

# Petrographic Analysis of Lepidolite-Pegmatites in Lema, Kwara State, North-central Nigeria: Implications for Lithium Mineralisation

\*M.A. Mohammed<sup>1</sup> and S.M Badari<sup>2</sup><sup>1</sup>Department of Geology and Mining, University of Abuja.<sup>2</sup>Aimurafaty Nigeria Limited, Ilorin, Nigeria.Corresponding Author's Email: [salihumuhammadjamu84@gmail.com](mailto:salihumuhammadjamu84@gmail.com)

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## ABSTRACT

This study investigates the mineralogical composition and potential for lithium mineralisation in lepidolite-pegmatite samples from the Lema Pegmatite Field in north-central Nigeria. Petrographic analysis was conducted on three representative samples (L1, L2, and L3) using thin-section microscopy under plane polarized light (PPL) and crossed polarized light (XPL). The results reveal that muscovite is the predominant mineral, constituting 45%, 50% and 55% of L1, L2 and L3 respectively, while Quartz is notably abundant, making up 20% in L1, 25% in L2 and 20% in L3. Plagioclase and Biotite are also present in significant amounts, indicating a complex mineral assemblage where muscovite could be co-existing with lepidolite of enhanced lithium content. The findings suggest that, while lepidolite is a significant lithium-bearing mineral, it may not be the dominant component in these samples, with Muscovite emerging as a major constituent. This diverse mineralogy highlights the geological complexity of the pegmatites and underscores the need for further exploration and characterisation to assess the economic potential of these rocks in supporting the ongoing energy transition. Future research should focus on quantitative assessments of lepidolite and its lithium content, alongside geochemical methods, to evaluate the viability of these deposits in the context of global lithium demand.

**Keywords:** lepidolite, petrography, pegmatite, mineralization, thin section

## 1.0. INTRODUCTION

This paper determines the petrography of three lithium ore (lepidolite) samples from lema pegmatite field under plane polarized light (PPL) and cross polarized light (XPL). The pegmatite of lema pegmatite field forms a prominent topographic features (patikiesan hill) and intrudes amphibolite, schists and gneisses as shown in the geologic map of lema area. This pegmatite is extensively kaolinized layer that could reach <4m.

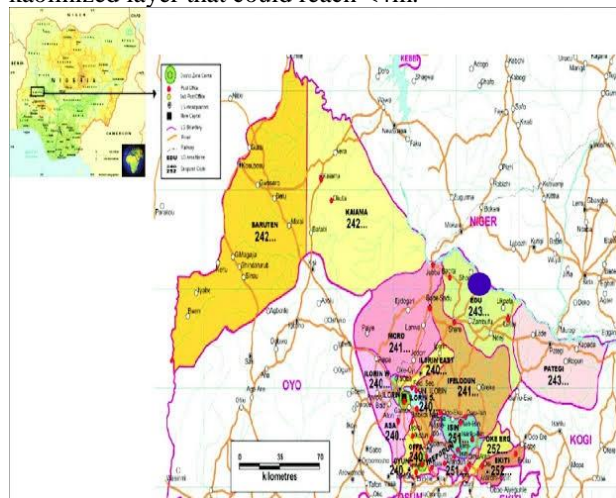


Figure 1.0 Map of kwara state showing EDU and the study area (after Abraham et al., 2015)

### 1.1. Research Limitation

This preliminary investigation is constrained to a limited dataset comprising three representative lepidolite-pegmatite samples, collected from Lema, due to logistical access restrictions and budgetary limitations. Future research endeavors should prioritize comprehensive mineralogical and geochemical analyses, incorporating quantitative assessments of lepidolite and lithium concentrations, to rigorously evaluate the economic viability of these deposits within the context of escalating global lithium demand.

