REPORT : Pegmatite Geology, Exploration Methods, and Exploration Plan for the Midnight Owl Lithium Project, Yavapai County, Arizona, USA

A granitic dike along a roadcut en route to the Midnight Owl pegmatite. Photo by the Author.

BrightRock Gold Corp.

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Table of Contents

Table of Tables

Table of Figures

Summary

Salient Pegmatite Geology

"Pegmatite" is a textural term that describes an igneous, typically granitic, rock with coarse – grained crystals > 1.0 cm. Pegmatites can be classified by their chemistry (e.g. LCT type), internal zonations, and their geometry (Guilbert and Park, 1986). Each of the listed parameters has critical implications for exploration.

Exploration Methods

The geologic map is the foundation and first tool for all successful mineral exploration projects. It is first used to find the mineralized pegmatite. Then, it is used to build the geologic block model.

Geochemical sampling is used to find zones of enriched lithium and to direct exploration efforts. Sampling is done upon the ground surface material and by assay of drill cuttings/core (Boyko et al., 2018).

Geophysical surveys can assist in differentiating the pegmatite from the surrounding host waste rock. Successful LCT pegmatite projects have employed both magnetic and radiometric surveys of their resources (Ingham et al., 2012).

Drilling is used to develop and continually improve the geologic model and the Resource Model of a project. The two drilling methods commonly employed in LCT pegmatite exploration are Reverse Circulation (RC) and Diamond Drilling. They each have unique operational parameters and results, and thus perform different functions in development of the Resource Model.

Midnight Owl Pegmatite Exploration Plan 1

A) Gather all previous work, written information, and generate the geologic map.
B) Acquire geochemical and geophysical data to guide drilling decisions.

Salient Pegmatite Geology

Pegmatite is a textural term that describes an igneous rock, most often granitic in composition, that is coarse-grained with grain size 1.0 cm or larger; crystals could reach as large as 10 m in length (Figures 1, 2). These rocks are of significant economic importance as they host significant quantities of rare metals including Ta, Li, Be, U, Cs, REEs, and others. They are the final fraction of exsolved and incompatible elements from crystallizing rock melts.

Figure 1: Giant spodumene laths in the historic Etta LCT pegmatite, SD, USA.
The laths, called "logs," of spodumene in this figure are 10 m long and up to 2 m thick. The man in yellow ellipse is approximately 2 m tall. From Guilbert and Park (1986).

Pegmatites are primarily classified in three ways: by enrichment of their metals and chemical composition, their internal zones, and by geometry. There are many pegmatite chemical compositions of significance; e.g. pegmatites that bear Niobium-Yttrium-Fluorine (NYF pegmatites). Pegmatites that bear Lithium-Cesium-Tantalum (LCT pegmatites), such as that in Figure 2, are of singular interest in this report.

Figure 2: Alignment of spodumene laths in the San Luis #1 LCT pegmatite in Argentina.
From Bradley et al. (2017).

Pegmatites commonly have internal zones (Figure 3). These zones are of critical importance to economic evaluation of the rock, as ore minerals will self-partition into particular zones within the pegmatite and leave the other zones barren of valuable commodities. Zones can be defined by observation of contituent mineralogy.

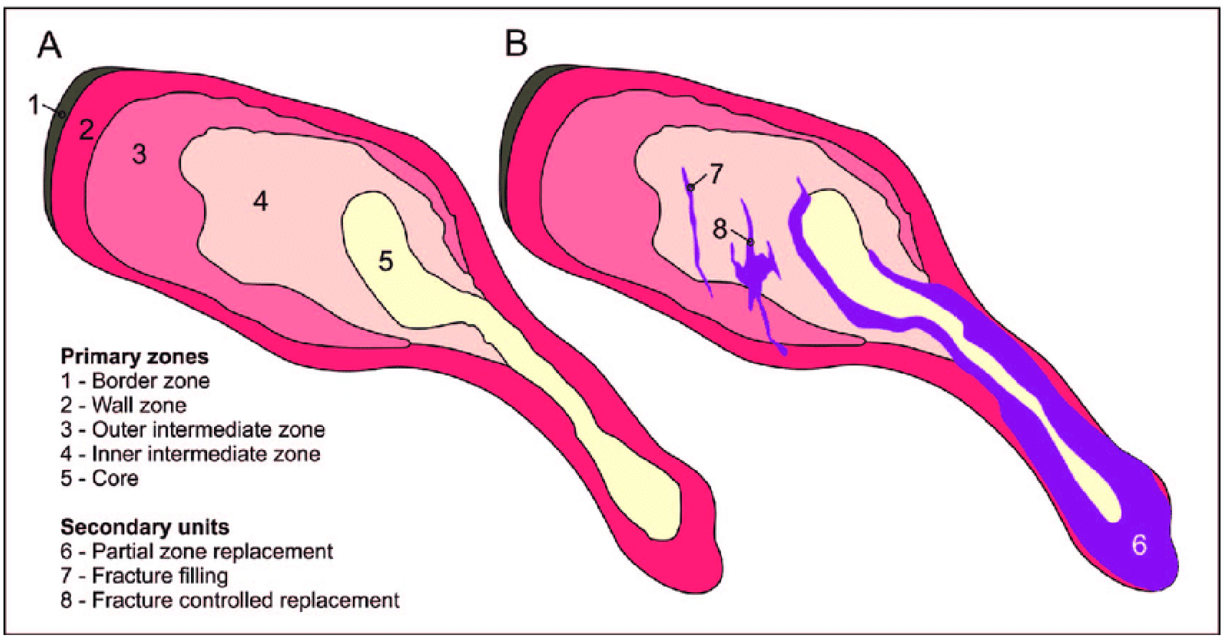

Figure 3: Zoned pegmatites; simple (A) and complex (B).
Complex pegmatite has replacement zones (or units) that are called secondary units. From Müller et al. (2022), and references therein.

