DOI: HTTPS://DOI.ORG/10.57233/IJSGS.V11I1.780 ISSNP: 2488-9229; ISSNE: 3027-1118

IJSGS FUGUSAU VOL.11(1) WEBSITE: https://fugus-ijsgs.com.ng

INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL SUSTAINABILITY
(A PUBLICATION OF FACULTY OF SCIENCE, FEDERAL UNIVERSITY GUSAU, NIGERIA)

Geology of Basement Complex rocks in Kabo area, Kano, Northwestern Nigeria: Insights into the Trends of Mineralization in the Region

Mutari Lawal[1,2*], Mohammed Abubakar Mohammed[1], Kehinde Ayomikun Alalade[2], Hassan Hamidu[2], Ahmad Mahi Shuaibu[4], Nura Abdulmumini Yelwa[2], Yunusa Adinoyi Omanayin[3], Fareed Salman-Adeniyi[5]

[1]Department of Geology, Faculty of Science, University of Abuja, P.M.B. 117, FCT Abuja, Nigeria.
[2]Department of Geology, Faculty of Physical and Computing Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria
[3]Department of Geology, School of Physical Sciences, Federal University of Technology, Minna, Nigeria
[4]Department of Geology, Federal University Lokoja, Nigeria
[5]Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria, Nigeria

***Corresponding Author's email address:** mosalah1733@gmail.com

Received on: January, 2025 **Revised and Accepted on:** February, 2025 **Published on:** March, 2025

ABSTRACT

Nigeria is situated in a mobile zone separating older cratons of West Africa and Gabon, and underlain by nearly equal proportions of sedimentary and crystalline rocks. The crystalline basement rocks comprises three lithological groups (the Basement Complex, the Younger Granites and the Tertiary-Recent Volcanics) that were affected by Pan African (~550 Ma) thermo-tectonic events. The Basement Complex (Precambrian) encompasses gneisses- and migmatite-complex with schist belts, granites and minor charnokites and syenites with complex history and geochronology. In Kano (Kabo NE, Sheet 80 of Nigerian Geological Survey Agency maps) NW Nigeria, outcrops of these late Precambrian – lower Paleozeoic crystalline rocks are being mined of economic minerals. However, only a few studies exist on the geology of Kabo region. Therefore, this study describes the geology (lithology, composition, associated structures and field relationship) of rocks that characterize Kabo region, Kano and discuss trends of associated mineralization using field mapping and thin section petrography. Our data also includes high-resolution photographs of evidential geology of the area, parts of which are now defaced due to intense mining activities. Results showed that Kabo area is underlain by three rock groups: a migmatite-gneiss complex, an infolded schist belt (Younger Metasediments) and the Older Granites (porphyritic biotite granites, porphyroblastic biotite-rich gneiss and fine-medium grained granites). The porphyroblastic biotite-rich gneisses of the Older Granite division trend mainly in NE-SW and cut through the migmatite-gneiss complex; they exhibit preferred mineral alignment, suggesting that they are probably granitization products of the migmatite-gneisses, later metamorphosed and deformed. The granitized bodies are enriched in tourmaline that occur both in the NE-SW porphyroblastic rocks and the schist belt. The study thus serves as guide for investment decisions on solid mineral exploration in the area, and as a handbook for students of geology and tourists who now find Kano as a relatively safe geoheritage site.

Keywords: Basement Complex, Northern Nigeria, Kano

1.0 INTRODUCTION

1.1 Background

Nigeria is situated in a mobile zone separating older cratons of West Africa and Gabon, and underlain by nearly equal proportions of sedimentary and crystalline rocks (McCurry, 1971; Ajibade and Wright, 1989; Ajibade, 2016; Lawal *et al*., 2017; Ejiga *et al*., 2022; Ominigbo, 2022; Omanayin *et al*., 2023; Lawal and Hassan, 2023; Akintoye *et al*., 2023; Abdulmalik and Ahmed, 2024). The Basement Complex includes igneous and metamorphic rocks of Precambrian age that cover about half of Nigeria, dividing Nigeria into North and South "geologically". Basement complex rocks are important elements for consideration not just for their mineralization potentials but also because they act as container for sedimentary basin fills, parents of particles that constitute sediments found in the basins, and their associated structural processes also influence the architecture of depositional basins during the Phanerozoic time in Nigeria.

The focus of this study is on the Northern Basement rocks Kano, northwestern Nigeria. The area has become very attractive for geological mapping because it commands relative safety (in terms of security), contain good outcrops, with significant potential for mining of solid minerals e.g., tantalite, tourmaline and granite. In addition to mining potentials, Kano region, Kabo (NE-NW Sheet 80 map series of the NGSA) in particular, comprises migmatite-gneiss with infolded schists and the "Older Granites" with evidence of the Pan-African orogeny, albeit with complex geochronology. Erosion was postulated to have affected much of Nigeria during the early Paleozoic – late Mesozoic times (McCurry, 1971), removing much of the rocks of this age bracket, reaching as far as Ghana.

