%). Consequently, it was assumed that throughout the pegmatite, 1.5% of the rock mass was attributed to other minerals.

4.2.5. Quartz

The XRD analysis determined that the average content of quartz was 27% of the rock mass (with a range of 21.5% to 42.4%). As all other minerals had high proportions of Si in their molecular structures, it was considered that normative calculations would not be applicable to determine quartz content. Instead, it was considered that with the other four main minerals calculated, and an assumed "other minerals" allocation of 1.5%, the remainder of the rock mass could be allocated to quartz. Consequently the formula derived for to determine the quartz content is:

$$Quartz\% = 98.5 - (albite\% + microcline\% + muscovite\% + spodumene\%)$$

5. Preparation of Composites for Estimation

5.1. Overview

The data set comprising 141 composite samples will be used to estimate the mineral content of the modelled pegmatites at the Grandao deposit. The various normative calculations and regression formulas discussed in Section 4 were used to generate mineral composition in the composite samples. These provide a spatial data set suitable for estimation of the mineral components of the deposit.

5.2. Results

The mineral content of each of the composites was calculated then summary statistics and correlation plots prepared. Summary statistics are shown in Table 5-1.

Table 5-1: Calculated Minerals in Drilling Composites

Mineral	Albite	Quartz	Microcline	Muscovite	Spodumene
Parameter					
Mean	34.36	32.25	8.31	10.62	12.96
Median	35.24	30.27	8.11	10.36	14.04
Std Devn	5.28	6.28	1.03	1.31	4.62
Variance	27.91	39.40	1.06	1.72	21.33
Minimum	20.39	24.74	5.87	7.49	0.88
Maximum	56.23	54.79	12.73	16.26	21.65
Count	141	141	141	141	141
Percentiles					
10%	28.1	26.9	7.3	9.3	5.6
20%	30.9	27.7	7.6	9.8	9.8
30%	33.2	28.3	7.8	10.0	11.8
40%	34.1	29.5	8.0	10.2	12.9
50%	35.2	30.3	8.1	10.4	14.0
60%	35.9	31.2	8.3	10.6	14.7
70%	36.8	33.0	8.5	10.8	15.4
80%	37.9	35.3	8.8	11.2	16.3
90%	39.0	41.4	9.4	12.0	18.0
100%	56.2	54.8	12.7	16.3	21.7

Correlation plots of the major minerals are shown in Figure 5-1. Comparisons with metallurgical samples show that the trends in the XRD mineralogy are present in the calculated mineralogy and the range of compositions in the XRD is reflected in the calculated data.