Geometry of the pegmatite is similarly important for economic evaluation. Large pegmatite mineral deposits commonly occur as vertical dikes or horizontal sills (Figure 4). Other geometries such as pipes, lenses, bulges, and pods have also been reported. Pegmatites may occur in "swarms" of many dikes, lenses, and pods in a mineralized geographic area (Figure 5).

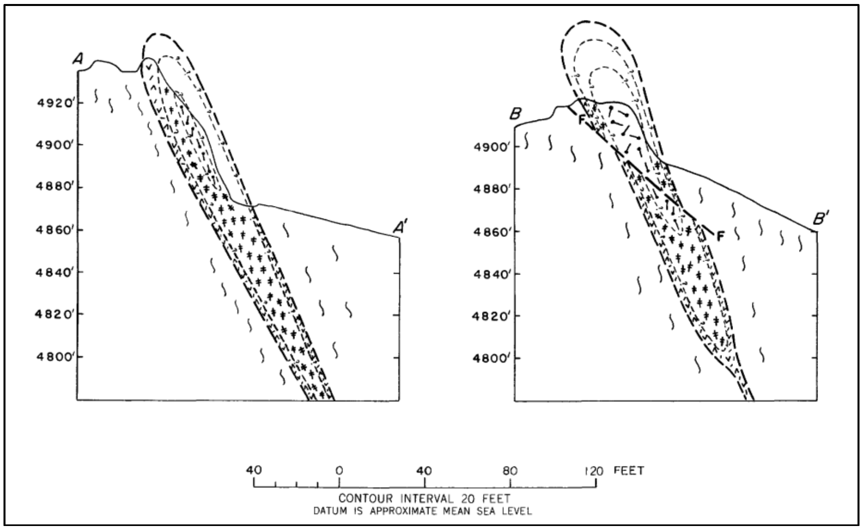

Figure 4: Sitting Bull LCT pegmatite cross section, SD, USA.
Note the tabular geometry and near vertical orientation of this pegmatite dike. From Norton and Others (1964).

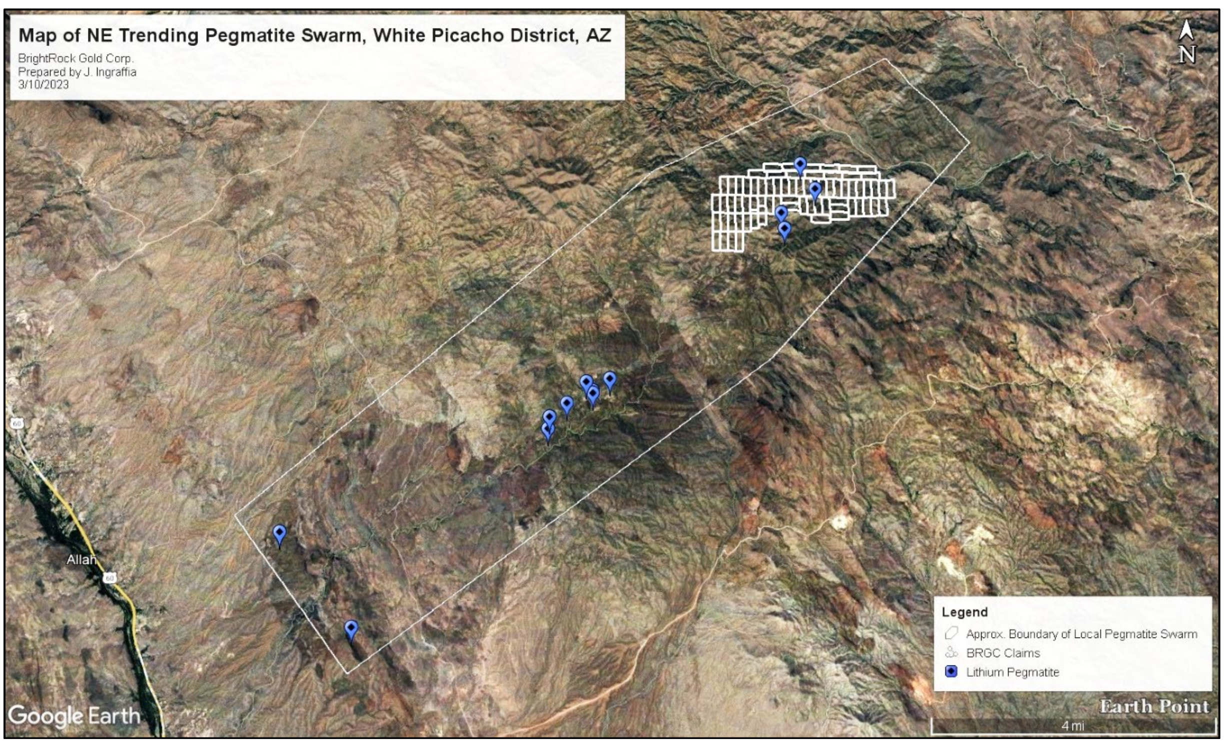

Figure 5: Pegmatite swarm map, local White Picacho District area, AZ, USA.
Note the NE trend of the pegmatite swarm. Data from (Mindat, 2023), (Bradda Head Lithium Ltd., 2023), and (Sunderland, A., 2023).

