

WALABANBA PROJECT BISMARK PEGMATITE ANALYSIS

The Bismark prospect is located on Anningie Station, situated on EL26848 of the Walabanba Project operated by Todd River Resources (TRT). The prospect is part of the Anningie Tin Field with historical tin production from alluvial mining derived from weathered pegmatites going back to 1935.

The geology of the prospect area is dominated by broadly folded metamorphic quartz-mica schists with lesser interbedded quartzites of the Lander Rock Formation, intruded by coarse grained gabbro. The country rocks have been intruded by vertically dipping north-north west trending pegmatites and quartz rich aplitic veins with an average width of 2 – 3 m, up to a maximum width of 24 m, and a mapped strike length averaging 150 m and up to 540 m in length.

The pegmatites are quartz rich, and contain varying amounts of feldspar, muscovite and tourmaline. Tin mineralisation within the pegmatites is patchy and occurs as infill within pre-existing fractures.

In 2017, TRT conducted sampling and mapping of the Bismark prospect area with a focus on the discovery of economic lithium. Lithium-bearing pyroxene (spodumene) and lithium-bearing mica (lepidolite) was reported in pegmatites of the Anningie Tin Field by Pontifex (1965); however the location of these samples is not clearly documented.

During the 2017 field program, TRT collected 340 rock chip samples in two separate campaigns. 12 rock chip samples were submitted for XRD mineral identification. The results from the XRD mineralogical analysis, analysed by the Spratt et.al (2017) are shown in

Sample_ID	Lithology	Quartz	Fluorapatite	Spodumene	Albite	Microcline	Muscovite	Cassiterite	Unidentified	Li2O ppm	Grouping
		SiO ₂	Ca ₅ (PO ₄) ₃ F	LiAlSi ₂ O ₆	NaAlSi ₃ O ₈	K(AlSi ₃ O ₈)	KAl ₂ (AlSi ₃ O ₁₀)(OH) ₂	SnO ₂			
B009	GRIS	25.7	-	19.2	40.7	3.4	2.4	-	8.6	16,492	1
B010	GRIS	40.9	-	50.2	-	-	2.7	-	6.2	42,199	1
B015	PEG	38.3	-	-	3.5	1.6	39.8	-	16.8	3,962	3
B016	PEG	41.5	2.9	-	8.1	-	30.3	-	17.2	3,768	3
B021	GRIS	39.3	-	50.7	2.7	-	-	-	7.4	44,137	1
B022	PEG	41.8	-	-	21.4	-	25.7	1.4	9.7	1,227	3
B025	GRIS	1.5	-	-	9.3	78.9	2.9	-	7.5	1,033	4
B026	PEG	17.2	-	-	5.8	-	58.7	-	18.4	7,945	3
W17329	PEG	41.7	-	-	17.9	27.5	5.4	-	7.5	95	5
W17331	GRIS	6.3	-	-	84.8	5.8	3	-	0.3	22	2
W17352	GRIS	4.3	-	-	79.3	3.3	9.3	-	3.8	95	2
W17355	QV	15.9	0.9	-	72.3	7.3	1.8	-	1.9	52	2

Table 1. Spodumene was positively identified in three of the 12 samples submitted for XRD. Li₂O assays of the three spodumene-bearing samples returned values above 1.65% with a maximum assay of 4.4%. Of the remaining nine samples submitted for XRD, the next highest Li₂O assay is 0.8%; spodumene was not identified in remaining nine samples.



XRD samples identified with spodumene contained:

- Li₂O 1.65% - 4.4%;
- Spodumene 19.2% - 50.7%;
- Quartz 25.7% - 40.9%;
- Albite (Na-rich plagioclase) 2.7% - 40.7%;
- Microcline (K-rich alkali feldspar) 0 – 3.4%
- Muscovite 0 – 2.7%;

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B009	GRIS	25.7	-	19.2	40.7	3.4	2.4	-	8.6	16,492	1
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Table 1: XRD Mineralogical Analysis Results of 12 Bismark Samples from Spratt et.al (2017)

The XRD samples have been loosely divided into five groups; these are:-

1. N=3; Spodumene-bearing (19 – 51%) with high Li₂O values between 1.65 – 4.4%, Quartz 25 – 40% and Albite 25 – 40%, low muscovite;
2. N=3; Low Li₂O (< 95ppm) with high (74 – 85%) albite and 0.4 – 0.84% SnO₂;
3. N=4; Muscovite rich (25 – 59%), low albite (< 21%), low microcline (< 2%), moderate quartz (17 – 42%) and moderate Li₂O (0.12 – 0.8%);
4. N=1; high microcline (79%), low quartz (1.5%), low albite (< 10%), low muscovite (< 3%) and moderate Li₂O up to 0.1%;
5. N=1; Typical quartz-feldspar-mica pegmatite with 42% quartz, 18% albite, 28% microcline and 5% muscovite, low Li₂O (< 95ppm).

Groups 1, 3 and 4 represent the most favourable pegmatite mineralogy for the presence of spodumene. Given that spodumene breaks down readily in the weathering environment, the absence of spodumene in the XRD samples does not necessarily preclude its presence in fresh pegmatite. It is inferred that rock chip samples of pegmatite containing greater than 1% Li₂O may contain up to 12% spodumene in fresh rock even though it was not identified in the analysed XRD samples.

It must be pointed out that the limited size of the XRD data set precludes any statistical validity of the XRD data and that the groupings are purely indicative.

XRD mineral analysis of sample B021 returned a value of 50.7% and assayed for 4.4% Li₂O. Spodumene (lithium-bearing pyroxene) has a theoretical Li₂O content of 8.03%.



Interpretation of the XRD and assayed results theoretically indicates that the sample may contain up to 55% spodumene OR the sample may contain small amounts of other lithium-bearing minerals that were not identified by XRD e.g. lepidolite. Lepidolite can contain up to 7.7% Li_2O .

340 Rock chip samples from Bismark were analysed by ALS Laboratories in Adelaide. The analytical method used for the first campaign of sampling (199 samples) was ME-MS89 and includes analysis for Cs, Be, Li, Nb, Rb, and K with a sodium peroxide fusion finish for complete sample digestion; however this method did not provide analysis of the major elements i.e. K, Mg, Si, Al etc. The second campaign of sampling (141 samples) used the MS91-PKG analytical method with a sodium peroxide fusion finish for complete sample digestion; which included analysis for the major elements; but does not analyse for Be.

In addition to the chemistry sampling, a portable XRF (pXRF) was used to analyse the rock chip samples. 27 of the rockchip samples (B001 – B029) were analysed in Soil mode; this series includes the samples analysed for the XRD mineralogical analysis. The remaining 311 of 340 samples were analysed in Geochem mode.

