

# Field Investigation Of Lithium And Associated Mineralization Potentials, Marafa Oja Environs, Kwara, North Central, Nigeria

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## Abstract

Global demand for lithium resources is increasing rapidly, primarily due to its essential role in modern industrial, aerospace, defense, and especially lithium-ion battery technologies. Despite this surge, the lithium mineralization within the Nigerian Basement Complex remains significantly underexplored. Africa is recognized as a continent rich in mineral resources, including lithium, which is commonly found in rare-metal pegmatites. Historically, these pegmatites were mined sporadically for tin and tantalum across various regions. In recent years, Africa has emerged as a major focus for mining companies and international investors participating in the global “race” for lithium—often referred to as “white gold.” Currently, Africa accounts for over 10% of the world’s lithium production, with deposits of varying sizes and ore grades identified in several countries. This study examined the lithological features and lithium enrichment prospects of the Marafa Oja area in Kwara State, North-Central Nigeria. The field investigation involved detailed mapping and sampling, with an emphasis on analyzing the relationships among different rock units to assess their mineralization potential. Based on the findings, the local geology was established, and possible zones of mineralization were identified. Four distinct lithologies were identified in the area: biotite granite gneiss, amphibolite/amphibole schist, medium-grained granite, and pegmatite veins. The primary structural trends within the tenement run approximately NE/SW, with secondary trends in the NW/SE direction. Through systematic mapping and targeted sampling of suspected ore-bearing rocks, the study found the area is highly prospective for pegmatite-hosted mineralization, especially for minerals like muscovite and tantalite. Further evidence of local mining activities, combined with structural interpretations and observable field signatures, highlights areas with the greatest potential for future exploration. Overall, the research underscores the significance of the Marafa Oja area as a promising target for lithium and rare-metal exploration within Nigeria’s broader mineral landscape.

**Keywords:** Lithium Occurrences, Pegmatites, Kwara, Volcanic Clay, Brine And Geothermal Deposit

## 1. INTRODUCTION

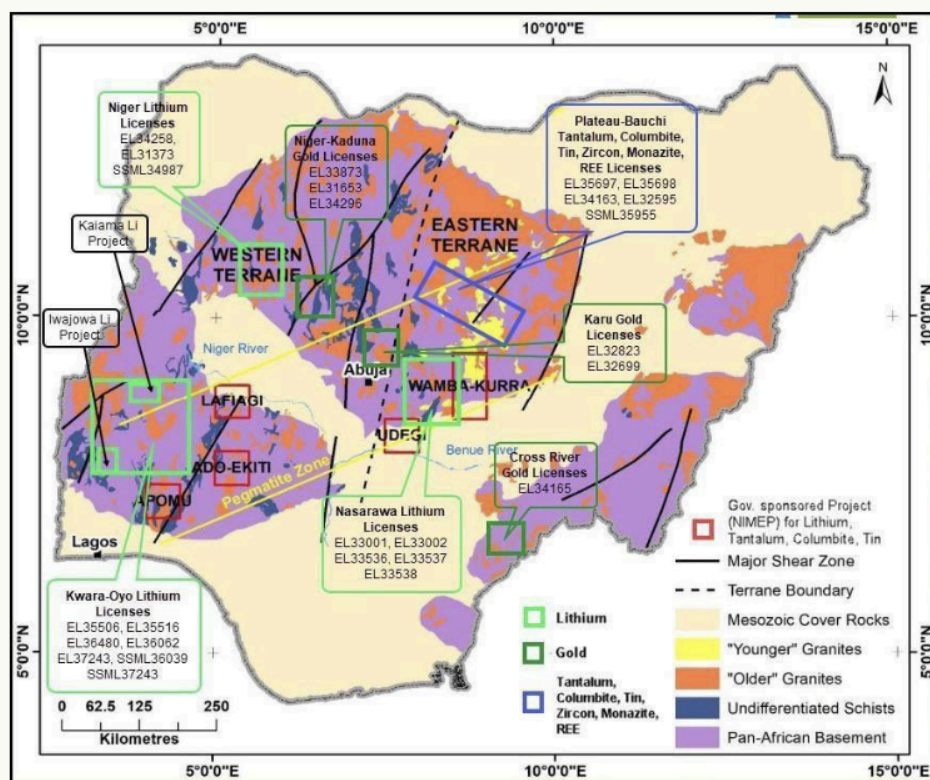
“The earth does not conceal metals in her depths because she does not wish that men should dig them out, but because provident and sagacious nature has appointed for each thing its place” (Agricola, *De Re Metallica*, 1556—translated by H. C. Hoover & L. H. Hoover, London, Mining Magazine, 1912).

Lithium (Li) is a soft, silvery-white alkali metal with the lowest density of all known solid metals in the periodic table under standard conditions on Earth (Rumble, 2025). In its pure form it is soft enough to be cut with a knife but is highly reactive and flammable in the presence of water or moisture. It therefore must be stored in vacuum, in an inert argon atmosphere (not nitrogen, which forms lithium nitride), or in inert liquid such as purified kerosene or mineral oil to prevent vigorous exothermic reaction with water (vapor) that forms highly flammable hydrogen (Rumble, 2025). When alloyed with other metals and used as a building block for pharmaceuticals, its unique properties make it essential for a wide range of applications (Kesler and Simon, 2015). Today, Li is chiefly used for manufacture of rechargeable batteries, yet these are only the latest in a long line of applications for Li (Emsley, 2011). It is used in some non-rechargeable batteries for applications including heart pacemakers, toys, and clocks (Thakur et al., 2025). Lithium oxide is used for manufacturing special ceramics and glass where it is used to control thermal expansion (Kesler and Simon, 2015). Lithium is also used to expand the usable temperature range of lubricating greases and improve water resistance (Delgado et al., 2006). Its natural hygroscopic properties also mean that Li is frequently used in industrial air conditioning and dehumidification systems (Kelley, 1938). Lithium is added to aluminum-base alloys for manufacture of aerospace materials, aircraft, bicycle frames, and high-speed trains to reduce their density and improve their response to stretching (tensile stress) and deformation (tensile strain) and increase fatigue-crack-growth resistance, and lithium-magnesium alloys are used for armor plating (Starke, Jr., 2014). Lithium and Li hydride are used as solid fuel and as high-energy additives to rocket propellants, and lithium hydride and deuteride serve as a fusion fuel in staged thermonuclear weapons (Simone and Bruno, 2012). Several psychiatric medicines also contain lithium compounds in the form of lithium salts, primarily for treating bipolar disorder and for major depressive disorder (Rybakowski, 2020). Economically viable deposits of lithium occur in three major categories: in pegmatites typically as the minerals spodumene and lepidolite; in volcanic clays as hectorite, montmorillonite and bentonite; and from brine and geothermal deposits which includes solar evaporates, playa lakes, and extracted subsurface brines from petroleum and geothermal production. Lithium, the lightest of metals, is a widely used critical industrial mineral. The USGS has classified Lithium as a critical mineral on the last several Critical Minerals lists (USGS, 2023a; USGS, 2023b). The crustal abundance of Lithium is 20-70 ppm by weight. It is usually found in granites, typically granitic pegmatites.