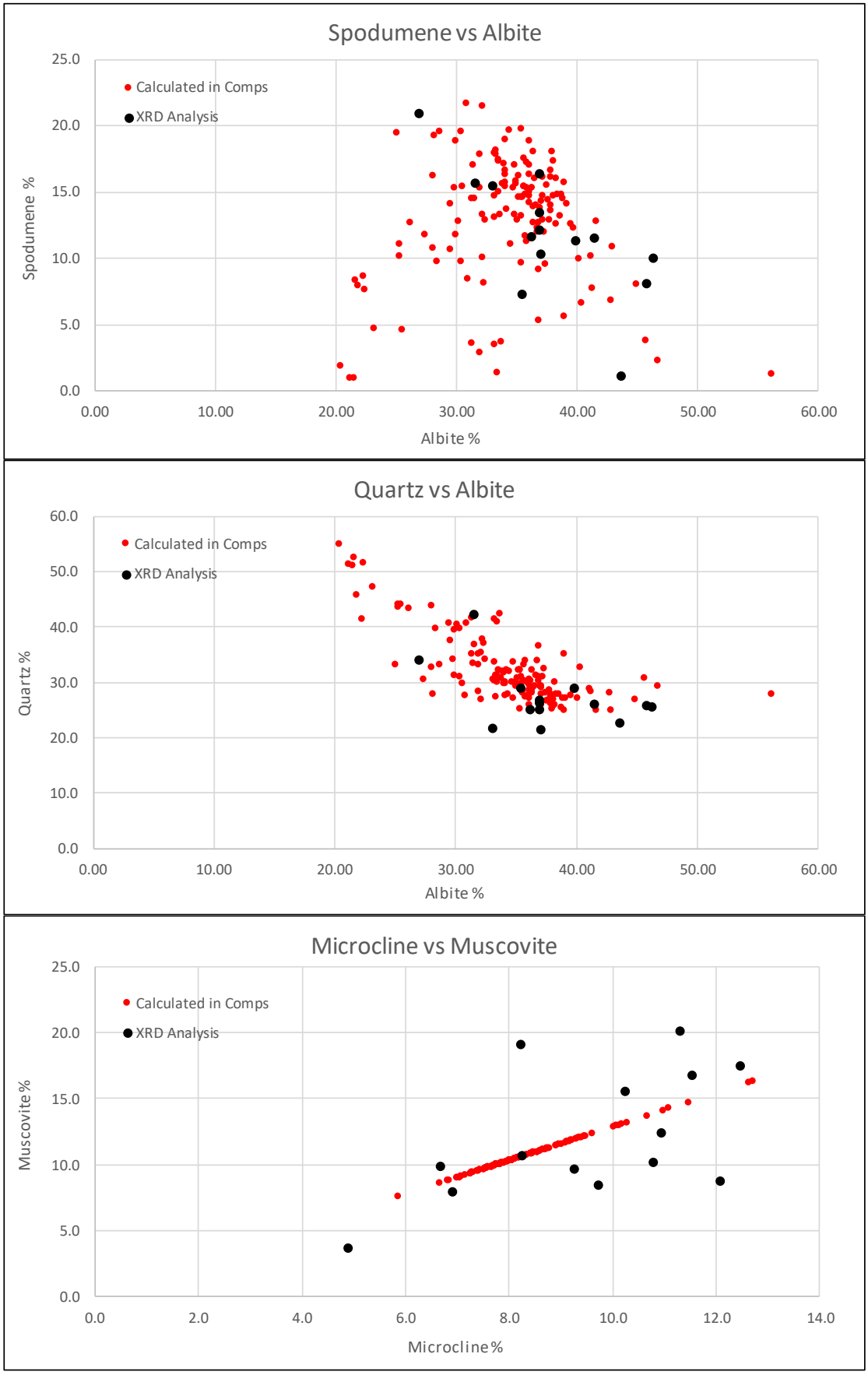


Figure 5-1: Correlation of Major Minerals in Drilling Composites

6. QEMSCAN Analysis

6.1. Overview

QEMSCAN analysis was conducted on five metallurgical samples. The QEMSCAN system uses scanning electron microscopy to determine mineralogy. Three of the samples had also been analysed using XRD. The QEMSCAN results are reported in spreadsheets provided to PayneGeo by Savannah. The spreadsheets are detailed below:

18_1108_02 INCA Mineral Summary Report [FINAL].xlsx
Mineralogy report MIN3501 (A19379).xlsx – ALS Laboratories
N8279QS18 Nagrom Mineralogy Report.xlsx – Bureau Veritas Laboratory

The five samples and their corresponding chemical analyses from XRF are identified in Table 6-1.

Table 6-1: Identification of Samples and XRF Results for QEMSCAN Analysis

Sample ID	Sample Description	Li_2O %	Na_2O %	K_2O %	Fe_2O_3 %	Al_2O_3 %	SiO_2 %
1	DFS Part 1 Grandao Composite	0.97	3.69	2.92	0.47	16.17	73.77
2	DFS Part 1 Reservatorio Composite	1.04	3.30	2.98	0.82	16.85	72.77
3	M188 JR013 Master Comp >500	0.95	3.56	3.11	0.38	15.48	74.85
4	M188 JR013 Master Comp < 501	0.96	4.08	2.74	0.61	16.89	72.39
5	ALS Grandao Master Composite	1.33	3.62	2.56	0.70	16.00	73.80

The data was provided to PayneGeo after the preliminary evaluation using the XRD results had been completed. Rather than combine the QEMSCAN and XRD results, the QEMSCAN results were used to check the reliability of the normative mineralogy calculations.

6.2. Results

Mineralogy for the five samples was determined by QEMSCAN. In addition, three of the samples had been separately analysed using XRD analysis. The results are shown in Table 6-2. There is a substantial variation observed between the XRD and QEMSCAN results for albite and microcline in particular, suggesting that the individual scans may not be fully representative of the sample analysed.

The normative mineralogy formulae derived in Section 4 were applied to the chemical assay data of the five samples. The resulting calculated mineralogy is also shown in Table 6-2. The derived normative mineralogy compares well with the QEMSCAN and XRD mineralogy, with the normative value lying between the two scan values for most minerals. Results are shown graphically in Figure 6-1.