### 2.0. Geological Setting

Lema, located in Edu Local Government Area of Kwara State, North-Central Nigeria, lies within the Precambrian Basement Complex—a region well known for its geological complexity and rich mineral potential. The area hosts zoned pegmatites intruding various metamorphic rocks including gneisses, schists, and amphibolites, which form part of the Migmatite-Gneiss Complex. The Lema region is dominated by Precambrian basement rocks, mainly migmatite, granitic gneiss, biotite schist, and amphibolite, which are cross-cut by pegmatite veins. These pegmatites intrude along regional foliation trends, suggesting syn- to post-tectonic emplacement related to the Pan-African orogeny. This tectonic regime

is known to have facilitated pegmatite formation through partial melting and fluid activity (Garba et al., 2019). Recent geological investigations have confirmed that Lema pegmatites exhibit well-developed zoning, with mineralogical variations that indicate multiple intrusive events. These zones host minerals such as muscovite, quartz, albite, tourmaline, rubellite, and lepidolite, a lithium-bearing mica (Filippov et al., 2022). Detailed geochemical studies have revealed that Lema's pegmatites belong to the Li-Be-Ta (Type III) and Li-Cs-Be-Ta (Type IV) rare-metal pegmatite families, which are associated with high economic potential for lithium, beryllium, cesium, and tantalum (Garba et al., 2019; Tadesse et al., 2019). Lepidolite, found as relics within weathered kaolinized profiles, is the principal lithium-bearing mineral.

Tantalite, columbite, microlite, and beryl have also been reported, particularly within the outer and intermediate zones of pegmatites. The Lema pegmatites exhibit well-developed zoning with mineralogical variations indicative of multiple intrusive events (Garba et al., 2019). Studies confirm that pegmatite formation is often influenced by partial melting and fluid activity during post-tectonic phases (Adekeye et al., 2021). Advanced processing methods such as dry separation and flotation are increasingly used to separate lepidolite from complex ores (Filippov et al., 2022). The presence of lithium-rich minerals like lepidolite is strongly linked to the peraluminous nature of pegmatites, which are associated with S-type granite magmatism (Hudson-Edwards, 2024). Quantitative mineralogical studies support the economic potential of lithium-bearing pegmatites in Nigeria's Basement Complex (Garrett, 2021; Liu et al., 2022). Recent regional surveys by NGS (2024) and Akinola et al. (2021) have delineated fractured zones with favorable mineralisation prospects. The growing demand for lithium due to battery technologies makes studies like this crucial for resource evaluation (Tadesse et al., 2019; Wang et al., 2023). Regional structural patterns show that the Lema pegmatites are controlled by NW-SE, N-S, and NE-SW fractures, a reflection of Pan-African brittle deformation episodes. These fractures served as conduits for mineralizing fluids and influenced the emplacement of pegmatites. Hydrogeophysical surveys employing ground magnetics, VLF-EM, and VES techniques have delineated fractured zones, depth to basement, and mineralized layers in parts of central Kwara, including Lema. These methods also help assess the groundwater potential in relation to the basement lithology (Akinola et al., 2021).

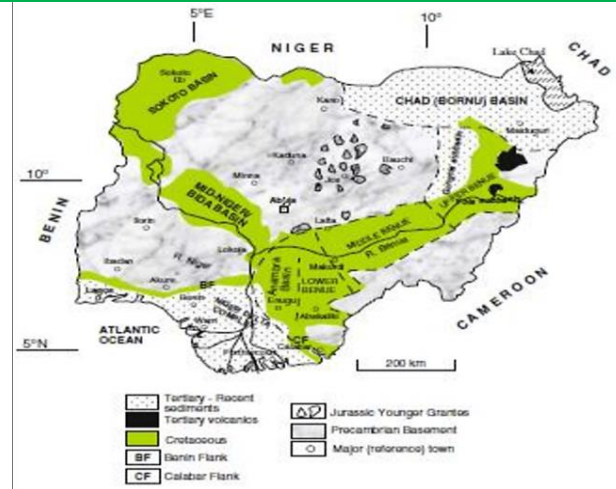


Figure 1.1. Geological map of Nigeria (After, Obaje, 2004)

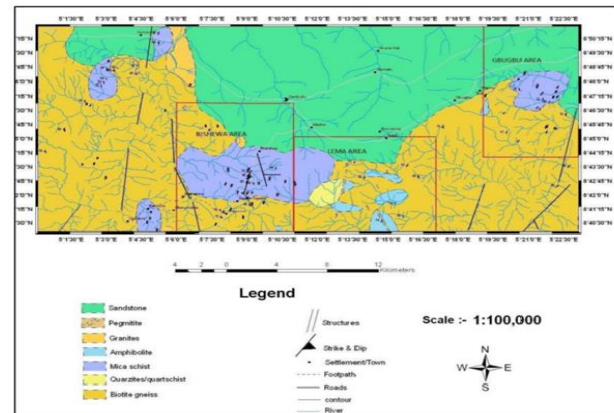


Figure 1.2. Geological map of part of Edu (Lafiagi sheet) showing lema pegmatite field (after Garba, 2019)