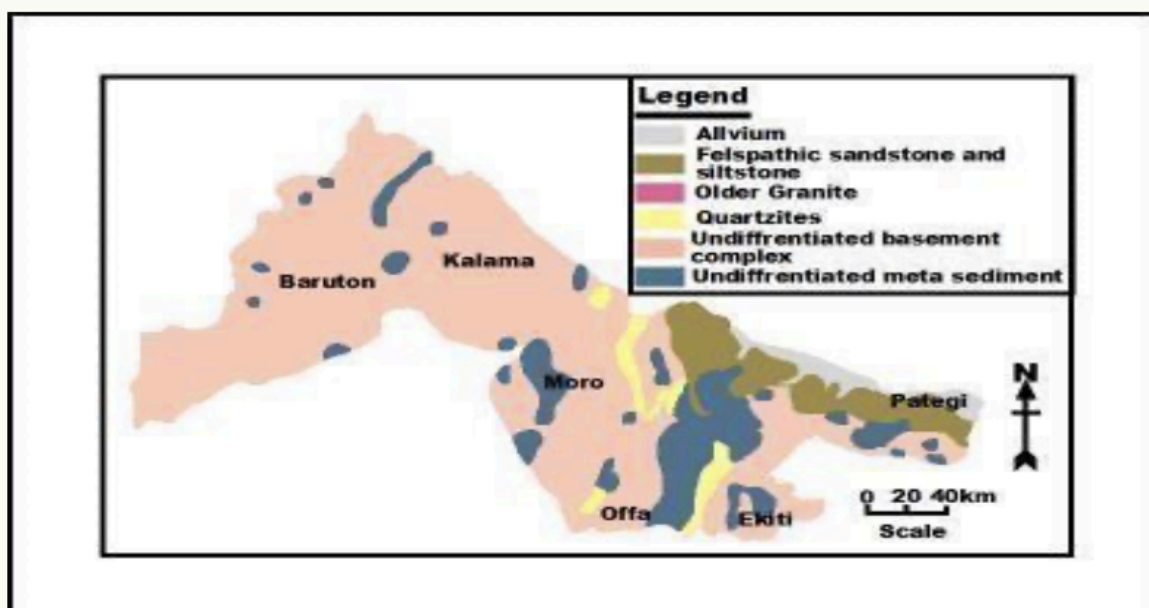
and lamprophyre dykes (Oyawoye, 1970; Rahman, 1988) (Fig. 1). The Pan-African pegmatites and the Older Granite intrusive 'Hardrock lithium' is the term used for lithium deposits found in igneous rocks and these account for roughly 25% of world production. The host rocks of these deposits are almost exclusively pegmatites, with minor occurrences in alkaline granites, leucogranites, aplites and quartz veins. Pegmatites are considered genetic and one of the world's most important sources of lithium. In Nigeria, rare-metal mineralization involving tin (Sn), niobium-tantalum (Nb-Ta), and lithium (Li) are found within two distinct geological environments (Matheis and Emeforieta, 1990): (1) The Jurassic Younger Granites, and (2) The Proterozoic-Paleozoic (Pan-African) pegmatites. Early Jurassic Granite complexes, rare-metal mineralization of mostly cassiterite (Sn) and columbite (Nb>>Ta) occur as hydrothermal veins, and disseminations in albitized biotite granites, with rare lithium and RREs in associated alkaline granites. In contrast the Proterozoic-Paleozoic mineralization of tantalite (Ta>Nb), in association with cassiterite (Sn) and lithium minerals, are found in Pan-African pegmatites. The two styles of mineralization are different (Kinnard, 1984). The Pan-African Older Granites are not known to be mineralized with rare metals. The

Pan-African pegmatites (550-430Ma) (Proterozoic- Paleozoic) are widely distributed within the Precambrian Basement Complex of Nigeria where they transect all the major rock units except the youngest quartz veins s have always been considered as related because they were both emplaced (with overlapping ages) during the widespread Pan-African collisional orogeny (Rahaman, 1988; Matheis, 1987; Matheis and Caen-Vachette, 1983).