Table 6-2: Mineralogy of Samples – QEMSCAN, XRD and Normative

Sample ID	Mineralogy by XRD					
	Albite	Quartz	Microcline	Muscovite	Spodumene	Total
1	38.2	28.5	14.0	8.0	11.0	99.8
2	32.5	28.3	15.6	10.9	12.1	99.5
3						
4						
5	40.0	34.0	4.0	3.0	16.0	97.0
Sample ID	**Mineralogy by QEMSCAN**					
	Albite	**Quartz**	**Microcline**	**Muscovite**	**Spodumene**	**Total**
1	31.8	33.5	8.4	11.3	11.4	96.4
2	30.0	28.4	7.7	12.7	15.8	94.6
3	23.8	30.0	6.3	32.4	5.5	98.0
4	31.6	26.9	11.3	18.9	9.9	98.6
5	28.4	31.9	10.6	9.1	16.9	96.8
Sample ID	**Normative Mineralogy**					
	Albite	**Quartz**	**Microcline**	**Muscovite**	**Spodumene**	**Total**
1	36.5	29.3	9.1	11.6	12.0	98.5
2	32.7	31.8	9.3	11.9	12.8	98.5
3	35.2	29.4	9.7	12.4	11.7	98.5
4	40.4	26.8	8.5	10.9	11.9	98.5
5	35.8	28.0	8.0	10.2	16.4	98.5