Exploration Methods Used to Find Pegmatites

Geologic Methods

Geologic Mapping

The geologic map is the foundation and primary tool to explore for any mineral resource (Figure 6). The map is used to: (1) identify surface exposure of the pegmatite, (2) define the internal pegmatite zoning and mineralogy, (3) determine pegmatite geometry, azimuthal orientation, and structural characteristics, (4) identify any mineralization trends of the pegmatite region, (5) differentiate the pegmatite from local host waste rock (Ingham et al. 2012). A geologic map, after exploration, becomes the foundation for the geologic model and Resource Model.

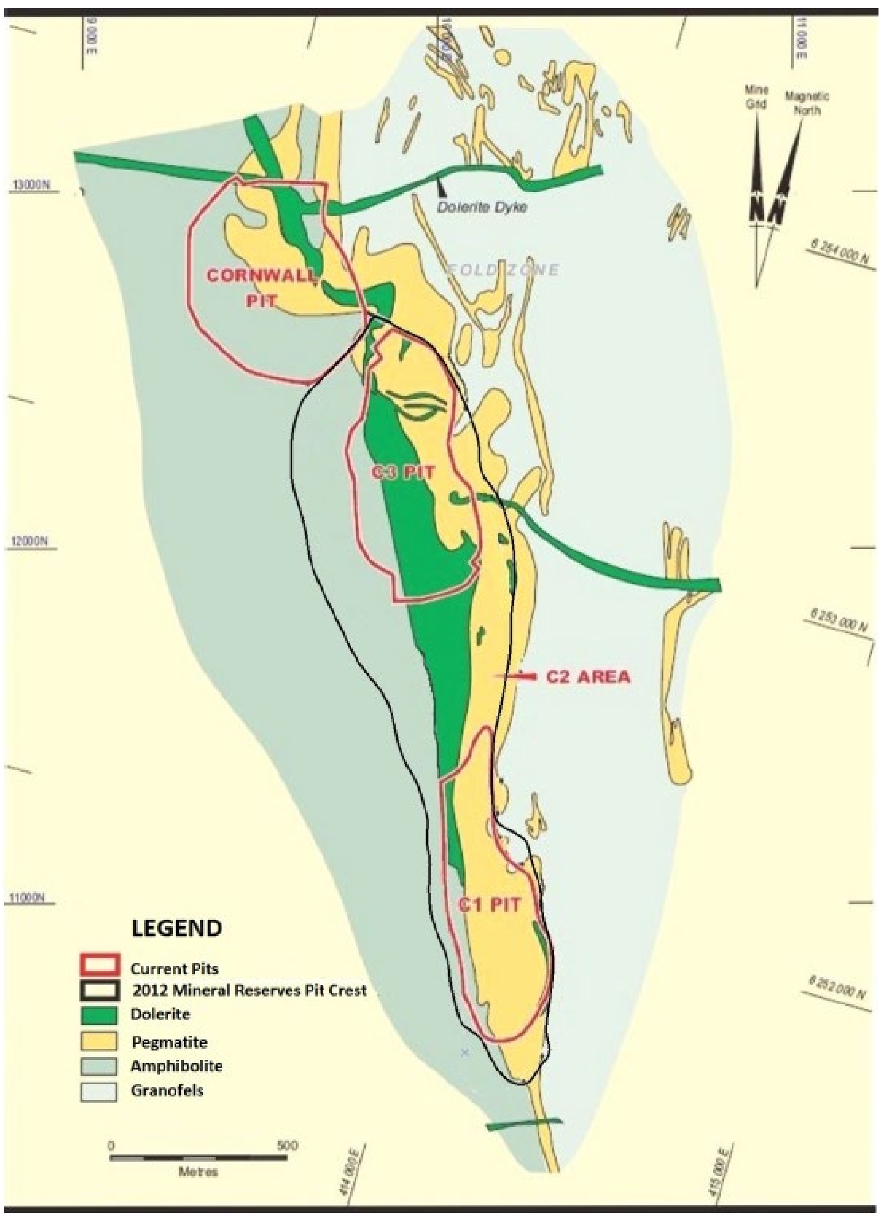

Figure 6: Local geologic map of Talison's Greenbushes lithium pegmatite, WA, Australia. Opened in 1888 for tin, Greenbushes is the oldest and longest continually operating pegmatite mine in West Australia. From Ingham et al. (2012).