**Figure 1: Geological Map of Nigeria Showing Major Rock Groups**



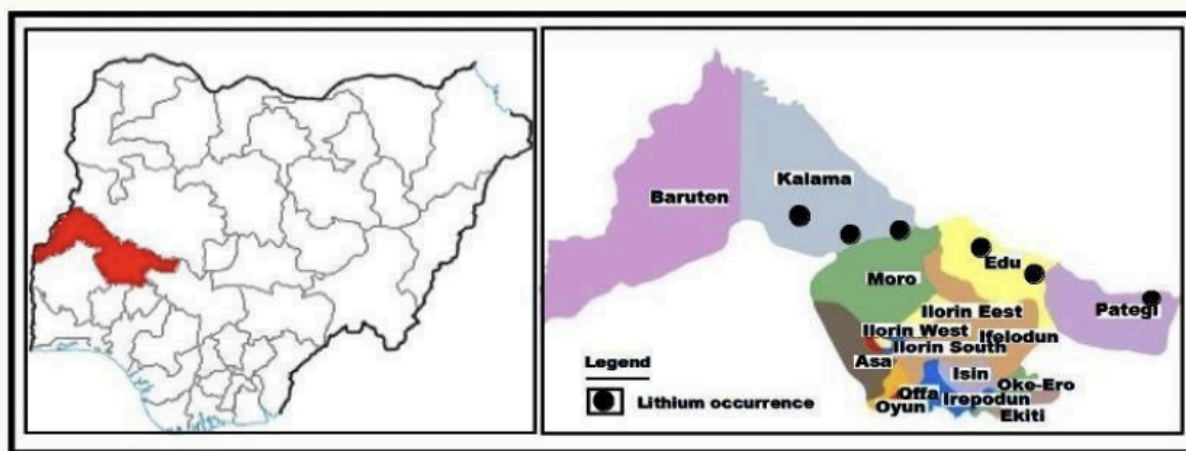
## 2. KWARA'S LITHIUM DEPOSITS



**Figure 2: Generalized geological map of Kwara State**

Kwara State lies immediately north of Oyo State and contains large lithium deposits in the central and northeast parts of the state (Fig. 2). In October 2023, the Nigeria Geological Survey Agency (NGSA) revealed the discovery of several "high-grade" lithium deposits in Kwara State, with ore grades ranging from 1 to 13%  $\text{Li}_2\text{O}$ . The geological setting of Kwara State is the same as that of other states in the southwestern region. It is predominantly underlain by rocks of the Archean gneiss-migmatite complex with isolated relics of supracrustal schist and amphibolite belts intruded in some places by Pan-African granites and pegmatites (Fig. 3). The lithium deposits are disseminations and mineral veins in the rare-metal pegmatites cutting various rocks, including mica schist, amphibolite, and gneiss, but mainly in the mica schist. Most of the mineralization is limited to three pegmatite districts:

(1) Kaiama-Bani, (2) Gbugbu-Lema and (3) Pategi-Share in Kaiama, Edu, and Pategi LGAs, respectively. Minor incidents were also reported in Oyun and Ifelodun LGAs (Figure 3).



**Figure 3: Location of Kwara State and Local Government Areas**

**Table 1. Main lithium minerals**

| Mineral         | Formula                                                                       | Remarks                                               |
|-----------------|-------------------------------------------------------------------------------|-------------------------------------------------------|
| Spodumene       | $\text{LiAlSi}_2\text{O}_6$                                                   | A number of the pyroxene group                        |
| Holmquistite    | $\text{Li}_2(\text{Mg,Fe})_3\text{Al}_2\text{Si}_8\text{O}_{22}(\text{OH})_2$ | A number of the amphibole group                       |
| Lepidolite      | $\text{K}(\text{Li,Al})_3(\text{Si,Al})_4\text{O}_{10}(\text{Fe,OH})_2$       | A number of the mica group (phyllosilicate)           |
| Polyolithionite | $\text{KLi}_2\text{AlSi}_4\text{O}_{10}(\text{Fe,OH})_2$                      | Another member of the mica group                      |
| Zinnwaldite     | -                                                                             | No longer recognized as a distinct mineral (see text) |
| Hectorite       | $\text{Na}_{0.3}(\text{Mg,Li})_3\text{Si}_4\text{O}_{10}(\text{OH})_2$        | Chlorite group                                        |
| Cookeite        | $(\text{LiAl}_2)\text{Al}_2(\text{AlSi}_3\text{O}_{10}(\text{OH})_8$          | Another phyllosilicate (sheet                         |

|               |                                                                                                                                           |                                                                                            |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
|               |                                                                                                                                           | silicate)                                                                                  |
| Eucryptite    | Li(AlSiO <sub>4</sub> )                                                                                                                   | A nesosilicate (like olivine) but related to phenakite (Be <sub>2</sub> SiO <sub>4</sub> ) |
| Amblygonite   | (LiNa)Al(PO <sub>4</sub> )(Fe,OH)                                                                                                         | Phosphate                                                                                  |
| Lithiophilite | LiMn(PO <sub>4</sub> )                                                                                                                    | Phosphate                                                                                  |
| Triphylite    | LiFe(PO <sub>4</sub> )                                                                                                                    | Phosphate                                                                                  |
| Elbaite       | Na(Li <sub>1.5</sub> Al <sub>1.5</sub> )Al <sub>6</sub> Si <sub>6</sub> O <sub>18</sub> (BO <sub>3</sub> ) <sub>3</sub> (OH) <sub>4</sub> | Tourmaline group                                                                           |
| Jadarite      | NaSiB <sub>3</sub> O <sub>7</sub> OH                                                                                                      | A recently discovered Li mineral                                                           |

### Characteristics of Nigerian Lithium

1. Commercial deposits first identified in 2018 in Kaduna State by a Chinese company
2. Found in Pan-African rare-metal pegmatites within Schist Belts but confined to the WNW-ENE trending Pegmatite metallogenic province. None in Older Granites
3. Lithium Pegmatites are numerous occurring in swarms as small bodies averaging 500 x100 x20 m in dimension
4. Mineralization is structurally controlled while lithium medium to coarse grained minerals occur as discrete crystals or felted masses.
5. Lithium concentrations in mineralized pegmatites are relatively high, ranging from <2% to as high as 8% Li<sub>2</sub>O (recommended cut-off grade is 0.4% Li<sub>2</sub>O).
6. The lithium are spodumene (Li pyroxene) which is dominant, and lepidolite (Limica), or a combination of both spodumene and lepidolite. Other reported minerals are amblygonite (Li phosphate) and petalite (Li-feldspathoid)

**Table 2. Lithium Ore Deposits in Nigeria (MMSD, 2022)**

| Deposits              | State    | Associated minerals     |
|-----------------------|----------|-------------------------|
| Panda                 | Nasarawa | Pegmatite               |
| Wamba                 | Nasarawa | Quartzite               |
| Kabba                 | Kogi     | Quartzite               |
| Kushaka, Birnin Gwari | Niger    | Pegmatite/Petalite      |
| Isanlu Egbe           | Kogi     | Pegmatite               |
| Ilesha                | Osun     | Pegmatite               |
| Ijero Aramoko         | Ekiti    | Pegmatite               |
| Arikyia Tsauni        | Nasarawa | Pegmatite and Quartzite |
| Kafin Maiyarki        | Nasarawa | Granite                 |
| Itakpe Area           | Kogi     | Quartzite and Pegmatite |
| Oke Ogun              | Oyo      | Quartzite               |

|                     |          |                       |
|---------------------|----------|-----------------------|
| Ago Iwoye           | Ogun     | Pegmatite             |
| Hong                | Adamawa  | Lepidolite/Kunzite    |
| Zuru                | Zamfara  | Petalite              |
| Kafanchan           | Kaduna   | Spodumene/Kunzite     |
| Lere                | Kaduna   | Petalite              |
| Jos- South          | Plateau  | Quartzite/Lapidolite  |
| Ganjuwa             | Bauchi   | Lithium Oxide/ Lithia |
| Gidan Boda, Baruten | Kwara    | Spodumene             |
| Keffi               | Nasarawa | Lepidolite            |

### 3. OCCURRENCES OF LITHIUM ORE

Lithium occurs in three (3) major categories (Table 1 and 3)

- i. Pegmatites typically have the minerals spodumene and lepidolite.
- ii. Volcanic clays such as hectorite, montmorillonite, and bentonite (sedimentary rocks).
- iii. Brine and geothermal deposits, which include solar evaporates, playa lakes, and extracted subsurface brines from petroleum and geothermal production.