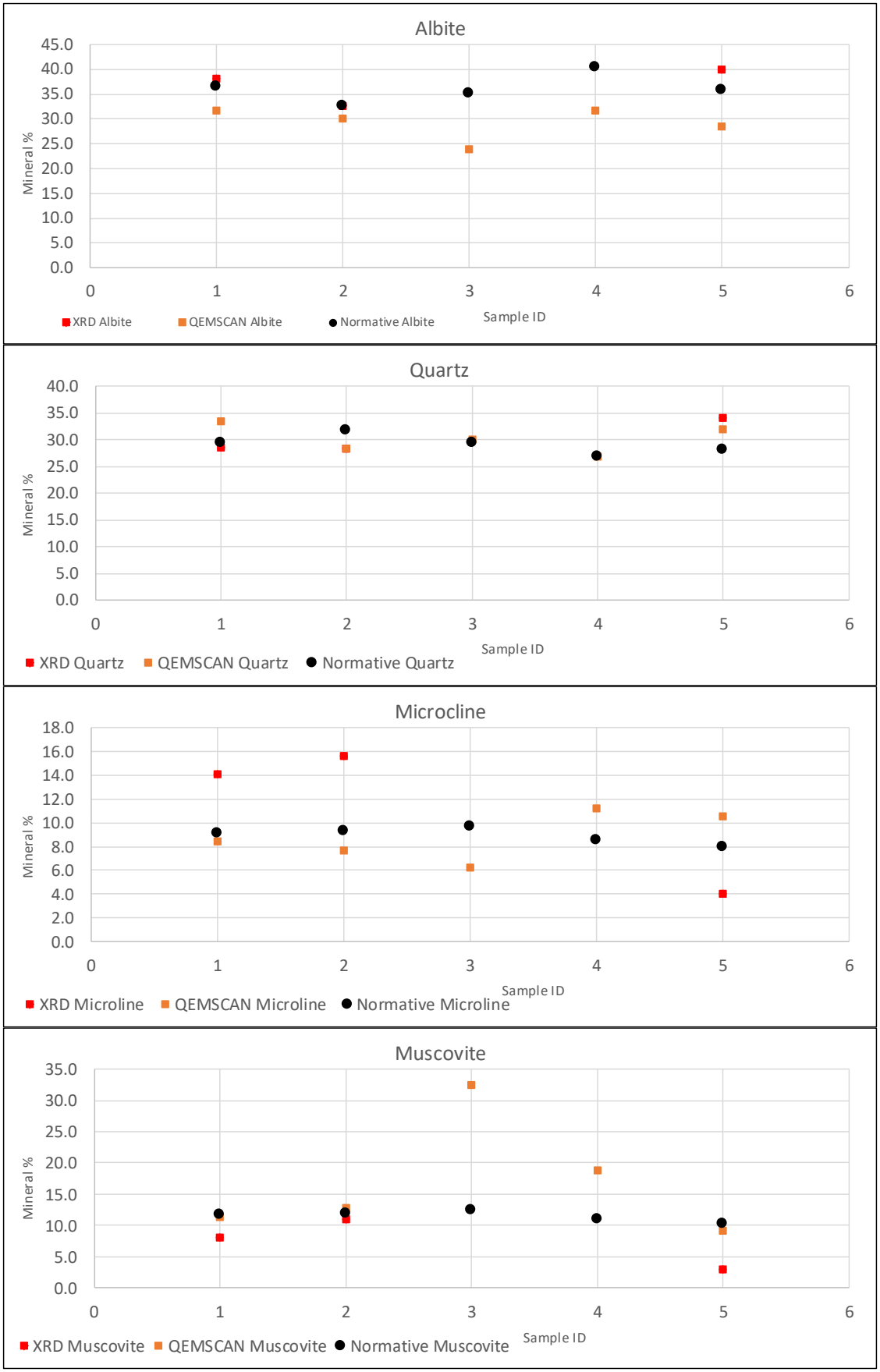


Figure 6-1: Comparison of QEMSCAN, XRD and Normative Mineralogy in Metallurgical Samples

7. Application of Mineralogy to Mineral Resource Models

7.1. Oxide Data Available

To allow quantification and scheduling of the by-product minerals in any future lithium production, it would be beneficial to have the mineralogy coded into the Mineral Resource block models. Where extensive oxide XRF analyses are available (currently only the Grandao deposit), the normative mineralogy formulas can be applied to the XRF data to determine mineralogy from the samples and that mineralogy can be interpolated into the block model. As Li_2O has already been estimated from the detailed drilling data at each deposit, that value can be used to determine the spodumene content. The formulae are summarised in Table 7-1.

Table 7-1: Mineralogy Formulae for Estimation Using Oxide Assay Data

Mineral	Normative Mineralogy Calculation
Spodumene	Li_2O (model) * 12.36
Albite	albite=Na_2O*8.46*1.17
Microcline	microcline=K_2O*3.12
Muscovite	muscovite=1.2043*microcline + 0.73
Quartz	Quartz% = 98.5 – (albite% + microcline% + muscovite% + spodumene%)

7.2. Oxide Data Not Available

Currently only the Grandao deposit has extensive oxide assay data. For the other deposits in the project, it may be useful to have indicative mineralogy applied to the models for preliminary planning and scheduling of by-product minerals. This can be carried out without oxide assay data if a number of assumptions are made. The key assumptions are:

- Spodumene content can be determined from the modelled Li_2O grade
- Albite and spodumene have a consistent inverse relationship therefore albite can be determined from the spodumene content (Section 3, Figure 3-1)
- Muscovite and microcline are uniform throughout the pegmatite and their content in XRD samples is representative (Section 3, Table 3-2)