Geochemical Sampling

Surface geochemical sampling is done to vector into the location of highest exploration potential. There are several techniques for surface geochemical sampling; the technique chosen is dependent upon the degree of prior knowledge regarding where the mineralized pegmatite exists. The geochemical information from sampling is processed into geospatial data and overlayed onto topography to view elemental intensities, that may then be used to guide further exploration. For example, the lithium geochemical intensity map from samples taken from an exposed pegmatite in west Arizona (Figures 7, 8).

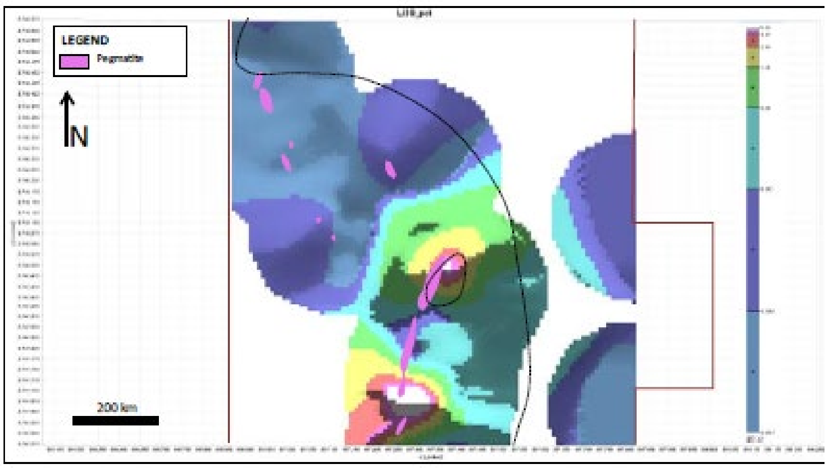

Figure 7 (left): Lithium geochemical intensity map from Lucky Mica pegmatite surface sampling campaign, AZ, USA.
From Paiement and Laporte (2017).

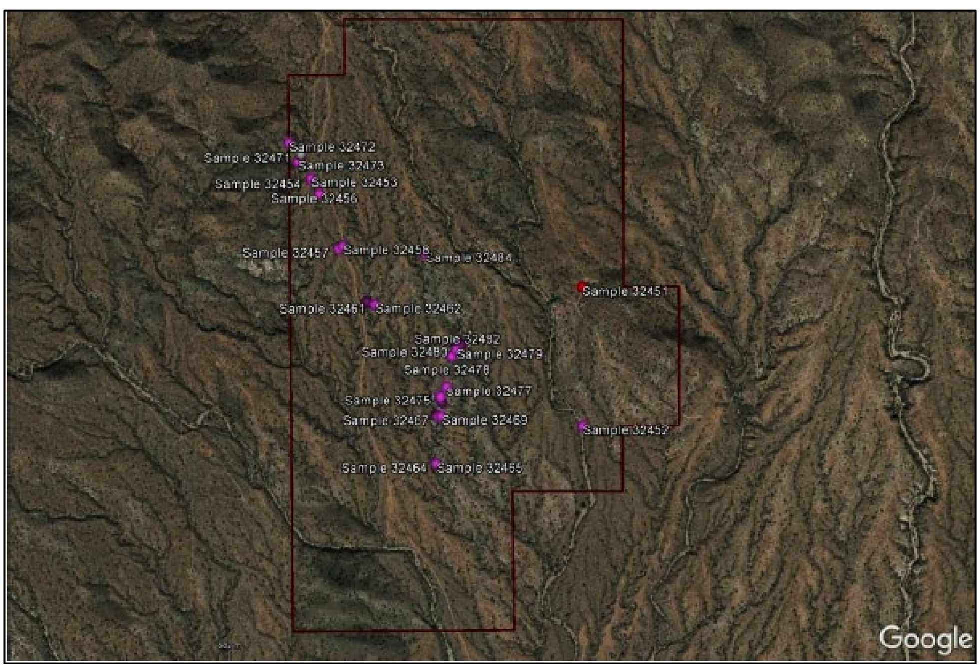

Figure 8: Surface geochemical sampling of the Lucky Mica pegmatite, located west of Wickenburg, AZ, USA.
From Paiement and Laporte (2017).

The assays of drill samples are the building blocks of the Mineral Resource and Mineral Reserve. Assays and inspection of drill core, and to a lesser extent, drill cuttings, are used to plot different elemental intensity zones and their host rocks within 2D and 3D space (Figures 9, 10, 11). The assay data is interpolated between drill holes by geostatistical methods, such as kriging, to create the Mineral Resource. Once chemistry of the pegmatite ore rock is known, it can be filtered through the model to determine pegmatite geometry underground with reasonable confidence. This must be cross referenced with the drill core before reporting of a 43-101 or similar document.