#### 3.1 Pegmatites deposits:

The classification of coarse- to fine-grained granitic pegmatites containing Li-bearing minerals such as spodumene, lepidolite, and petalite (Table 3) has varied within the geologic literature over the past century. Currently, the most-used classification scheme is that of Černý (1991) and Černý and Ercit (2005), who divide pegmatites into families and classes based on variations in the temperatures and depths of pegmatite emplacements. In this scheme, pegmatites containing Li-bearing minerals belong to the LCT family and occur within abyssal, miarolitic, and rare element classes (Černý and Ercit, 2005). Müller et al. (2022) point out that this methodology, though widely used, is not ideal, because it relies on prior knowledge of pressure-temperature conditions of pegmatite emplacement for classification, which may not be known for a given pegmatite. Because of this and other ambiguities associated with the Černý and Ercit (2005) classification scheme, Wise et al. (2022) presented a new framework to divide pegmatites into three groups based on the composition of accessory minerals present in pegmatites. Under this new scheme, pegmatites containing Li-bearing minerals are all classified as “group 1” pegmatites that are not dependent on genetic conditions for classification, as it is noted that Li-bearing minerals in pegmatites can form at a variety of temperatures and pressures as either residual melts of granitic magmatism or direct products of anatexis

**Table 3: Names and Formulas of Key Lithium-Bearing Minerals**

| <u>Mineral</u> | <u>Deposit type</u> | <u>Formula</u>                                                                                               |
|----------------|---------------------|--------------------------------------------------------------------------------------------------------------|
| Amblygonite    | P                   | (Li,Na)AlPO <sub>4</sub> (F,OH)                                                                              |
| Cookeite       | VS, P               | LiAl <sub>4</sub> (Si <sub>3</sub> Al)O <sub>10</sub> (OH) <sub>8</sub>                                      |
| Elbaite        | P                   | Na(Li,Al)Al <sub>6</sub> (Si <sub>6</sub> O <sub>18</sub> )(BO <sub>3</sub> ) <sub>3</sub> (OH) <sub>4</sub> |
| Eucryptite     | P                   | LiAlSiO <sub>4</sub>                                                                                         |

|                       |        |                                                                                                                        |
|-----------------------|--------|------------------------------------------------------------------------------------------------------------------------|
| Hectorite             | VS     | $\text{Na}_{0.3}(\text{Mg},\text{Li})_3\text{Si}_4\text{O}_{10}(\text{OH})_2$                                          |
| Illite <sup>1</sup>   | VS, P  | $(\text{K},\square)(\text{Mg},\text{Li})_3(\text{Si}_4\text{O}_{10})(\text{F},\text{OH})_2$                            |
| Jadarite              | VS     | $\text{LiNaSiB}_3\text{O}_7(\text{OH})$                                                                                |
| Lepidolite            | P, RMG | $\text{K}(\text{Li},\text{Al})_3(\text{Si},\text{Al})_4\text{O}_{10}(\text{F},\text{OH})_2$                            |
| Lithiophilite         | P      | $\text{LiMnPO}_4$                                                                                                      |
| Montebrasite          | P      | $\text{LiAlPO}_4(\text{OH},\text{F})$                                                                                  |
| Petalite              | P      | $\text{LiAlSi}_4\text{O}_{10}$                                                                                         |
| Polyolithionite       | P      | $\text{KLi}_2\text{AlSi}_4\text{O}_{10}\text{F}_2$                                                                     |
| Smectite <sup>1</sup> | VS     | $(\square,\text{Ca})(\text{Mg},\text{Li})_3(\text{Si}_4\text{O}_{10})(\text{OH},\text{F})_2 \cdot n\text{H}_2\text{O}$ |
| Spodumene             | P      | $\text{LiAlSi}_2\text{O}_6$                                                                                            |
| Swinefordite          | P      | $\text{LiMg}_2(\text{Si},\text{Al})_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$                             |
| Tainiolite            | P, VS  | $\text{KLiMg}_2\text{Si}_4\text{O}_{10}\text{F}_2$                                                                     |
| Triphylite            | P      | $\text{Li}(\text{Fe},\text{Mn})\text{PO}_4$                                                                            |
| Zabuyelite            | CBB, P | $\text{Li}_2\text{CO}_3$                                                                                               |
| Zinnwaldite           | P, RMG | $\text{KLiFeAl}(\text{AlSi}_3)\text{O}_{10}(\text{F},\text{OH})_2$                                                     |

Abbreviations: CBB = closed-basin brine, P = pegmatite, RMG = rare metal granite, VS = volcano-sedimentary <sup>1</sup>Formula based on Thacker Pass Li smectite and Li illite from Emproto et

### 3.2 Sedimentary deposits:

Sedimentary lithium deposits are found as accumulations of lithium-rich clays in lacustrine sediments and evaporites, and volcanogenic clays formed by hydrothermal leaching and weathering of rhyolitic tufts and volcanoclastics (Bowell et al., 2020; Balaram et al., 2024). Lithium is found within smectites (illite and hectorite) and fine-grained lepidolite, in which lithium is contained within the smectite lattice and absorbed ions on the surfaces. Several large deposits of volcanogenic clays containing low-grade lithium have recently been discovered in Serbia and Nevada, USA (Balaram et al., 2024). Clay or sedimentary deposits account for approximately 9% of known global lithium resources. (Fig. 5). The leading producers of sedimentary lithium ores are China, Russia, Serbia, and the United States. In Africa, few or no lithium resources are derived from sedimentary deposits except for lithium-bearing alluvial clays in the Manono-Kitolo areas of Katanga Province in the DRC (Dewaele et al., 2016). However, there are reports of lithium-enriched volcanic clays in the Tertiary East African rifts in Tanzania, where volcanic rocks have yielded 1.76%  $\text{Li}_2\text{O}$ , with residual soils containing up to 0.2%  $\text{Li}_2\text{O}$  (Putzolu et al., 2025).