The formulae are summarised in Table 7-2.

Table 7-2: Assumed Mineralogy for Mineral Resource Models Without Oxide Assay Data

Mineral	Normative Mineralogy Calculation
Spodumene	Li_2O (model) * 12.36
Albite	albite= 36.18 - calc_spodumene * 0.6461
Microcline	9.5
Muscovite	12.2
Quartz	Quartz% = 98.5 – (albite% + microcline% + muscovite% + spodumene%)

8. Conclusion and Recommendations

The detailed XRD mineralogy and XRF oxide assay data from 14 metallurgical samples has allowed normative mineralogy formulae to be derived for the Grandao pegmatite. Application of the derived formulae to the assay data generated from exploration drilling (141 composites and 127 original samples) has produced calculated mineralogy results and mineral relationships consistent with the XRD analysis.

Based on results from the Grandao deposit, it is concluded that the oxide assays in the composite data can be reliably used to quantify the mineral content of the pegmatite within the Mineral Resource block models. The dominant mineral in the pegmatite is albite and the mineral with the greatest confidence in the estimate is spodumene. It is considered that due to the relatively uniform mineralogy of the pegmatite and the strong negative correlation of the albite and spodumene (together representing around 50% of the rock mass) the mineralogy can be calculated with sufficient confidence for the quantification and scheduling of the by-product minerals.

Currently the minor deposits at the MBLP do not have oxide assay data. However, they do all have reliably estimated Li_2O values. Based on the Li_2O grade and assumed relationships with albite, muscovite and microcline the mineral assemblage in these deposits can be predicted. In these cases, the derived mineralogy will have a relatively low level of confidence and should be used only for preliminary evaluation of by-products.