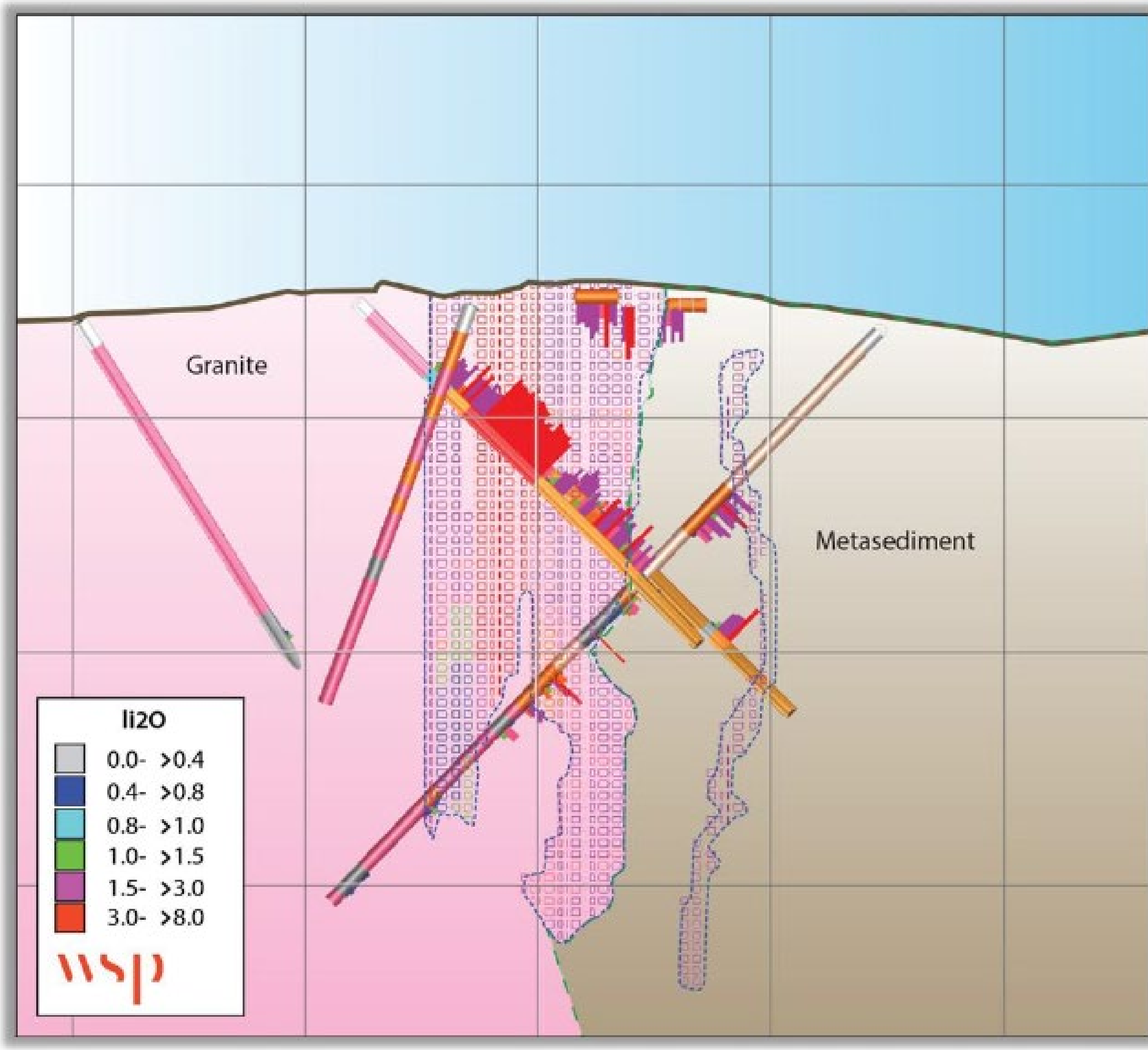

Figure 9: Frontier Lithium's PAK pegmatite in cross-section block model view, ON, Canada. The pegmatite occurs primarily at the contact of the granite intrusion (pink) and local country metasediment rocks (brown). The highest grade lithium, by Li2O, is the red intensity marks drawn from the oriented drill holes through the pegmatite. From Boyko et al. (2018).

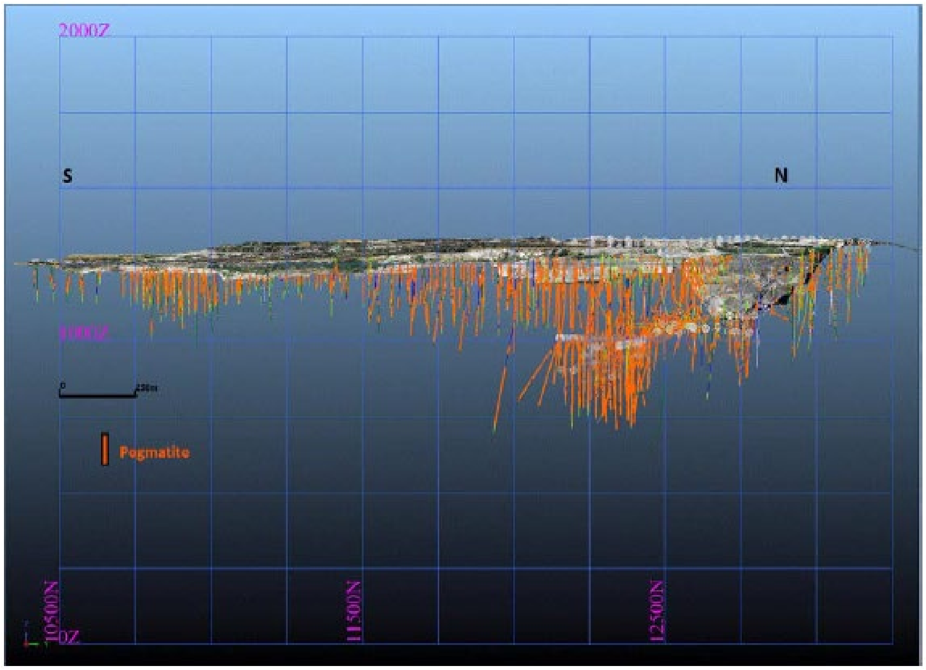

Figure 10: Greenbushes pegmatite drill hole intersections, WA, Australia.
The pegmatite (orange intercepts) is determined by correlation between the intersected geology and the correlated geochemistry of the rocks at those respective depths From Ingham et al. (2012).