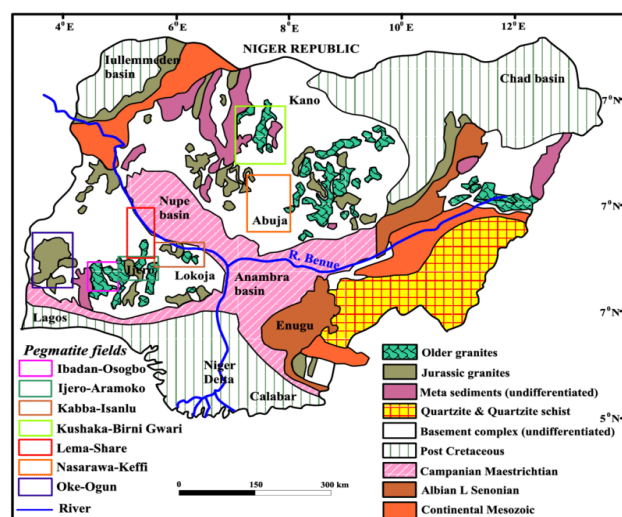


Figure 1.3. Geological map of the Nigeria showing the pegmatite in the study area (after okunlola 2005)

## 2.0. MATERIALS AND METHODS

### 2.1. Sample collection

Fresh representative samples of lepidolite-pegmatite were collected from three different locations in the field and labelled L1, L2 and L3, were collected from three different locations using GPS. The samples were sent to university of Ilorin geological Lab for petrographic analysis.

### 2.2. Sample preparation

Petrographic preparation of the samples was done at geology lab at University of Ilorin. The process involves cutting of the rocks into small rectangular pallet of 3mm by a cut-off saw, and polished in order to reveal their internal structures, the polished samples were then mounted on a glass slide using araldite. The rock slide was studied under a petrological microscope (model NP-107B) to determine the physical and optical properties of the samples in both plane and crossed polarized light, thereby inferring the modal composition of each mineral present in the samples. Photomicrographs of important sections were taken by combined use of the petrographic microscope and digital camera.

## 3.0. RESULTS AND DISCUSSION

The petrographic study of the samples includes microscopic description

### 3.1. Results

#### 3.1.1. Microscopic description (Thin section)

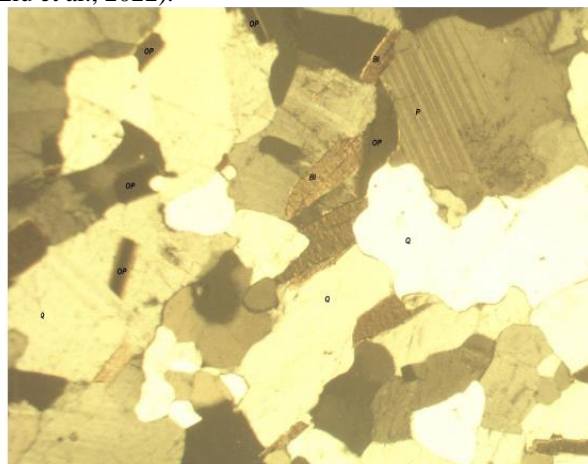
The prepared thin section was examined and studied under plane polarized light (PPL) and cross polarized light (XPL). Photomicrographs of important sections (L1-L3) were analyzed from the thin section (Table 1). Minerals were identified using standard optical properties such as color, pleochroism, relief, cleavage, and birefringence. The application of these techniques consistent with modern petrographic protocols used in lithium exploration (Wang et al., 2023)

#### 3.1.2. PPL description

In the thin section (figure 3.1-3.6), muscovite mica, quartz, and biotite mica and plagioclase feldspar were the major rock forming minerals based on their characteristics. Under PPL, quartz appeared colorless with low relief and no pleochroism, while muscovite showed gray coloration with moderate relief and strong pleochroism. Biotite exhibited light brown color, distinct pleochroism, and a platy habit, indicative of its structural alignment. Plagioclase appeared brownish-red and showed no pleochroism. These mineralogical features are consistent with those reported in recent studies of lithium-bearing pegmatites in the Nigerian Basement Complex (Garba et al., 2019; Adekeye et al., 2021).