To allow the mineralogy of the minor deposits to be estimated with greater confidence, it is recommended that composite samples be prepared using the pulps from the exploration drilling then assayed for oxides using XRF. The number of composites should be determined by assessing the geometry and continuity of the pegmatites and likely contribution of each deposit to the final mining inventory.

Any other mineralogy data that may be available and not used in this study (petrography, XRD, QEMSCAN) should be located and used to test the derived formulae. Likewise, any by-product minerals generated from mineral separation test work should also be used to test the reliability of the normative calculations.

The reliability of the calculations could be improved with a larger database of quantitative XRD analyses. It is recommended that at least one XRD or QEMSCAN analysis should be obtained for each of the minor deposits to determine if the mineralogy is consistent with the Grandao deposit.

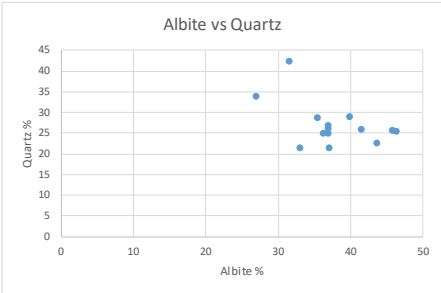
Appendix 1

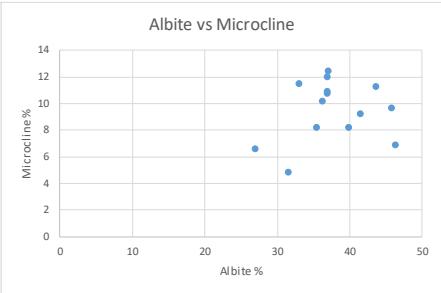
Mineral and Chemical Results from Samples Analysed by XRD

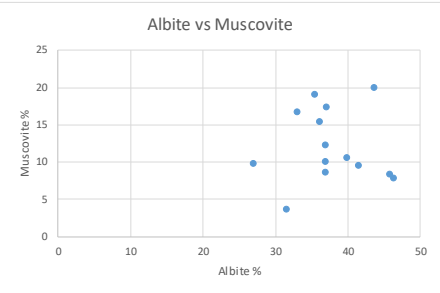
Full Assay Suite (XRF) for Samples Analysed by XRD

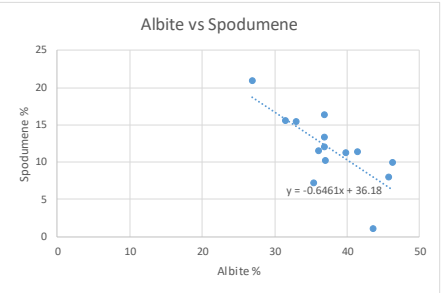
SAMPLE ID	Li_2O ppm	Fe_2O_3 %	Al_2O_3 %	SiO_2 %	TiO_2 %	Mn %	S %	P %	SnO_2 %	Ta_2O_5 %	Nb_2O_5 %	Na_2O %	PbO %	CaO %	MgO %	K_2O %	Rb ppm	LOI_{1000} %
M00111	6230	0.338	16.302	73.185	0.011	0.037	0.007	0.156	0.007	0.004	0.007	3.169	<0.001	0.079	0.096	3.276	643	1.76
M00116	12490	0.335	16.497	73.026	0.007	0.052	0.001	0.131	0.009	0.004	0.008	3.130	<0.001	0.173	0.035	2.601	560	1.38
M00125	7680	0.345	16.341	73.542	0.007	0.050	<0.001	0.173	0.008	0.003	0.005	4.608	<0.001	0.149	<0.001	2.305	509	0.92
M00133	8520	0.582	16.484	71.783	0.010	0.060	<0.001	0.255	0.004	0.004	0.007	3.853	<0.001	0.423	0.049	3.194	673	0.98
M00139	10570	0.404	16.322	73.436	0.012	0.068	<0.001	0.156	0.007	0.002	0.003	4.034	<0.001	0.182	0.015	2.641	536	0.89
M00147	5270	0.530	16.175	73.717	0.006	0.086	<0.001	0.202	0.010	0.002	<0.001	4.539	<0.001	0.270	0.040	2.889	572	0.93
M00158	12990	0.451	16.439	73.993	0.008	0.061	<0.001	0.203	0.007	0.002	0.006	3.335	<0.001	0.270	0.010	3.041	582	0.80
M00176	9890	0.495	16.216	73.511	0.007	0.056	0.002	0.218	0.004	0.003	0.004	3.990	<0.001	0.336	<0.001	2.702	529	0.81
M00225	9820	0.351	16.134	73.746	0.006	0.081	0.002	0.176	0.004	0.004	0.007	3.649	<0.001	0.298	<0.001	3.087	574	0.87
M00235	640	0.224	16.279	72.454	0.006	0.048	<0.001	0.136	0.008	0.002	0.002	4.689	0.003	0.239	<0.001	4.078	847	0.87
M00242	8010	0.349	16.921	72.997	0.004	0.039	0.003	0.148	0.004	0.001	0.006	3.530	0.001	0.286	0.003	3.662	640	0.98
M00248	16870	0.453	15.490	74.827	0.019	0.054	0.002	0.175	0.002	0.003	0.006	3.338	<0.001	0.349	0.025	1.709	312	0.60
Stage 1 Bulk Comp	9680	0.471	16.168	73.773	0.018	0.082	0.003	0.181	0.006	0.003	0.005	3.686	<0.001	0.292	0.034	2.916	556	1.08
Stage 2 Bulk Comp	12603	0.477	16.418	73.290	0.013	0.098	0.003	0.186	0.004	<0.001	0.007	3.758	0.001	0.263	0.015	2.614	527	0.95
Average	9376	0.41	16.30	73.38	0.01	0.06	0.00	0.18	0.01	0.00	0.01	3.81	0.00	0.26	0.02	2.91	575.71	0.99
St Dev	3921	0.10	0.31	0.71	0.00	0.02	0.00	0.03	0.00	0.00	0.00	0.52	0.00	0.09	0.03	0.58	115.21	0.28
Maximum	16870	0.58	16.92	74.83	0.02	0.10	0.01	0.26	0.01	0.00	0.01	4.69	0.00	0.42	0.10	4.08	847.00	1.76
Minimum	640	0.22	15.49	71.78	0.00	0.04	0.00	0.13	0.00	0.00	0.00	3.13	0.00	0.08	0.00	1.71	312.00	0.60