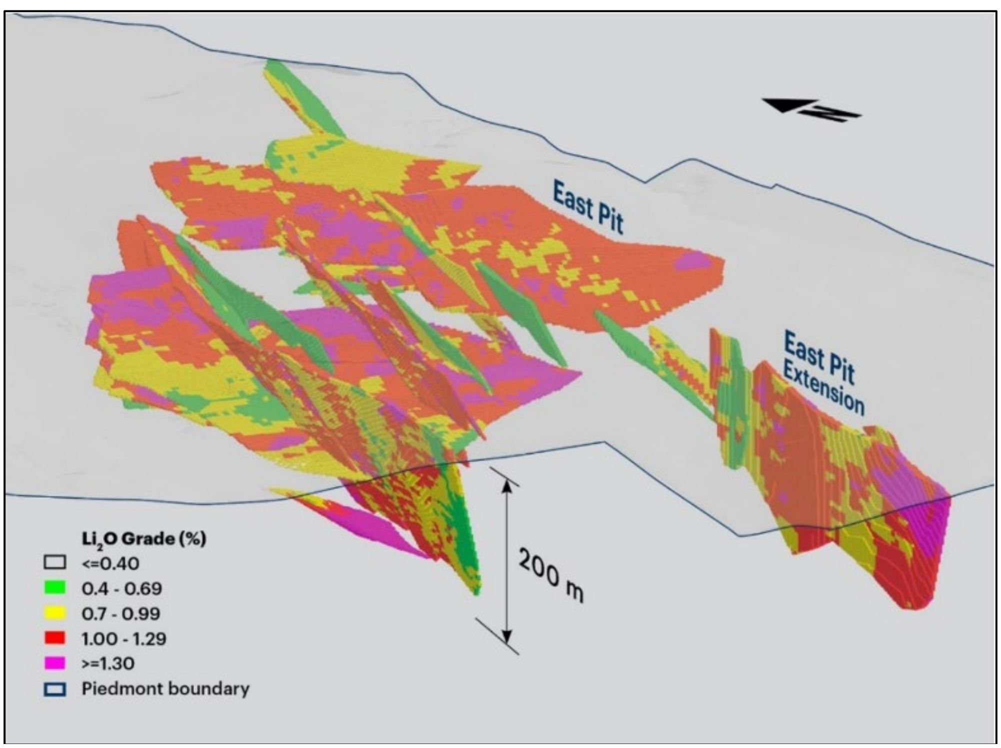

Figure 11: Piedmont Lithium's Core pegmatite project block model, NC, USA.
Isometric view. From Piedmont Lithium Limited (2021).

Geophysical Measurements

Geophysical methods can be used to help discern the pegmatite from host rocks when used in conjunction with known geochemical anomalies and a geologic map. Magnetic surveys are used in pegmatite exploration to determine structural framework and may delineate host rocks of pegmatites (Figure 12; Essential Metals, 2022). Magnetic surveys have seen extensive use on LCT pegmatite mining projects (Ingham et al., 2012; Boyko et al., 2018; Piedmont Lithium Limited, 2021). By determination of structural control of granitic emplacement and linking structural dilational zones, fluid migratory pathways can be established that may have trapped mineralized pods or lenses of pegmatite ore.