#### 3.1.3. XPL description

The samples under crossed polarized light show properties such as birefringence and extinction. The quartz displayed low interference colors and undulose extinction, indicating tectonic deformation. Plagioclase showed typical albite twinning and low birefringence. Muscovite presented moderate birefringence and interference colors. These optical properties support the classification of the samples as peraluminous granitic pegmatites with mineralogical zonation, as observed in similar regions across Nigeria (Hudson-Edwards, 2024; Liu et al., 2022).

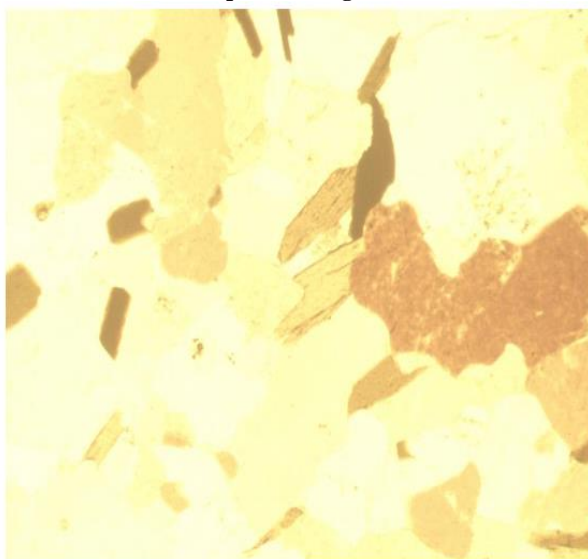


XPL-L1

Magnification: X4

Op= Opaque Minerals, Q= Quartz, Bi= Biotite and P= Plagioclase Feldspar.

**Figure 3.1: photomicrograph of sample L1 under crossed polarized light**



PPL-L1

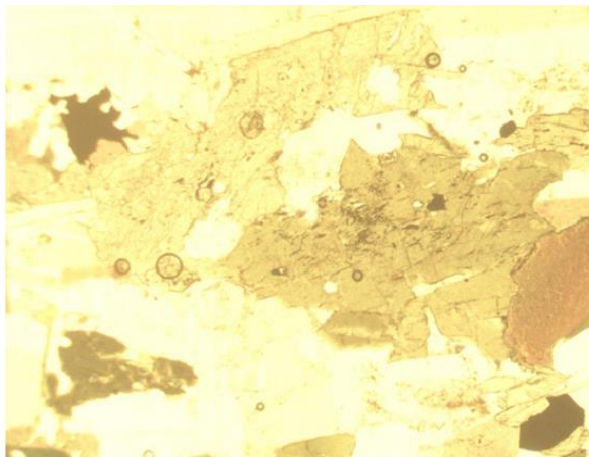
**Figure 3.2: Photomicrograph of sample L1 under plane polarized light**



XPL-L2 Magnification = X4

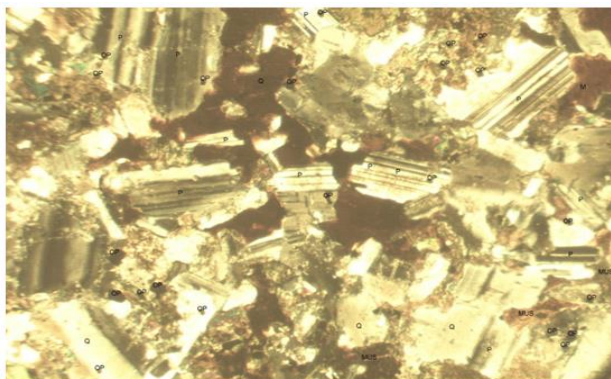
Op= Opaque minerals, Q= Quartz, Mus= Muscovite, P= Plagioclase feldspar.

**Figure 3.3: Photomicrograph of sample L2 under crossed polarized light**



PPL-L2

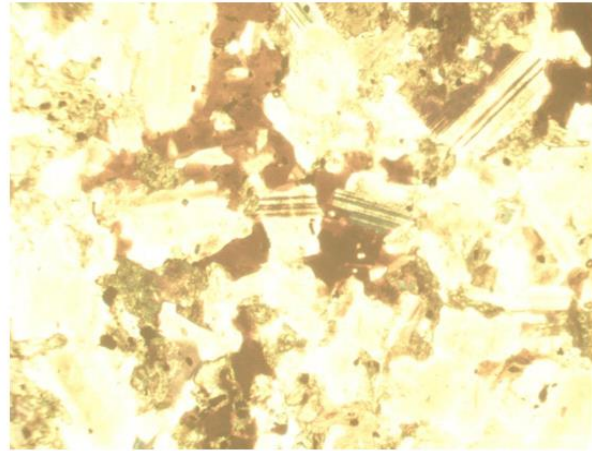
**Figure 3.4: Photomicrograph of Sample L2 under Plane Polarized Light**



XPL-L3 Magnification= X4

Op= Opaque minerals, Q= Quartz, Mus= Muscovite, P= Plagioclase feldspar.