K, Nb and Ta are not reported by the pXRF in Soil mode; these elements are only reported in Geochem mode. Be, Li and Cs are not reported at all by pXRF. During acquisition of the rock chip samples and analysis, two pXRF units were used; one unit required repair and a substitute unit was used in the interim. The substitute pXRF unit was not set up to report Ta; hence 88 of the 340 samples are missing Ta results for pXRF in Geochem mode analysis.

A comparison of the available pXRF results with chemistry shows that results, for available elements of interest i.e. Nb, Ta, Rb and associated Sn, values are largely variable with some discrepancy between the two method results. Spearman Rank Correlation for assay values compared to pXRF return R^2 values of: Nb 0.49, Rb 0.72, Ta 0.48 and Sn 0.53. There exists good correlation with Rb and a reasonable correlation with Ta; however the other elements show a poor to moderate correlation. The poor correlation may be due in part to the coarse grained nature of the pegmatites, in particular with Sn mineralisation and the selective sampling and small sample window of the pXRF.

The generally poor to moderate correlation between assay and pXRF methods does not lend the results from the pXRF to be substituted or used in lieu of chemical assays. This may change in the future if reliable results from pXRF sampling can be maintained and the pXRF unit settings are standardised.

Scatter graphs of lithium associated elements have been produced to attempt matching similar samples as those in Group 1, 3 and 4 and other samples with high lithium content possibly relating to spodumene mineralisation. Elements associated with spodumene mineralisation are: Rb, Nb, Cs, Be, Ta, Sn, Ga and Hf.



Based on Cerny (1993) pegmatite classification, various elemental fractionations can discriminate pegmatites into Rare-Earth (REE) type, Beryl type, Albite-Spodumene type and Complex type pegmatites. Potassium is used as the basis for some of the pegmatite classifications. Major elements i.e. potassium (K) and sodium (Na) were not reported in the chemistry for the sample batch containing the XRD samples. Potassium is however reported for the second batch of samples.

Frater (2005) has used the geochemistry from a number of pegmatites to produce classification scatter plots, (Table 2 after Cerny 1993), to discriminate the pegmatite fractionation of the Bynoe Pegmatite Field. These classifications show that pegmatites in the Bynoe Field can be classified from REE type though to Albite-Spodumene type pegmatites.

Fractionation Classification of Rare Element Pegmatites					
Element	Rare Earth Type	Beryl Type	Complex Type	Lepidolite Type	Albite – Spodumene Type
Li	19 -209	19 - 622	37 - 8400	93 - 4640	5110 - 50000
Rb	92 - 183	101 - 1065	183 - 9970	274 - 1865	1737 – 5490
Cs	< 12	4 - 132	9 - 9400	28 - 236	104 - 793
Be	6 - 101	4 - 494	3 - 605	65 - 440	97 - 180
Sn	70 - 800	13 - 536	12 - 3170	63 - 1000	89 - 894
Nb	53 - 1280	8 - 260	8 - 213	25 - 155	44 - 150
Ta	9 - 710	2 - 204	12 - 4620	9 - 346	37 - 108
Rb/Cs	32 – 12	~18	8.5 – 1.2	13 – 7	24 – 6.5
Nb/Ta	6 – 1.7	3.3 – 1.4	1.1 – 0.3	2.5 – 0.1	2 – 0.4

Table 2: Classification of Rare Element Pegmatites (modified after Cerny 1993)

An analysis of singular elemental range classifications for the Bismark samples (n=339), based on the ranges in Table 2, returned 27 samples that are classified as Beryl Type (median Li of 37 ppm and ranging from 20 to 219 ppm Li); 138 samples that are classified as Complex Type (median Li of 354 ppm and ranging from 40 to 8120 ppm Li); and 24 samples that are classified as Lepidolite Type (median Li of 274 ppm and ranging from 100 to 1770 ppm Li). No Rare Earth or Albite-Spodumene Type classifications were returned for the single element query.

Group	Sample ID	Li ppm	Rb ppm	Cs ppm	Be ppm	Ga ppm	Sn ppm	Nb ppm	Ta ppm	Rb/Cs	Nb/Ta	Class by Element	Class by Ratio
1	B021	20500	77.8	18.1	4.6	16.7	14	3	5.27	4.3	0.6		Complex Type
1	B010	19600	317	94.7	16.2	23.8	216	11.2	24.4	3.3	0.5		Complex Type
1	B009	7660	462	118	92.2	25.2	50	62.6	197.5	3.9	0.3	Complex Type	Complex Type
2	W17352	44	1295	395	105.5	68.4	5030	159.5	315	3.3	0.5		Complex Type
2	W17355	24	410	105	22.4	49.3	3260	256	388	3.9	0.7		Complex Type
2	W17331	10	628	136	20.7	44.7	6630	121	317	4.6	0.4		Complex Type
3	B026	3690	10900	2890	45.5	157.5	480	101.5	139	3.8	0.7		Complex Type
3	B015	1840	6000	1425	480	132.5	1080	152	253	4.2	0.6	Complex Type	Complex Type
3	B016	1750	5380	1695	29.3	45.8	411	46.4	64.5	3.2	0.7	Complex Type	Complex Type
3	B022	570	3270	333	104.5	82.4	18200	217	304	9.8	0.7		Albite-Spod Type
4	B025	480	16800	2250	4.4	43.6	29	1	2.6	7.5	0.4		Lepidolite Type
5	W17329	44	2440	469	460	20.6	3800	19.3	32	5.2	0.6		Complex Type



Table 3: Chemical Results for Elements of Interest and Pegmatite Classification for Samples Analysed by XRD

Samples containing Li above 5000 ppm (n=5) are generally low in Rb, Cs, Be, Nb and Ta and thus fail to be classified as Albite-Spodumene Type. This subset includes the Group 1 samples that have been analysed by XRD and have positive identification of spodumene and albite.

Of the samples analysed by XRD; the singular element range for pegmatite classification (refer Table 2) classified three samples as Complex Type with these samples assigned to Groups 1 and 3 (Table 3). The element ratio pegmatite classification using Rb/Cs and Nb/Ta classified Groups 1, 2, the majority of 3 and 5 as Complex Type pegmatites. One sample of Group 3 was classified as Albite-Spodumene Type and Group 4 is classified as Lepidolite Type pegmatite.

It is interesting to note that Sample B009, containing 41% albite and 19% spodumene from the XRD mineralogical analysis was not classified as Albite-Spodumene Type, but rather as a Complex Type pegmatite in both the singular element and in the element ratio classifications.

Pegmatite classifications by element range (Figure 1) and by element ratios (Figure 2) are shown in the following figures; the pegmatite classification is grouped by colour and the Li₂O content is denoted by the size of the sampled rock chips.