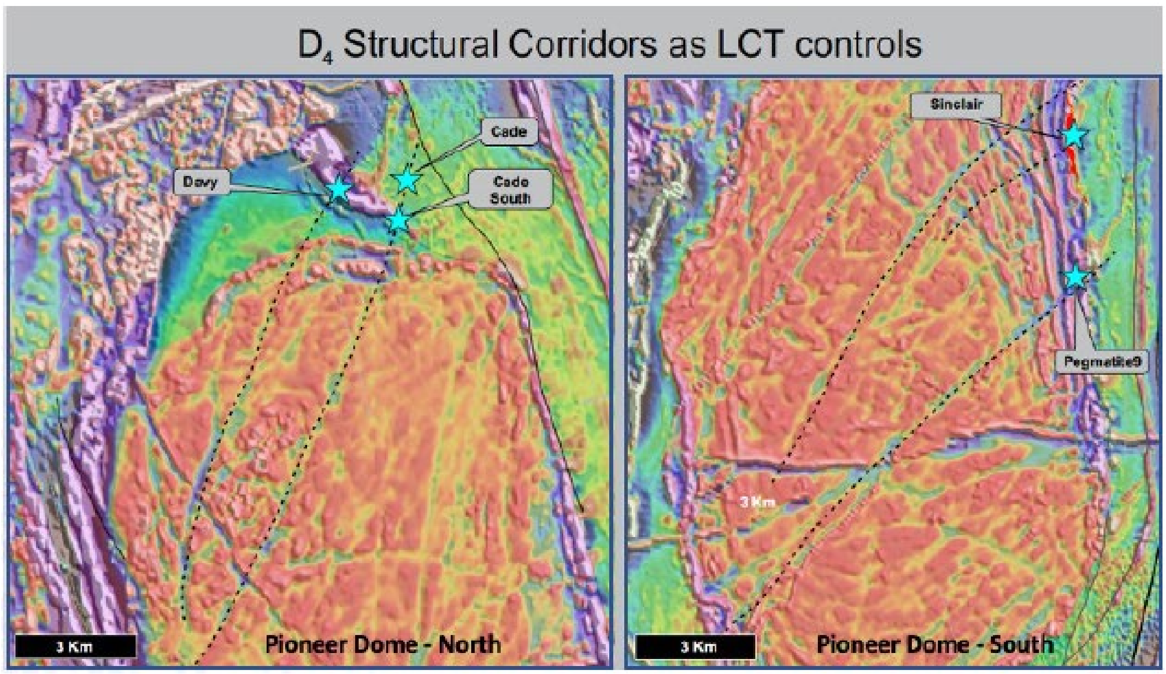

Figure 12: Magnetic anomaly map of the Pioneer Dome pegmatite system in WA, Australia. Major structural corridors (dotted lines) have been linked with pegmatite occurrences and exploration targets (labels). From Essential Metals (2022).

Radiometric surveys are commonly used to assist in delineation pegmatites by uranium-thorium-potassium (U-Th-K) activity (Ingham et al., 2012; Boyko et al., 2018). The highly fractionated geochemical nature of pegmatites lends itself to enrichment in those elements. Radiometric data is commonly taken simultaneously with magnetic surveys. The data is used in conjunction with known geochemical and geological spatial knowledge (Figure 13).

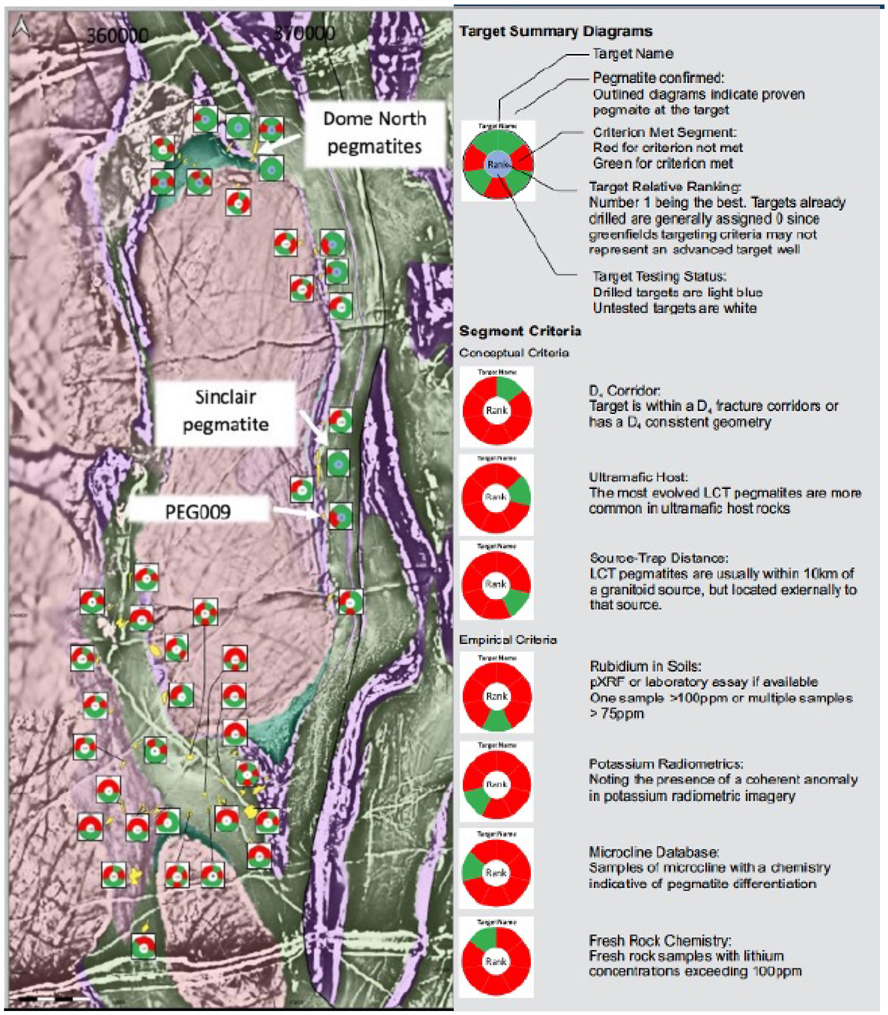

Figure 13: Radiometric exploration map of the Pioneer Dome pegmatite system, WA, Australia. Radiometric data is used in conjunction with geology of host rocks, soil geochemistry, and other geophysical measurements to quantify the best targets (right). From Essential Metals (2022).