### 3.3 Salt brine deposits:

These deposits consist of saline water from saltwater lakes and saltwater flats containing soluble carbonate, hydroxide, and chloride salts of lithium, oil field water, and geothermal brine. They contribute approximately 68% of global lithium production and are formed by the evaporation of saltwater in arid regions. The source of lithium is believed to be the leaching of shales and volcanics in adjoining sedimentary basins. The world's leading producers of saltwater lithium are the three "lithium triangle" states: Argentina, Chile, Bolivia, and China. Although there is currently no known saltwater lithium

occurrence in Africa, there is a good chance of finding it in areas within the East African Rift System with carbonate salts and salt pan, such as the Danakil Depression in Ethiopia, the Makgadikgadi Salt Pan in Botswana and the Chott salt pans of the Saharan region of eastern Algeria (Zatout et al., 2020).

#### 4. REGIONAL GEOLOGIC SETTING

The area of study is typical of the Nigerian Basement Complex (NBC) which covers approximately 60% of the Nigerian landmass. The Basement Complex has been described by various authors (Burke and Dewey 1972; Rahaman 1988; Annor and Freeth 1985; Odeyemi 1988; Annor et al 1995) as a complex rock assemblage which includes migmatites, gneisses, quartzites, para-schists and a series of basic to ultrabasic metamorphosed rocks which have been intruded by Pan African Granites and other late in-fills and intrusions such as pegmatite and aplite dykes and veins, quartz veins and extrusive diorites and dolerites.

The Basement Complex rocks have been broadly divided into four lithological units namely;

- i. The migmatite-gneiss complex with ages ranging from Archean (>3000Ma)- Liberian ( $\pm 2800$ m.y). Grant (1971), Black (1980) and Dada (1998);
- ii. the metavolcano sedimentary belt which is essentially made of the schists of low-grade metasediments of greenschist facies of Proterozoic age
- iii. the syntectonic to late tectonic granitoids of Precambrian to Lower Palaeozoic age which intrude both the gneiss complex and the schist belt and
- iv. Unmetamorphosed felsic and mafic dykes believed to be the youngest.

The topography of the study area is a reflection of the general landform of Kwara state. These are marked by moderately elevated tors, inselbergs and hills which are usually represented by granites, gneisses and occasionally quartzites which are prominent within the Basement Complex rocks. The natural vegetation is of rain forest belt with evidence of rich deciduous and occasional stunted trees including palms, Iroko, mahogany and other towering trees. These are green in the rainy season with fresh leaves and tall grasses but the land is open during the dry season showing charred trees and remains of burnt trees.

Climatically, there are two distinct seasons (rainy season and dry season); rainy season which spans about five months (March- October) and the dry season between the months of November and early March. The annual rainfall is between 1100mm-1260mm with a mean 1180mm (Odjugo 2009) while annual mean temperatures vary between 30°C -35°C.

#### 5. MAPPING METHODOLOGY

The field work was preceded by desk study of remotely sensed datas such as the satellite images, radiometric data, aeromagnetic data and topographical map. These datasets were processed, interpreted and integrated in a GIS environment. The mapping exercise commenced The main method adopted was through traversing; by walking along a line of more or less predetermined route from one point on the map to another, plotting the geology along the way. It's a method of keeping track of our progress across the study area. (*Stream traverse, road-cut traverse inclusive*). Other methods adopted were by following contacts (*especially areas where rocks are well exposed*), observing changes in soil which is an indication of change in lithology, also noticing man- made excavation, pitting, trenches etc.

Global Positioning System (GPS) (fig 4) was used to accurately locate position of exposures on the field map and at each outcrop location, the following observations were made; description of location, size of exposure, field relationship, rock type (*field name*), possible/visible mineralization, texture, colour, dip and strike direction, degree of weathering , coordinates, etc.

Representative rock samples were collected and properly labelled for further studies and possible mineral analysis (for samples with a possible deposit of an economically viable mineral). Appropriate pictures were taken with a scale of reference at each location.

Tools used for the geological mapping exercise include: GPS (global positioning system), sample bags, compass clinometer, geologic hammer, permanent marker, writing tools, field notes, digital camera, hand lens, reflective jackets, safety goggles and safety boots.



**Figure 4: Materials used in field study**

### 5.1 Field Relationship

The investigated area as earlier mentioned is typical of the Basement Complex of Nigeria and in the course of the mapping exercise, the following rock units were identified:

1. Biotite Granite Gneiss
2. Amphibolite/Amphibolite Schist
3. Medium-grained Granite
4. Pegmatite/Quartzo-feldspathic vein

### 5.2 Biotite Granite Gneiss

This unit was encountered severally and seems to be the dominant outcrop within the study area. They occur as low-lying and bouldery exposures of varying sizes. The rock in general is medium grained in texture, light grey in color. Most exposures are mixtures of weakly foliated and foliated variety in varying proportions. Most of the exposures show a transition between the granite and the gneiss. The foliation is marked by continuous mineralogical bandings on a millimetric to centimetric scale. The light-colored bands vary in widths and are rich in quartz and feldspars while the dark colored bands are rich in biotite and other ferromagnesian minerals. Some of the bands especially in the weakly foliated types are wavy and discontinuous. The general trend is NNE/SSE to NE/SW (fig.5 and 6). Mineralogically; the granite gneiss is composed mainly of quartz, plagioclase, biotite and some other mafic minerals.



**Figure 5: showing low lying exposure of granitic gneiss @ N 08 34' 33.2", 04 54' 48"E. (024 - strike of foliation).**



**Figure 6: showing low lying exposure of grey gneiss @ N 08 35' 33.4", 04 55' 18.8"E. (018/40W).**

### 5.3 Amphibolite/Amphibole Schist

The occurrence of amphibolite was observed at the southern part of the study area being surrounded by the granites (fig.7) It occurs as a low lying to bouldery, well foliated outcrop. It is fine to medium grained and exhibits a distinctive greenish coloration which is a pure indication of the presence of a high amount of ferromagnesian minerals such as amphiboles over the felsic ones.

The amphibole schist was encountered towards the centre portion of the study area occurring as low lying exposure, well foliated which is defined by its schistosity as seen in figure 5a with a general trend of NNE/SSW and dips westwards.