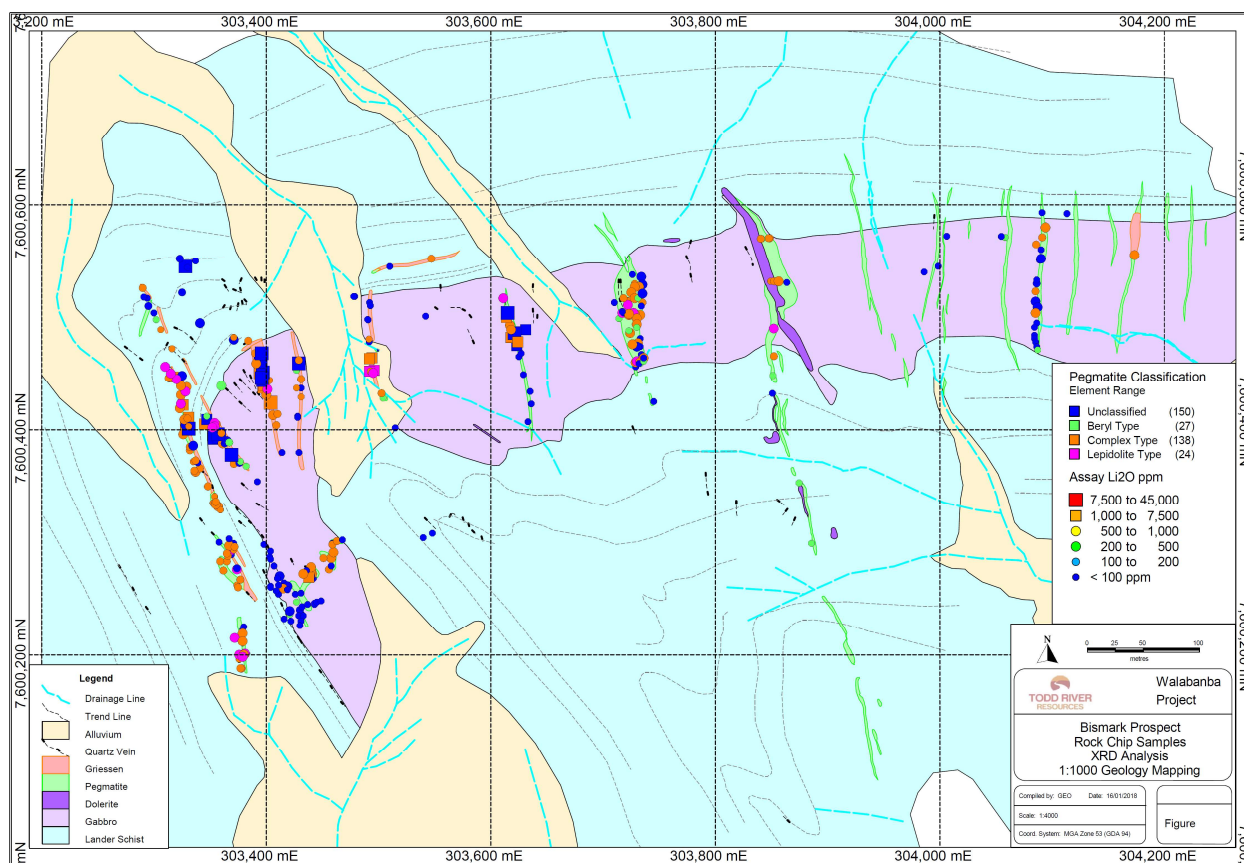




Figure 1: Bismark Rock Chip Samples – Lithium Assays Classified by Element Range

In both instances, the pegmatite classifications highlight the pegmatites on the western side of Bismark as being more prospective with fractionations containing high lithium potential i.e. Complex, Lepidolite and Albite-Spodumene Types. This is also evidenced by the assayed lithium content of these same pegmatites in the western portion of the prospect.

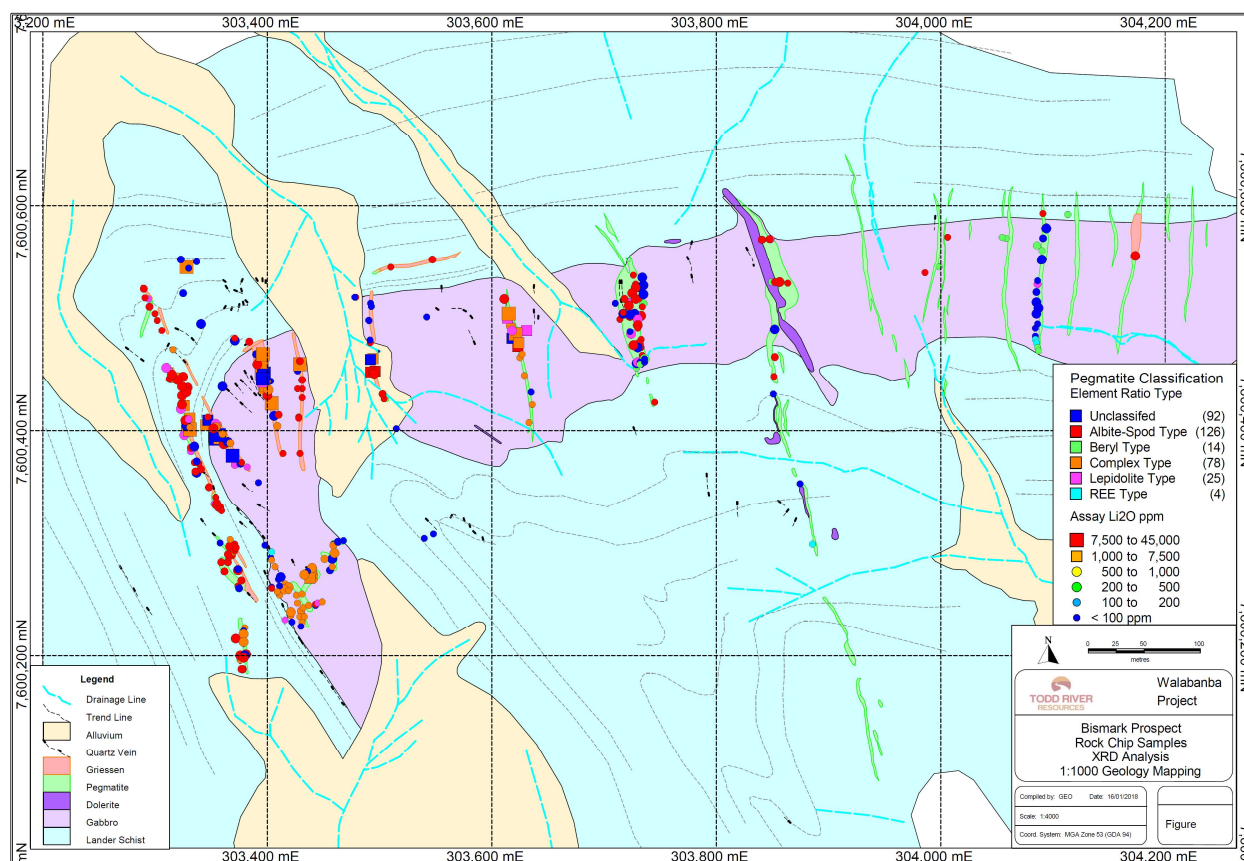


Figure 2: Bismark Rock Chip Samples Classified by Element Ratio

The pegmatite in the central portion of the prospect is the widest exposed pegmatite in the area and is up to 24 m in width. This pegmatite shows the largest variation in fractionation in both element range and element ratio pegmatite classifications. Element range shows Complex, Lepidolite and Rare Earth Type pegmatites within the core of the pegmatite body and unclassified type on the margins. This is duplicated in the element ratio classification with Albite-Spodumene, Lepidolite, Complex and Beryl Type pegmatites within the main body and unclassified type on the margins.