**Figure 3.5: Photomicrograph of Sample L3 Crossed Polarized Light**

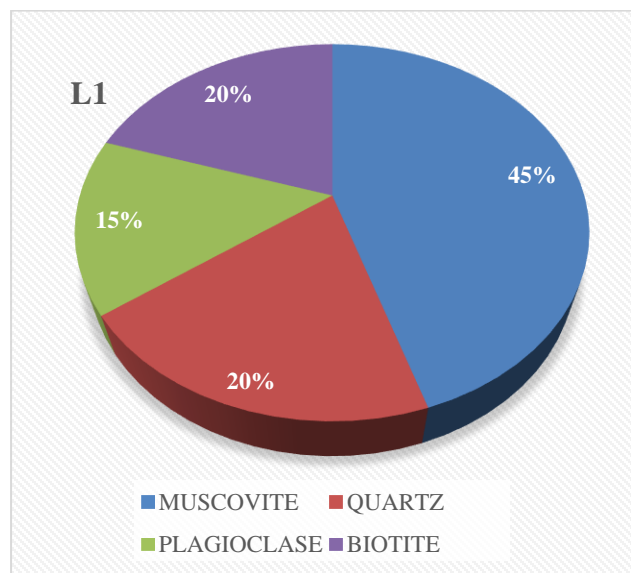


PPL-L3

**Figure 3.6: Photomicrograph of sample L3 under plane polarized light**

**Table 1.0: Estimated modal composition of lepidolite in the study area photomicrograph (L1-L3)**

MINERALS	L1 (%)	L2 (%)	L3 (%)	AVERAGE (%)
Quartz	20	25	20	22
Plagioclase	15	20	15	17
Biotite	15	-	10	10
Muscovite	45	50	55	55
Others	-	15	-	5