**Figure 7a: showing low lying exposure of amphibole schist @ N 08 34' 00", 04 55' 8.7"E. (014/50W) and Figure 7b showing bouldery outcrop of greenish amphibolite @ N 08 32' 41.9", 04 54' 2 8.2"E**

### 5.4 Medium-grained Granite

As part of the Older granite suite, this unit was encountered at the southern part of the study area with varying modes of occurrences from low lying to bouldery and domed-shaped bodies. They are generally grey to light grey in colour with fine to medium grained in texture. In hand specimen, it is composed of feldspar, quartz, biotite and probably hornblende as some accessory minerals observed such as garnets. The feldspar content varies from plagioclase to orthoclase depending on location (fig. 8). Its field

relationship with other rock types shows that it must have intruded on the gneisses and the amphibolites.



**Figure 8a: a low lying - bouldery exposure of granitic rock @ N 08 34' 55.4", 04 53' 26.5"E. Figure 8b: a close view of granite showing the garnet crystals @ N 08 32' 41.9", 04 54' 28.2"E. Figure 8c granite exposure with unit structure as a result of weathering @ N 08 33'27", 04 55'30.6"E.**

### 5.5 Pegmatites/Quartzo-feldspathic veins

In the course of this exploration mapping, pegmatites are the main targets owing to the fact that they play host to the mineral(s) of interest to this investigation. They are exceptionally coarse-grained igneous rock with interlocking crystals usually found in irregular dykes, lenses or veins. Their composition is generally that of granite and may be simple or complex and may include rare minerals rich in such elements as lithium, boron, fluorine, niobium, tantalum, uranium and rare earths. Pegmatites represent the last and most hydrous portion of magma to crystallize and hence contain high concentrations of minerals present only in trace amounts in granitic rocks.

Within the study area, pegmatites were encountered mainly as veins within the country/host rocks such as

the gneisses and granites. Their extent of exposures varies from centimeters to meters both in length and width. The vein direction of the pegmatites encountered varies from NE/SW to NW/SE.(fig.9)



Figure 9: low lying exposures of some pegmatite veins in varying directions

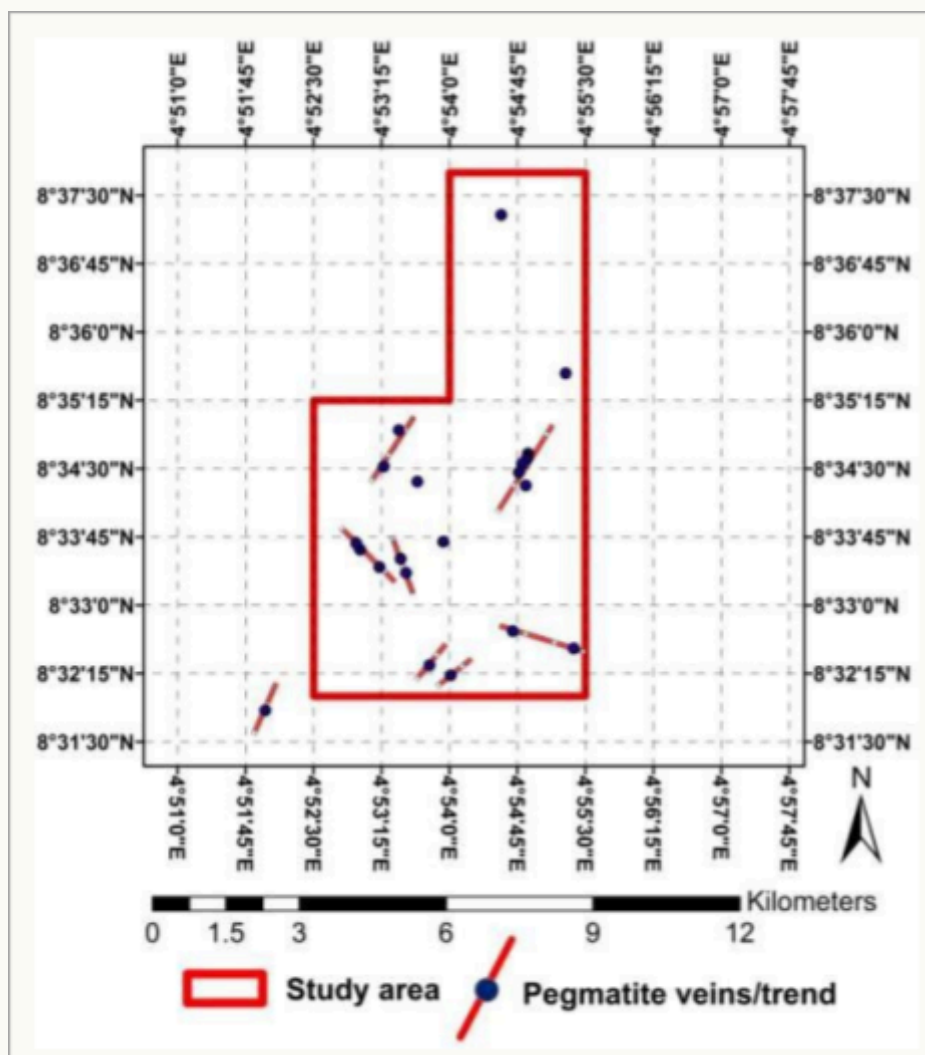


Figure 10. Map showing the pegmatite vein exposures in varying directions.

## 6. RESULT AND DISCUSSION

Having traversed the length and breadth of the tenement area, the investigated site is in no doubt highly prospective for pegmatite-hosted mineralization, especially muscovite and tantalite towards the southern half of the tenement. Apart from several desk study and airborne data interpretations previously carried out, evidence of local activities within and around the tenement coupled with some field signatures reveals areas that are most prospective, which have been marked for further exploration work with the help of geochemical analysis from selected samples.