While a full suite of elements is unavailable for the Bismark samples to compare with the examples given for the Bynoe Pegmatite Field in Frater (2005), scatter plots of the Bismark results compare favourably with the Bynoe examples as shown in the classification diagrams for the Bismark samples in Figure 3 to Figure 7. Diagrams taken from Frater (2005) are shown in Figure 8.

Some of the samples in the following figures are shown as non-classified as they do not



fall within the specified ranges for all elements or ratios as shown in Table 2. There is overlap of the ranges for various element and ratio classifications. When a sample falls within two or more classifications, i.e. Complex and Lepidolite, the classification with the highest potential is used; i.e. sample classed as Beryl and Lepidolite will be classed as Lepidolite, or when classified as Complex, Lepidolite and Albite-Spod the sample will be classed as Albite-Spodumene Type.

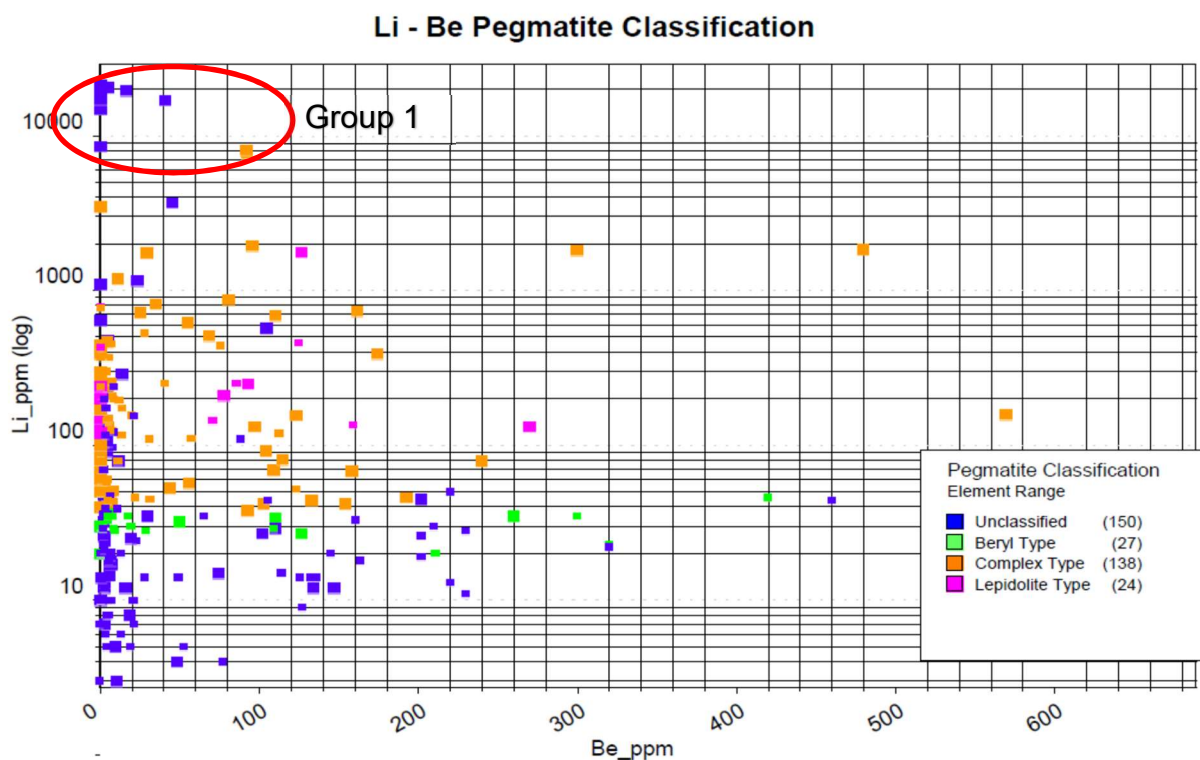


Figure 3: Li to Be Diagram Classified by Element Ranges (does not include samples B090 – B232 as Be was not analysed).