**Figure 3.7: Pie chart representation of modal composition of L1**

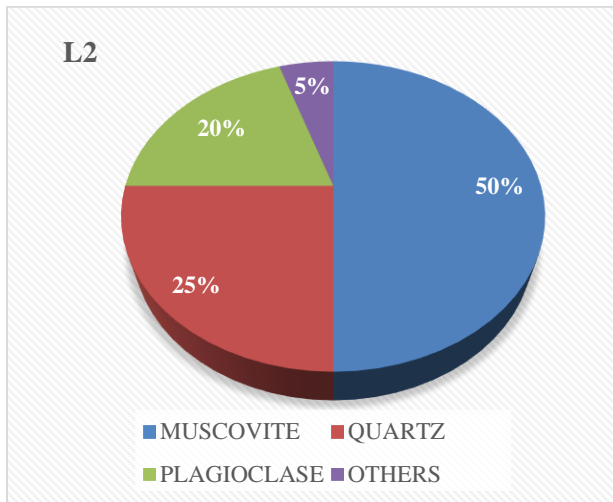


Figure 3.8: Pie chart representation of modal composition of L2

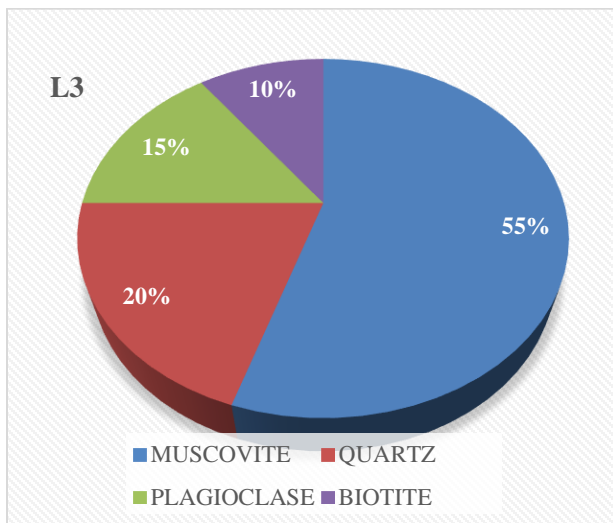


Figure 3.9: Pie chart representation of modal composition of L3

### 3.2. Discussion of Results

Energy geoscience plays a crucial role in the ongoing energy transition, particularly as pegmatite (granite) is recognised as the most significant type of crystalline-rock lithium deposit. Consequently, prospecting for lithium in lepidolite-pegmatite is more imperative than ever. The microscopic examination of the three representative samples (L1, L2, and L3) of lepidolite granite provides significant insights into the mineralogical composition and textural characteristics of these rocks, which are particularly relevant for understanding lepidolite mineralisation processes within the Basement Complex of Nigeria.

#### 3.2.1 Modal Composition and Mineral Identification

The modal composition presented in Table 1 indicates a notable variation in mineral content among the samples. The dominance of quartz, plagioclase, biotite, muscovite, and opaque minerals reflects the typical assemblage found in granitic rocks, particularly in regions influenced by metamorphic processes associated with the Basement Complex (Garrett, 2021).

Quartz constitutes an average of 38% of the studied rocks and is recognised for its resilience, as it is often the most abundant mineral in rocks of granitic compositions. Its anhedral grain shape and colourless appearance under plane polarized light (PPL) corroborate findings from similar studies, such as Filippov et al. (2022), which emphasise the stability of quartz in various geological settings. Plagioclase is identified by its characteristic grey colour and shows the presence of albite twinning under crossed polarized light (XPL). It constitutes an average content of 16% in the analysed samples. This mineral assemblage aligns with pegmatites of the Li-Cs-Ta family and supports recent classifications based on advanced mineralogical mapping (Garrett, 2021; Filippov et al., 2022). The variability in muscovite and biotite content reflects heterogeneity in crystallization environments, possibly linked to fluid enrichment events during pegmatite formation. The presence of opaque minerals, averaging 5%, may include cassiterite, columbite, or other accessory phases typical of evolved pegmatitic systems (Akinola et al., 2021).

The occurrence of micas such as biotite and muscovite, although minimal, is noteworthy. Biotite's light brown colour and pronounced pleochroism indicate its suitability for geothermometry, which can provide insights into the crystallisation and temperature conditions during granite formation.

#### 3.2.2 Optical Properties under PPL and XPL

The optical properties observed under PPL and XPL are essential for distinguishing between the various minerals present in the lepidolite granite. The birefringence and extinction angles observed in quartz and plagioclase suggest a complex history of deformation and recrystallization, potentially linked to tectonic activities in the Basement Complex of Nigeria (Adekeye et al., 2021).

The characteristic undulose extinction and low interference colours observed in quartz grains may indicate a history of stress and strain, consistent with the geological framework of the region, which has undergone multiple tectonic events. The identification of plagioclase twinning (i.e., albite twinning) reinforces the hypothesis of a dynamic thermal environment during crystallisation,

and the fine lamellae observed can provide insights into the cooling history of the granite (Diehl et al., 2020).

### 3.2.3 Implications for Lepidolite Mineralisation

The presence of lepidolite in the granite, although not quantified in the modal analysis, aligns with the understanding of lithium-bearing minerals in the Basement Complex of Nigeria. Given the global lithium demand, these mineralogical and textural features suggest promising exploration potential. Future investigations should focus on integrating geochemical assays and modern beneficiation methods to evaluate the economic viability of lithium extraction from these pegmatites (Liu et al., 2022; Wang et al., 2023). The mineralogical characteristics observed in this study suggest that these granitic rocks could represent viable sources for lithium extraction, particularly through advanced processing techniques as discussed in Filippov et al. (2022).

### 4.0. CONCLUSION

Lepidolite associated with granitic pegmatite mineralization within the Lema Pegmatite Field in north-central Nigeria has been studied through petrographic analysis. The results from the microscopic examination of the analysed lepidolite granite samples provide critical insights into the mineralogical composition and potential for lithium mineralisation. The significant presence of quartz and plagioclase, along with minor occurrences of micas (muscovite and biotite) and opaque minerals, indicates a complex geological history. This suggests the need for further exploration and characterisation of these rocks to assess their economic potential in supporting the ongoing energy transition. Future studies should focus on quantitative assessments of lepidolite and its lithium content, as well as the application of geochemical methods to evaluate the viability of these deposits in the context of global lithium demand.

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