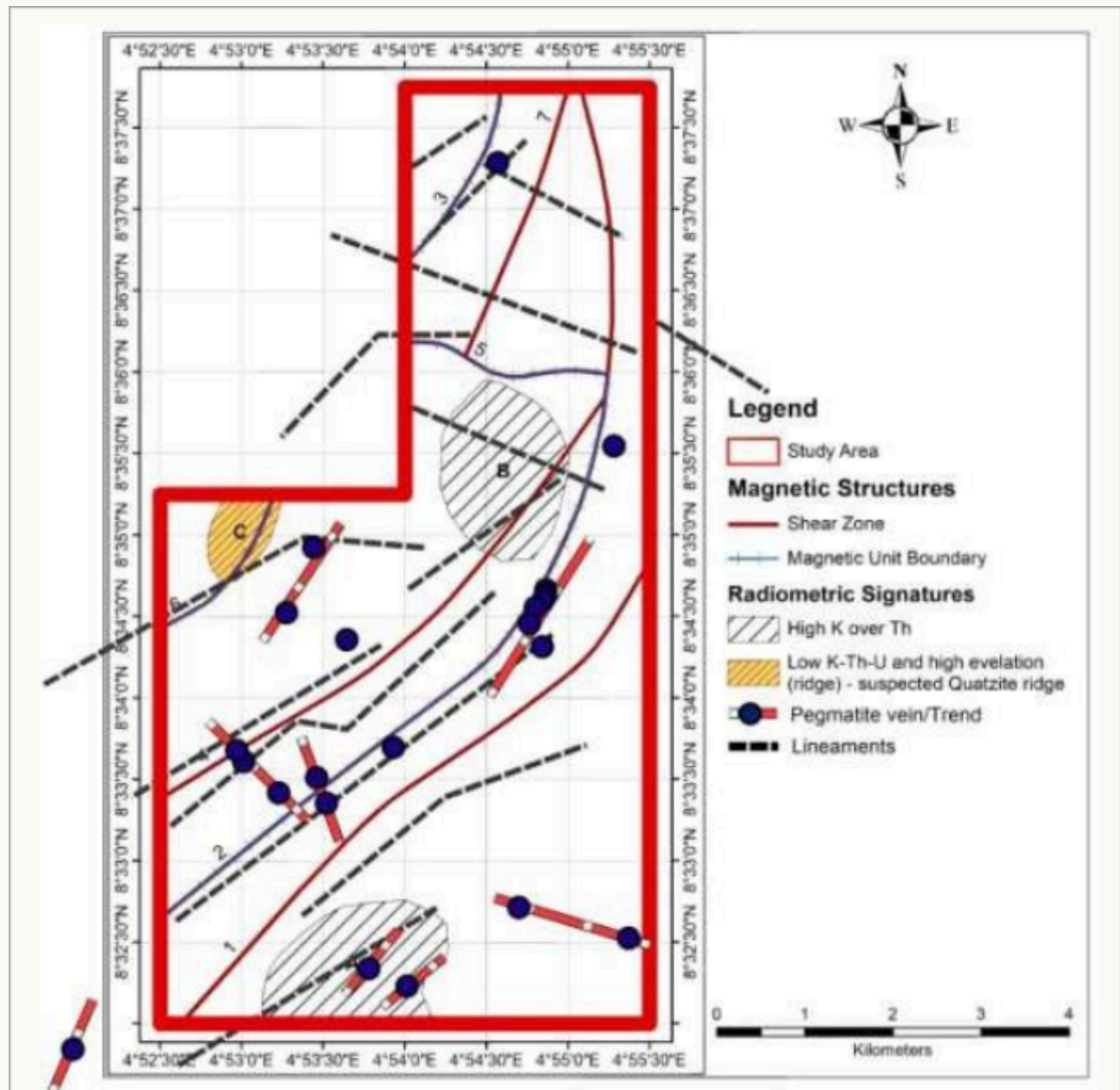
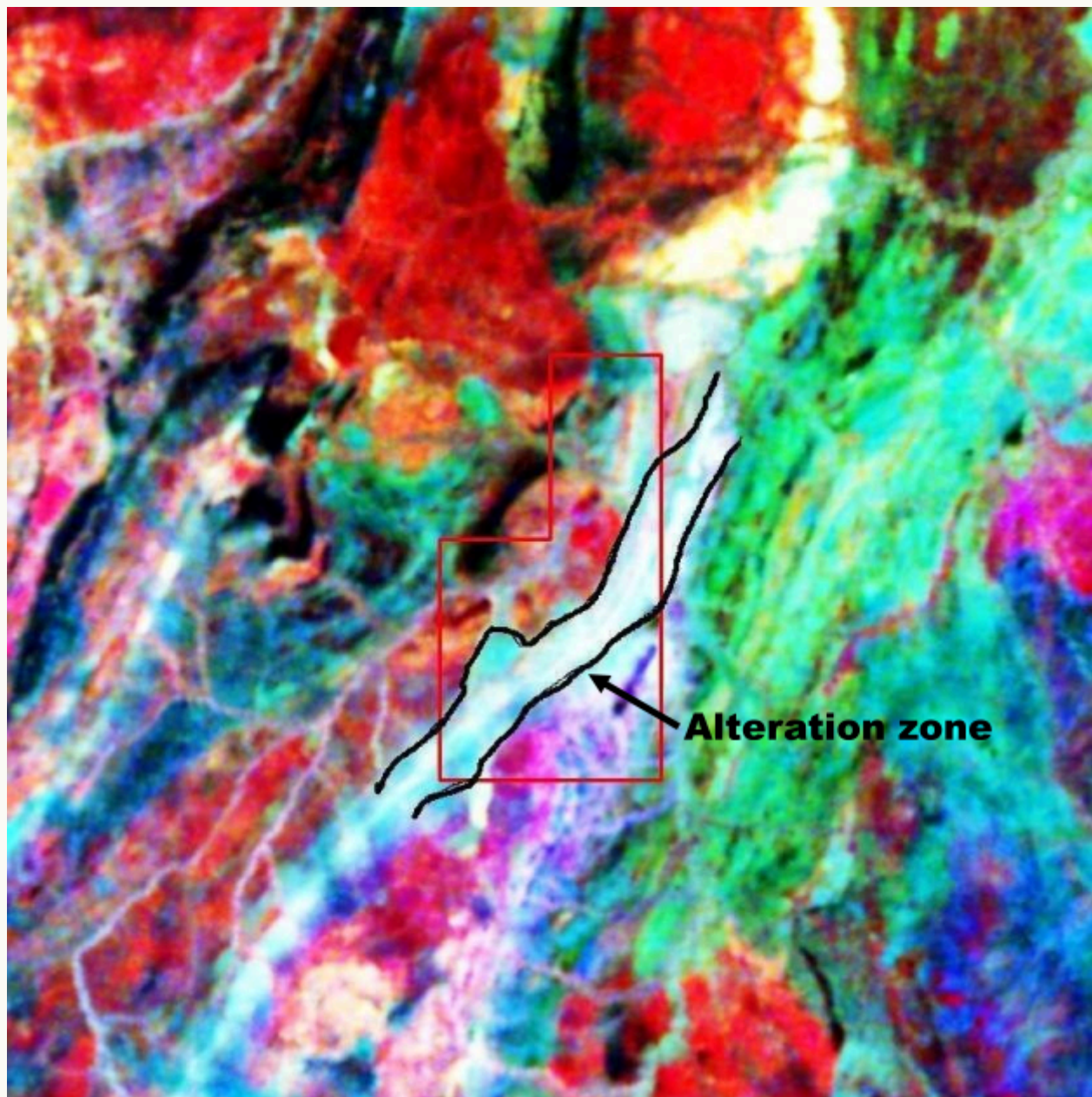