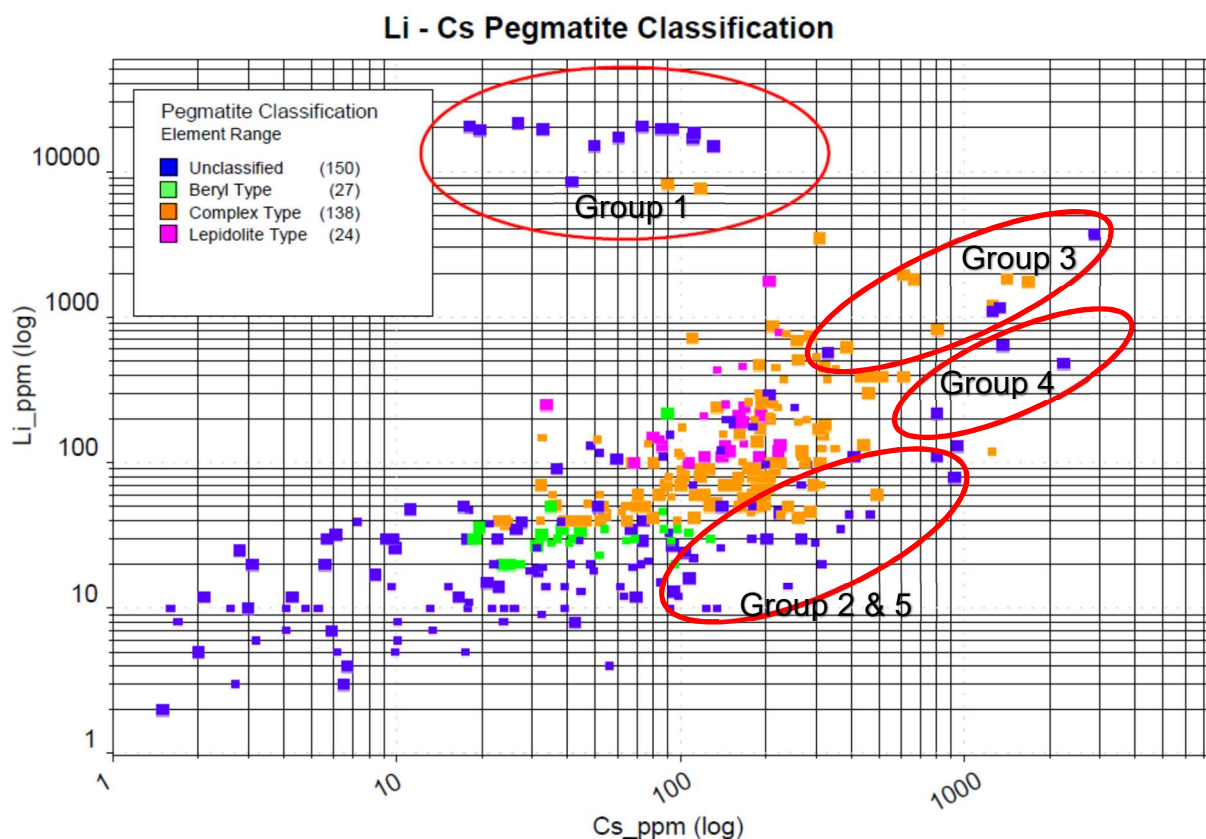


Figure 4: Li to Cs Diagram Classified by Element Ranges

A comparison of Li to Cs is not made by Frater (2005), but it is noted that the strongest correlation with Li is Cs ($R^2 = 0.67$), followed by Rb ($R^2 = 0.49$). Cs is also strongly correlated with Rb ($R^2 = 0.87$). In Figure 4, the highest Li samples are discretely clustered ($n = 15$) at the top of the chart, as circled above the general trend, with Cs values ranging from 20 to 132 ppm. A similar clustering is shown with Rb (not shown). This cluster of samples is highlighted in Figure 3 to Figure 7. All three of the XRD Group 1 samples (Spodumene-bearing (19 – 51%) with high Li_2O values between 1.65 – 4.4%, quartz 25 – 40% and albite 25 – 40%, low muscovite) are contained within this cluster of samples. 10 of the samples are classified as Complex Type by Element Ratio method and two samples are classified as Complex Type by Element Range method; the remaining samples are unclassified by both methods. Unclassified samples are due to one or more diagnostic elements falling outside of the range of the method type. These samples cannot be similarly distinguished within other datasets and are spread throughout the other datasets and charts.