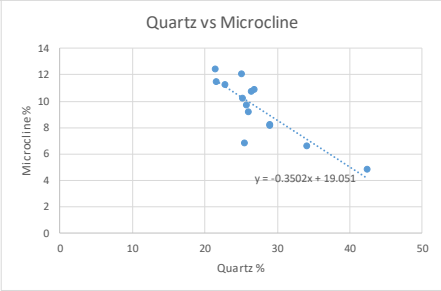
Correlation Plots of Minerals from XRD Results

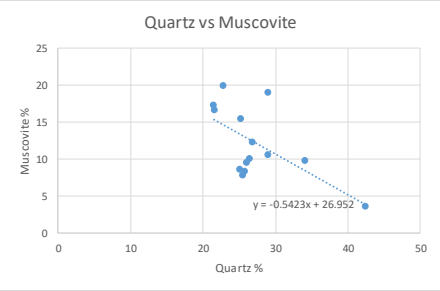


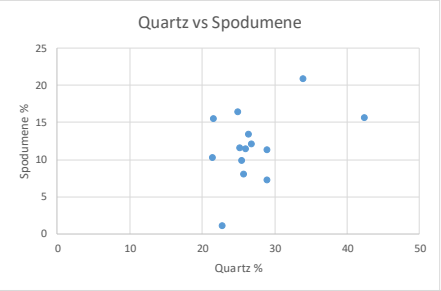


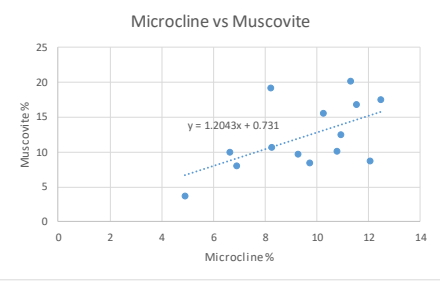


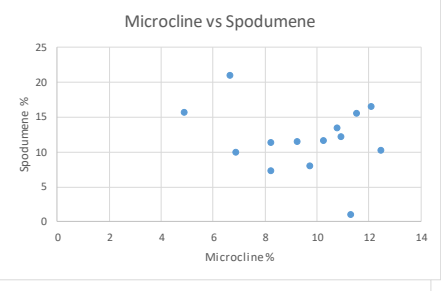


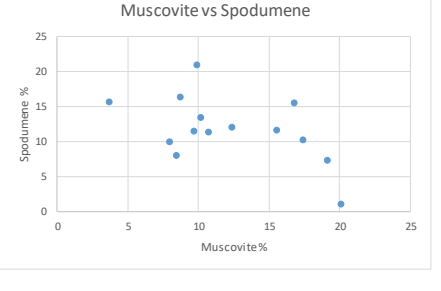
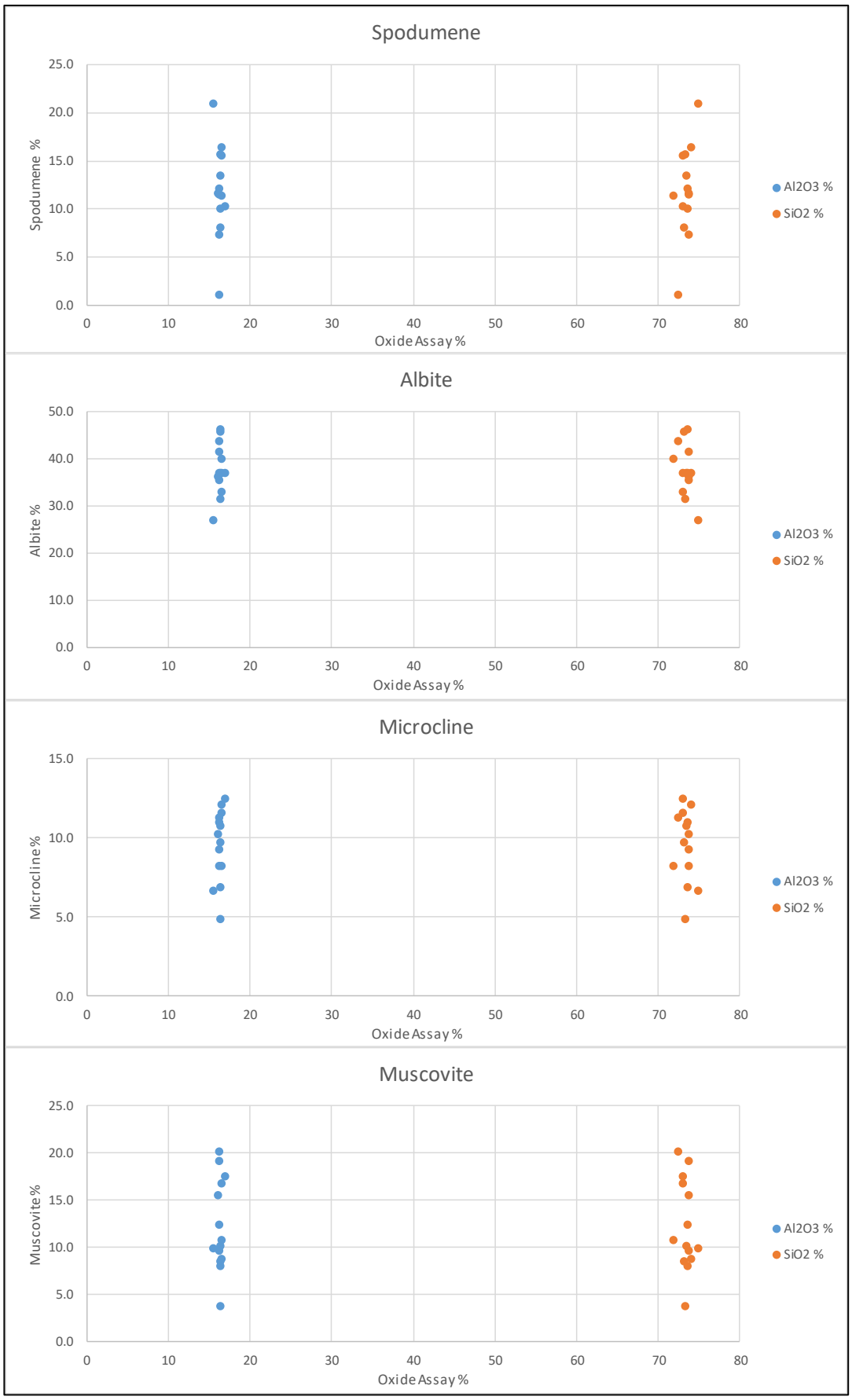












Plots of Mineral Content Against Al_2O_3 and SiO_2