Figure 11: Map showing airborne interpreted structures with superimposed pegmatite outcrops



**Figure 12: Ternary map showing the study area.**

Interpreted structures from the airborne magnetic and radiometric data (figures 11 and 12) show a ground confirmation, as most of the pegmatite veins align with the structure. It's also interesting to know that the zone of alteration from the radiometric map falls within the area where extensive and lengthy pegmatite vein was encountered within the tenement

## References

- Agricola, G., & Smoluchowski, L. (1951). De re metallica. *Physics Today*, 4(6), 22-22.
- Balaram, V., Santosh, M., Satyanarayanan, M., Srinivas, N., Gupta, H. (2024). Lithium: A review of applications, occurrence, exploration, extraction, recycling, analysis, and environmental impact. *Geoscience Frontiers*, 15(1), 101868.
- Bowell, R. J., Lagos, L., de los Hoyos, C. R., Declercq, J. (2020). Classification and characteristics of natural lithium resources. *Elements*, 16, 259–264

- Delgado, M.A., Valencia, C., Sánchez, M.C., Franco, J.M. and Gallegos, C., 2006, Thermorheological behaviour of a lithium lubricating grease: *Tribology Letters*, v. 23, p. 47–54
- Dewaele, S., Hulsbosch, N., Cryns, Y., Boyce, A., Burgess, R., Muchez, P. (2016). Geological setting and timing of the world-class Sn, Nb-Ta and Li mineralization, Manono-Kitotolo (Katanga, Democratic Republic of Congo). *Ore Geology Reviews*, 72, 373–390.
- Dewey, J. F., & Burke, K. (1974). Hot spots and continental break-up: implications for collisional orogeny. *Geology*, 2(2), 57-60.
- Emsley, J., 2011, *Nature's building blocks: An A-Z guide to the elements*, 2nd ed.: New York, Oxford University Press, 699 p
- Kelley, G.A., 1938, Air-conditioning with lithium chloride: *Journal of the Society of Motion Picture Engineers*, v. 30, p. 422–431.
- Kesler, S.E., and Simon, A.C., 2015, *Mineral resources, economics, and the environment*: Cambridge Press, <https://deepblue.lib.umich.edu/handle/2027.42/192747>.
- Kinnaird J.A 1984 Contrasting styles of SnNb-Ta-Zn mineralization in Nigeria. *J. Afr. Ear. Sci.* 2(2): 81-90.
- Matheis, G. 1987. Nigerian rare-metal pegmatites and their lithological framework. *Geological Journal*, 22(S2), 271–291.
- Matheis, G. and Caen-Vachette, V. 1983. Rb-Sr isotopic study of rare metal bearing and barren pegmatites in the Pan African reactivation zone of Nigeria. *Journal of African Earth Sciences* 1: 35-40.
- Matheis G, Emofurieta W.O. (1990). The Older Tin province rare-metal pegmatite in Nigeria. Technical University of Berlin (West) Special Research Project on Arid Areas and University of Ife, Nigeria, 10pp.
- Müller, A., Simmons, W., Beurlen, H., et al., 2022, A proposed new mineral-ogical classification system for granitic pegmatites—part I: History and the need for a new classification: *The Canadian Mineralogist*, v. 60, p. 203–227, <https://doi.org/10.3749/canmin.1700088>
- Putzolu, R. N., Armstrong, T. R., Benson, D. F., Boutt, K. L., Butler, A., Dolgoplova, R. J., Herrington, D. E., Ibarra, L. A. M. (2025). Volcano-sedimentary deposits: Overview of an emerging type of lithium resource. *Economic Geology*, 120(3), 541–573
- Rahaman, M. A. (1988) Recent advances in the study of the Basement Complex of Nigeria,” In: P. O. Oluyide, W. C. Mbonu, A. E. Ogezi, I. G. Egbuniwe, A. C. Ajibade and A. C. Umeji, Eds., *Precambrian Geology of Nigeria*, Geological Survey of Nigeria, Kaduna, 1988, p. 11-43.
- Rahaman, M. A. (1988) Recent advances in the study of the Basement Complex of Nigeria." In: P. O. Oluyide, W. C. Mbonu, A. E. Ogezi, I. G. Egbuniwe, A. C. Ajibade and A. C. Umeji, Eds., *Precambrian Geology of Nigeria*, Geological Survey of Nigeria, Kaduna, 1988, p. 11-43
- Rumble, J., ed., 2025, *Handbook of chemistry and physics*: Boca Raton, CRC Press, 1650 p.
- Rybakowski, J.K., 2020, Lithium—past, present, future: *International Journal of Psychiatry in Clinical Practice*, v. 24, p. 330–340
- Simone, D., and Bruno, C., 2012, Preliminary investigation on lithium hydride as fuel for solid-fueled scramjet engines: *Journal of Propulsion and Power*, v. 25, no. 4, p. 875–88
- Starke, Jr., E.A., 2014, Historical development and present status of aluminum-lithium alloys, in Eswara

- Prasad, N., Gokhale, A.A., and Wanhill, R.J.H., eds., Aluminum-lithium alloys: Boston, Butterworth-Heinemann, p. 3–26
- Thakur, J., Phogat, P., Shreya, S., Jha, R., and Singh, S., 2025, Non-rechargeable batteries: A review of primary battery technology and future trends Physical Chemistry Chemical Physics, <https://doi.org/10.1039/D4CP04614E>
- The USGS 2023 conterminous US time-independent earthquake rupture forecast. *Bulletin of the Seismological Society of America*, 114(1), 523-571.
- Zatout, M., Steinmetz, R. L. L., Hacini, M. Fong, B. S. (2020). Saharan lithium: Brine chemistry of Chotts from eastern Algeria. *Applied Geochemistry*, 115
- Černý, P., and Ercit, T.S., 2005, The classification of granitic pegmatites revisited: The Canadian Mineralogist, v. 43, p. 2005–2026
- Černý, P., 1991, Rare-element granitic pegmatites. Part I: Anatomy and internal evolution of pegmatite deposits: Geoscience Canada, v. 18, p. 49–67.



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