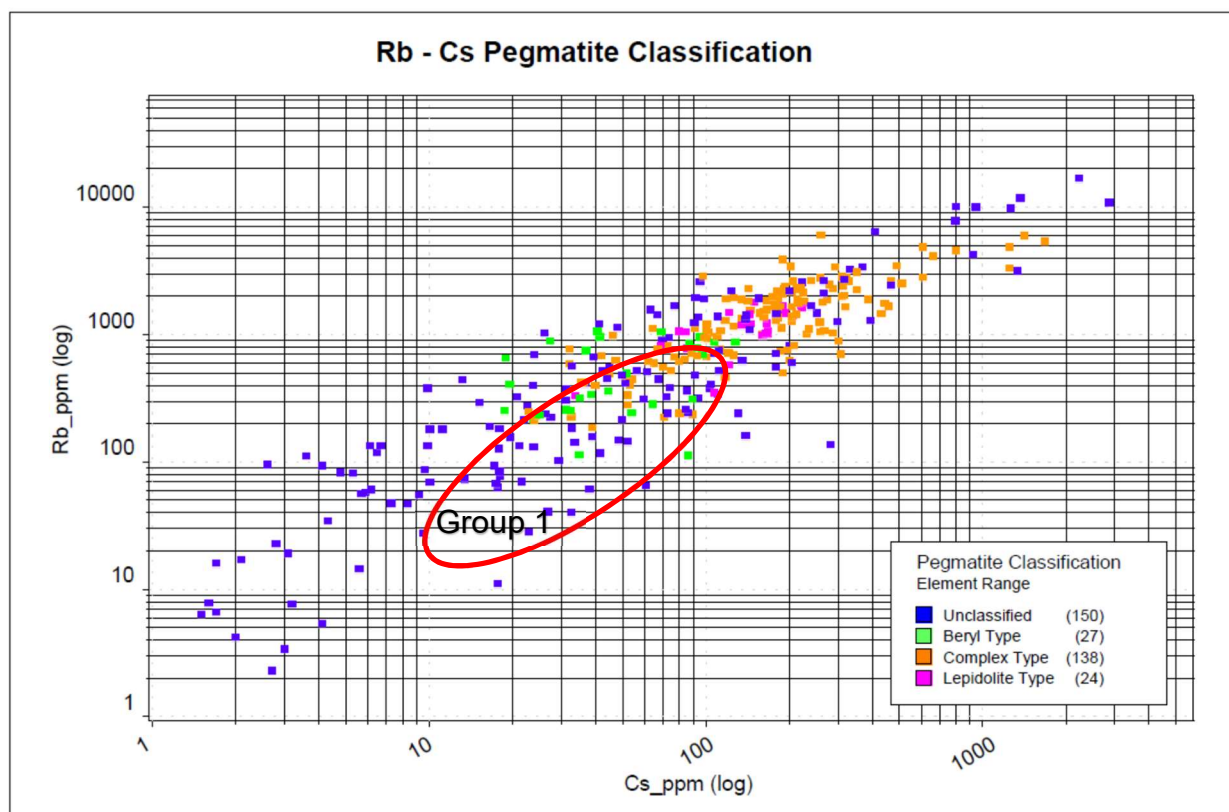


Figure 5: Rb to Cs Diagram Classified by Element Ranges

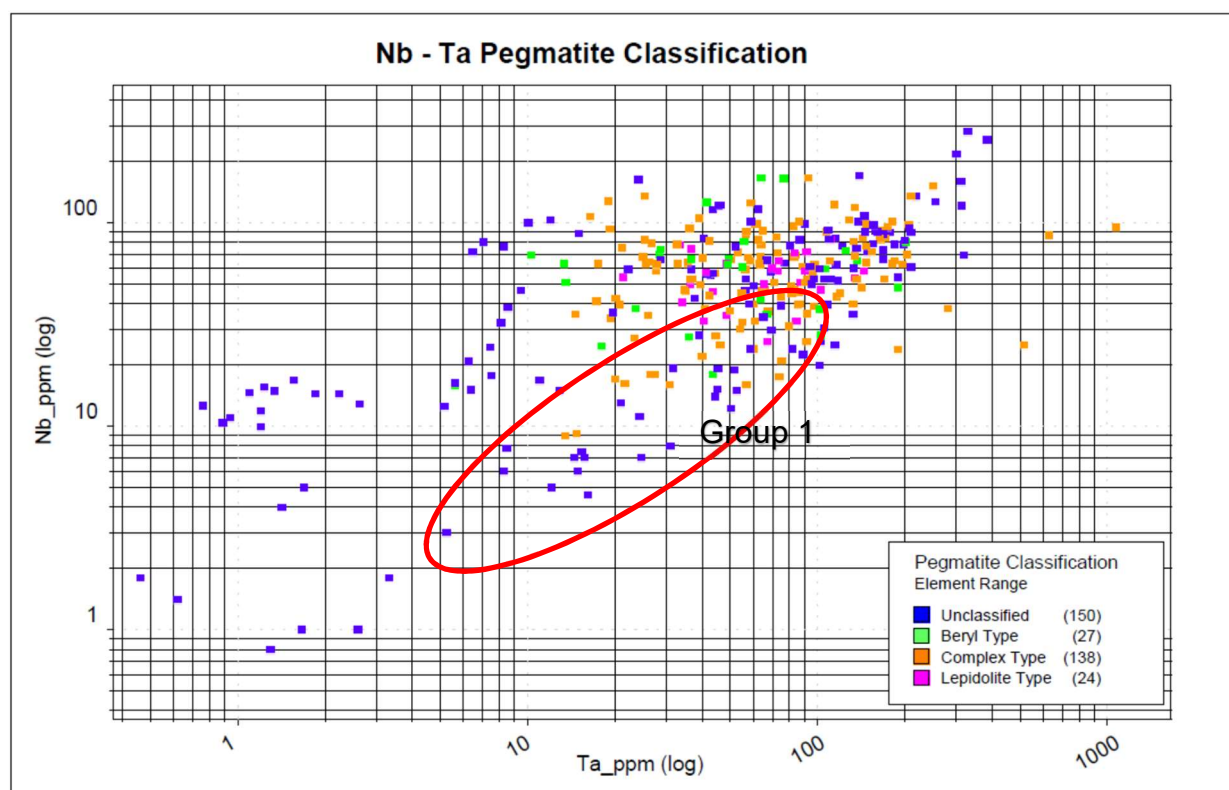


Figure 6: Nb to Ta Diagram Classified by Element Ranges

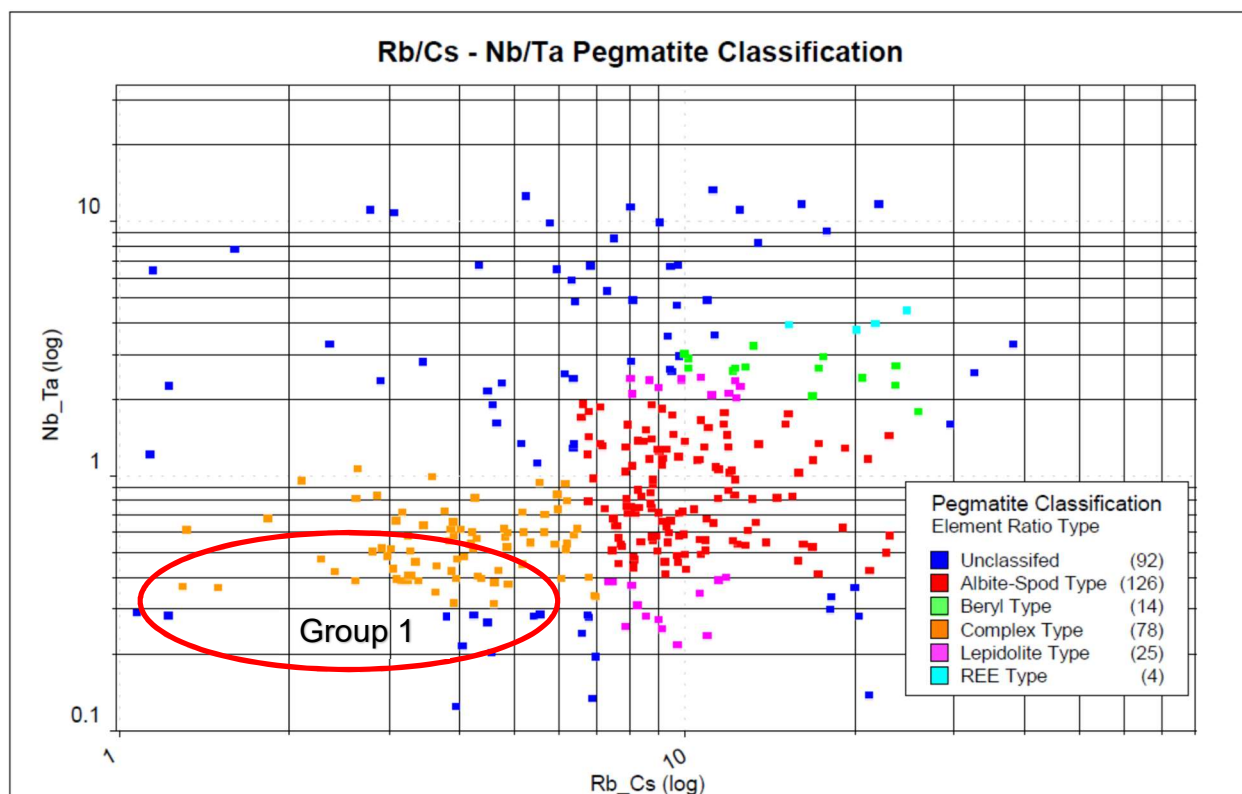


Figure 7: Nb/Ta to Rb/Cs Diagram Classified by Element Ratios

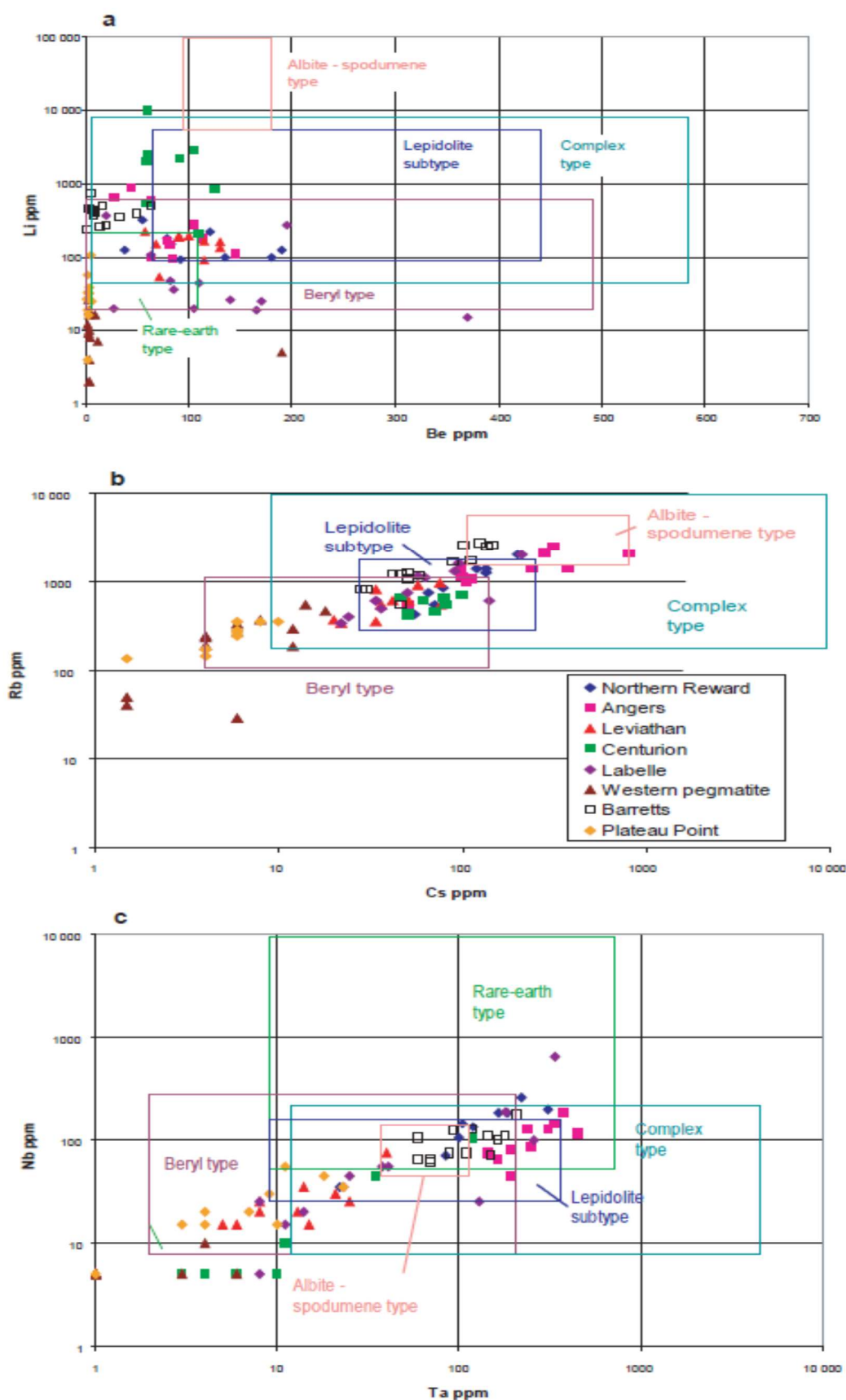


Figure 8: Pegmatite Discrimination Diagrams from Frater (2005)



Groupings of the samples analysed by XRD are shown in Figure 4: Group 1 samples are high in Li with up to 50% spodumene content (XRD analysis), with low to moderate levels of Cs; Group 3 samples are clustered on the right of Figure 4 with moderate Li, high Cs and Rb.

Selway et.al. (2005) reports that Mg / Li ratio is one of the best indicators for the degree of fractionation of pegmatites; Mg / Li ratios