Drilling

The objective of drilling is to continuously improve the deposit geologic solid model and the geostatisitical domains that are used for the Mineral Resource model. Classic and tested drilling methods for pegmatites are Reverse Circulation (RC) and Diamond Drilling (DD). There are countless references and discrete methods to the sampling approach with both approaches (BG Drilling, 2016). The primary rule when drilling either a RC or DD hole is to intersect the ore body at 90º to its planar surface to obtain true thickness of the pegmatite (Ingham et al., 2012; Piedmont Lithium Limited, 2021).

RC Drilling

RC drilling is fast, cost effective, and can be used to roughly determine rock units at depth. The operation, perhaps, may take 2 days less time and, perhaps, may be 25% - 40% less expensive relative to DD (McCoremick, 2019). Cutting samples may be taken while drilling via a riffle splitter-mount upon the individual drill rig (Ingham et al., 2012).

RC is known to be relatively inaccurate, as the drill bit tends to corkscrew downhole (BG Drilling, 2016). RC drilling also does not yield core samples. However, RC holes can be used to generate results quickly. In producing pegmatite projects, RC drilling has been employed around existing DD holes, where geologists can interpolate the rock units between the different holes by geology and assays (Ingham et al., 2012).

Diamond Drilling

DD drilling is used when accuracy and precision in the results is required. Early stage pegmatite projects have employed DD to clearly define their resource after extensive geological mapping, sampling, and geophysical surveys (Ingham et al., 2012; Boyko et al., 2018). Access to core for certainty of rock units and assays at discrete depths is used in the development of an accurate Resource Model.

DD is more expensive than RC and takes more time. Project management must expend more effort to carefully denote where and how exactly to place and drill the first hole. The process is more cumbersome; however, DD does have the potential to yield more reliable results in the long term.

Surface Drill Holes Available for Mineral Resource Modeling

Year	Series	RC Holes	RC Metres	Series	DD Holes[1]	DD Metres
1977-80				HP	31	7,885
1981				HP, JM	44	10,510
1982				HP, JM	30	4,539
1984				HP	12	1,463
1985				HP	11	1,410
1988				LD	2	370
1990				HP	5	756
1991				HP, NE, BG, KF, TC, GW	59	6,794
1993				HP	11	924
1994				GT	4	653
1996				HP, NC, NE	40	5,972
1997	RC	90	7,972	HP	8	790
1998	RC	9	1,549		0	0
1999	RC	13	2,378	HP, GT	15	6,521
2000	RC	10	762		0	0
2001	RC	7	1,044	HP, VT	13	1,666
2002	RC	40	5,199	HP	5	1,605
2004	RC	9	650			
2005	RC	11	976			
2006	RC	49	6,412			
2007	RC	15	3,234			
2008	RC	11	1,926	C1DD, C3DD	8	1,668
2010	RC	119	9,216			
2011	RC	5	264	C2DD	1	51
2012	RC	51	9100	C1DD C2DD C3DD	5 3 7	372 736 2543
Totals		439	50,682		314	57,228

Note:
(1) Excludes underground drill holes.

Table 1: RC and DD drill hole chronology at the Greenbushes pegmatite, WA, Australia. The Greenbushes pegmatite first saw extensive DD hole programs from 1977-1996, then transitioned to RC hole programs from 1996-2012. More RC holes have been drilled, while DD has accounted for more total distance drilled. From Ingham et al. (2012).

Midnight Owl Pegmatite Exploration Plan 1

The Midnight Owl project is unique in that it is within an established LCT pegmatite field that has received thorough geologic review (London and Burt, 1978; and references therein). Geologic maps of the open cut Midnight Owl mine are available, as are geologic maps of the greater White Picacho District. Local pegmatite geometries, zonations, and mineralogies have been thoroughly documented. Recently, local mineral exploration activity has found inferred pegmatites in the southwest corner of the BRGC claim block.

Early Exploration Plan

To best leverage these advantages in exploration for additional LCT pegmatites on the BRGC property, two early phases of exploration are considered here:

<u>Phase 1: Establish Foundational Knowledge</u>

A. Gather all documented geological information of the area.
    a. Maps, underground workings, sample data, reports.
    b. Visit the Arizona Geologic Survey.
B. Field-check existing geologic maps of the property
    a. Fill in missing pertinent information.
C. Examine the "inferred pegmatite" in the SW corner of the company claim block for validity.
    a. Field check if the unit is valid and continuous.
D. Geochemical sampling on a grid.
    a. Take additional samples across stratigraphy in suspect terrains.

<u>Phase 2: Gather Advanced Information</u>

A. Acquire remote sensing geophysical data.
    a. Aeromagnetics and radiometrics can be taken simultaneously.
    b. Combine with the geological map and geochemical spatial data.
B. Interpret the combined exploration data.
    a. Constrain pegmatite location and geometry.

Future Work

Drilling procedures and cuttings/core analysis logistics must be planned. The location where to take and secure the core must be established. Other remote sensing techniques such as Ground Penetrating Radar (GRP) and Hyperspectral investigations remain to be investigated for efficacy and applicability. These items are to follow the creation of a geologic map of the Midnight Owl area.

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