of less than 10 indicate elevated Li content and evolved and fertile fractionated pegmatites, Mg / Li ratios of less than 1 are usually indicative of spodumene-bearing pegmatite and are highly evolved. The Mg / Li ratio for the rock chip samples is spatially illustrated in Figure 9. Note that only 141 samples (B090 – B232) were analysed for Mg.

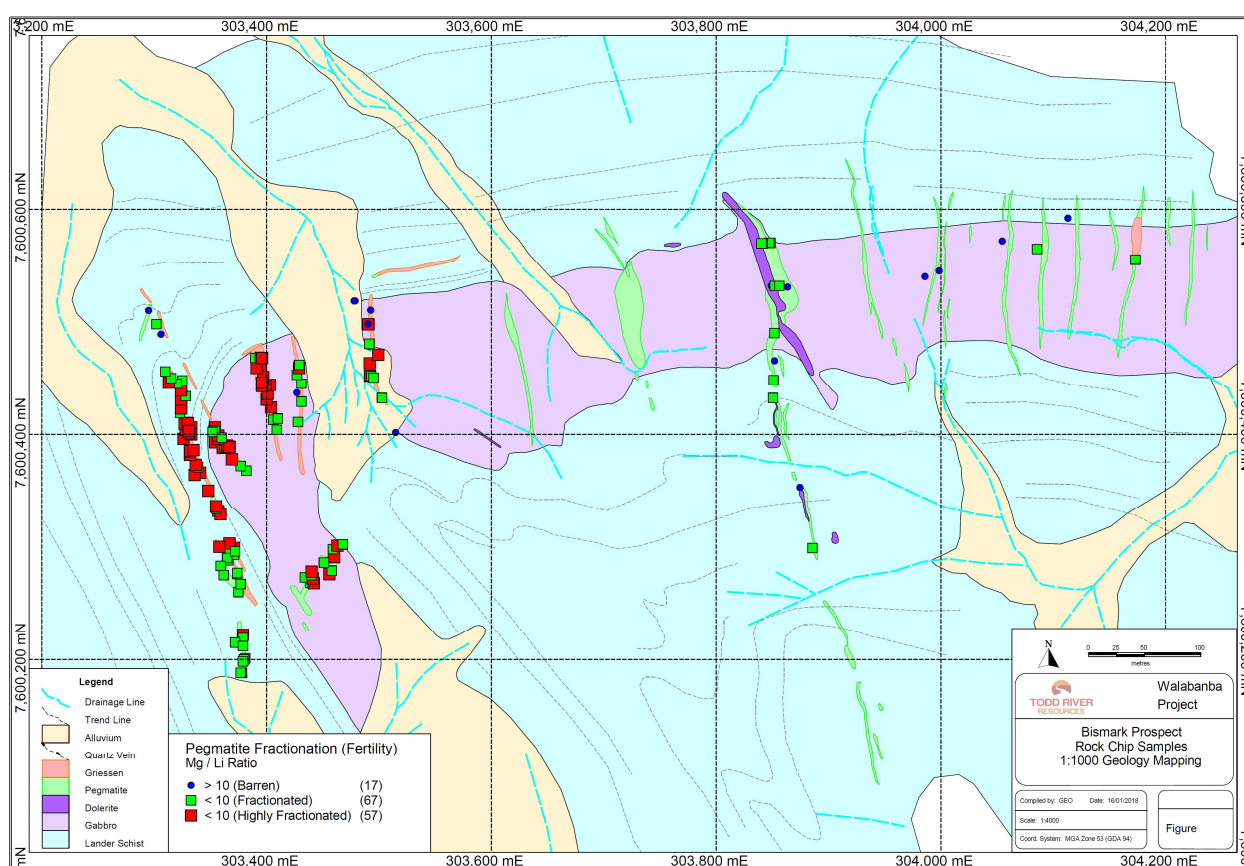


Figure 9: Bismark Rock Chip Samples Mg / Li Ratio - Fractionation Index

The most evolved and fractionated samples, as defined by Mg / Li ratios are in the western portion of the prospect. These highly fertile and prospective pegmatite are reflected in Figure 10 which shows the Li content of all sampled rock chips, where high Li content and spodumene-bearing pegmatites are present in the same highly fractionated and fertile area.

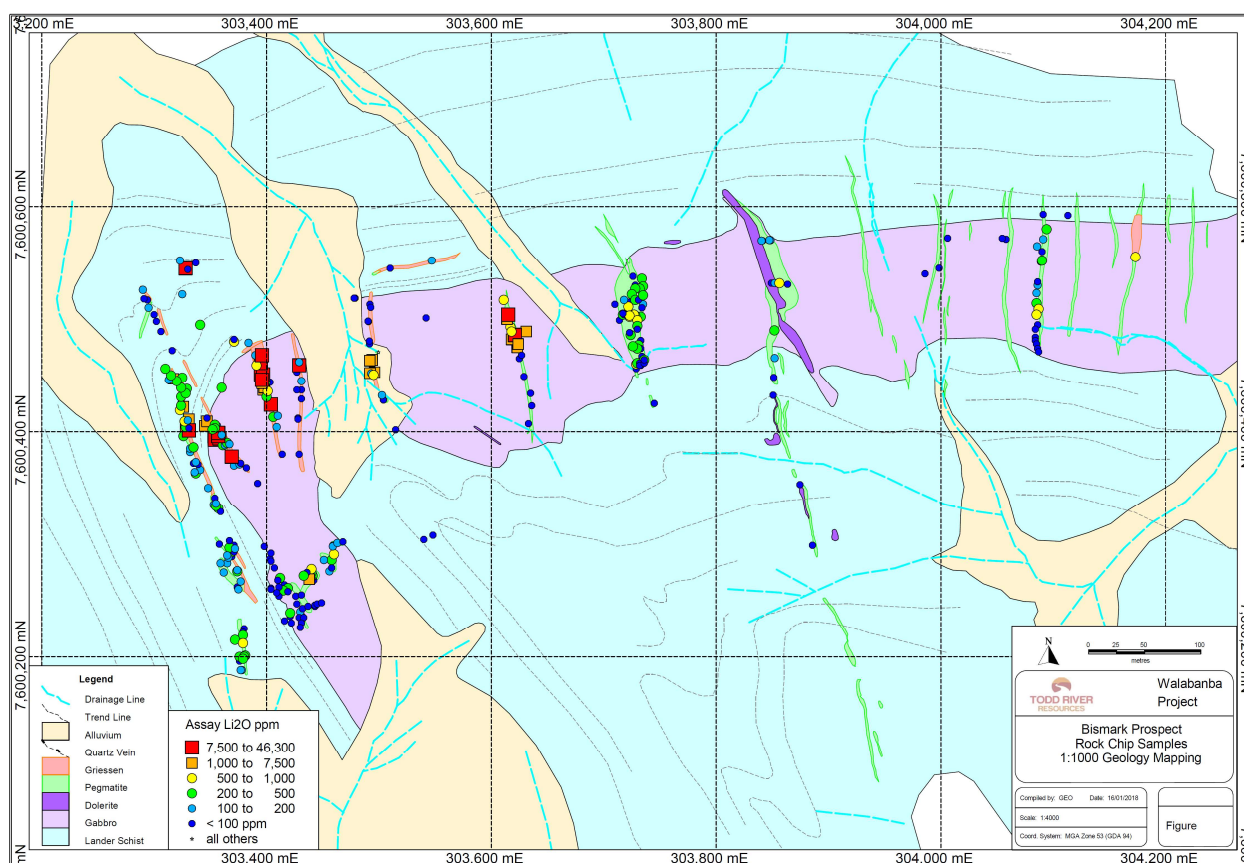


Figure 10: Bismark Rock Chip Samples - Li₂O ppm

Norton (1983) describes a mineralogical zonation of fractionated LCT pegmatites from the outer zone toward the core of fertile pegmatite as:

1. Sodic plagioclase + quartz + microcline
2. Plagioclase + quartz
3. Quartz + sodic plagioclase + perthite ± muscovite ± biotite
4. Perthite + quartz
5. Sodic plagioclase + quartz + spodumene (or petalite or montebrasite or both)
6. Quartz + spodumene
7. Quartz + microcline
8. Quartz
9. Lepidolite or lithian mica + sodic plagioclase + quartz + microcline

Bradley et.al (2017) further clarifies that the plagioclase-rich outer units may also include accessory beryl, garnet, tourmaline, apatite, and (or) columbite, and the inner zone 9 typically include tourmaline, beryl, topaz, apatite, other phosphates, and (or) Sn-Ta-Nb oxides.

At Bismark, the individual pegmatites within the western fertile area display a mineralogical zonation across the width of the pegmatites with an outer zone, generally represented by plagioclase + quartz + microcline ± muscovite (XRD groups 2, 4, and 5) which equates to Norton's mineralogical zones 1 to 3. The pegmatites within these



outer zones have low to moderate Li_2O varying up to 900 ppm and are generally classed as Complex, Lepidolite and Beryl type (element range) pegmatites.

The inner zone of the fertile Bismark pegmatites in this western area are comprised of plagioclase + quartz + spodumene + microcline + muscovite with Li_2O varying between 7,500 to 18,400 ppm and a central core of quartz + spodumene \pm muscovite with Li_2O up to 46,290 ppm equating to approximately 50 wt% spodumene content. These pegmatites are correlative to Norton's mineralogical zones 5, 6 and 7.

Seven samples representing some of the higher lithium-bearing pegmatites (B140, B161, B168, B178, B183, B190 and B196) have been submitted to Craig Rugless at Pathfinder Exploration for thin section mineralogical and petrographic descriptions pegmatite samples. The report is not due for completion until March.

The Bismark prospect is highly prospective for lithium-bearing pegmatites. Five individual pegmatite dykes, up to 100 m long and 6 m wide, within a distance of 300 m, have been sampled with assays of greater than 7,500 ppm Li_2O . Assay results have returned up to 4.6 % Li_2O with corresponding quantitative XRD analysis returning identification of spodumene with up to 50% content. Analysis of the assay results confirm the prospectivity of the pegmatites with many of the samples classified as Beryl, Complex and Lepidolite type pegmatites by element range and as Beryl, Rare Earth Element, Complex, Lepidolite and Albite-Spodumene by element ratio methods. The mineralogical zonation of the Bismark pegmatites are similar to other LCT pegmatites from lithium deposits.

It is recommended that further work is undertaken at the Bismark prospect and that the pegmatites are tested at depth by drilling.



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