DOI: https://doi.org/10.57233/ijsgs.v11i1.780 ISSNp: 2488-9229; ISSNe: 3027-1118

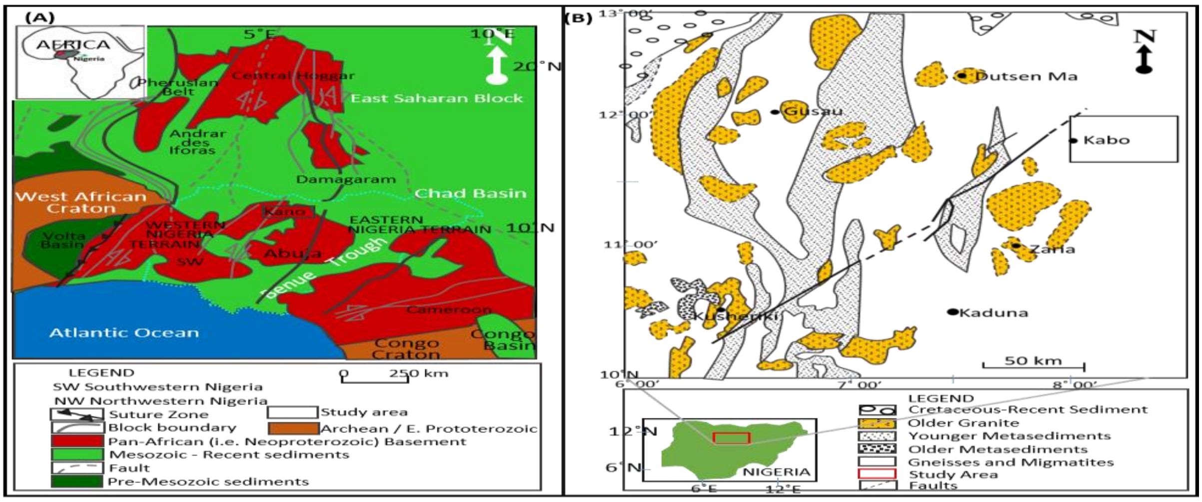
IJSGS FUGUSAU VOL.11(1) WEBSITE: https://fugus-ijsgs.com.ng

Unless detailed investigations are conducted for unravelling the history and simplified for better understanding, such geological scenario can have adverse effect on mining activities in the area. Some global examples related to study of basement complex geology include those of Precambrian – lower Paleozoic terranes of Oki and South Kitakami of Japan (Wallis *et al*., 2020; Therefore, we present a preliminary field mapping with a view to providing new insights into the geology and mineralization trends in the area. Specifically, the objective is to describe the geology using (lithology, composition, petrographic characteristics, associated structures and field relationship) of the rocks by conducting a preliminary high resolution field mapping with a view to providing new insights into the geology and mineralization trends in the area. Such as an approach can generate additional data for the study of geology and in making sound investment decisions.

1.2 Geological Setting

Nigeria lies in a mobile zone separating older cratons of West Africa and Gabon (i.e. Congo), and underlain by nearly equal proportions of sedimentary and crystalline rocks (Fig. 1). The Basement rock is composed mainly of gneisses and granitic rocks with extensive schist belts distributed west of a line 20˚NE through Kaduna, forming part of a series of rocks believed to have been affected by Pan-African orogeny (McCurry, 1971; Ajibade and Wright, 1989). The Pan African orogeny refers to tectono-thermal event of 500 Ma ago, during which some mobile belts were formed, surrounding older cratons, and with equivalents named Brasiliano and Adelaidean in South America and Australia respectively of Gondwana (Kroner and Stern, 2005). It is also equivalent of Cadomian Orogeny in western and central Europe and the Baikalian in Asian continent. The event has been identified as the final episode of an orogenic cycle which resulted in orogenic belts that were interpreted as amalgamation of continental domains during periods of about 870-550 Ma. The term Pan-African is now used to describe tectonic, magmatic, and metamorphic event of Neoproterozoic to earliest Palaeozoic age, especially for crustal bodies that was once part of Gondwana (Fig. 1). Because of its enormous spatial and temporal extent, the Pan-African is considered not a single orogeny but as a prolonged orogenic cycle reflecting the opening and closing of large oceans as well as accretion and collision of buoyant crustal blocks. Pan-African events culminated in the formation of the Late Neoproterozoic supercontinent, Gondwana (Kroner and Stern, 2005).

The geology of the Basement Complex of Nigeria (also known as Nigerian Basement Complex) has been well studied (e.g., McCurry, 9171; Oyawoye, 1972; Ajibade and Wright, 1989; Ajibade, 2016). Oyawoye (1972) subdivided the Basement Complex of Nigeria into four groups of lithology: Older Granites, Migmatitic Complex, Metasedimentary "Series" and Miscellaneous rocks. McCurry (1973) reviewed the Basement Complex rocks of Northern Nigeria. Effectively, the Basement Complex of Nigeria is commonly classified into four groups: (i) Ancient metasedimentary rocks and gneissic rocks (Birrimian or older), (ii) the Younger Metasediments/supracrustals (upper Proterozoic age) which are low-grade metamorphic rocks (micaceous/hornfelsic schists, quartzites and calc-silicate rocks), (iii) basic, intermediate and acid plutonic rocks (the "Older Granites") which intrude into the earlier rocks, and (iv) the youngest rocks ("suite of volcanic rocks") occur as intrusives into the Older Granites during the epeirogenic uplift that was consequent of the Pan African orogeny. However, Ajibade *et al*. (1987) and made contribution that subdivided the Nigerian Basement Complex into two provinces, namely the eastern and the western provinces.



DOI: https://doi.org/10.57233/ijsgs.v11i1.780 ISSNp: 2488-9229; ISSNe: 3027-1118

IJSGS FUGUSAU VOL.11(1) WEBSITE: https://fugus-ijsgs.com.ng

Figure 1: The Pan African Mobile Belts and the Basement Complex of Northern Nigeria. (A) The geological setting of the Pan-African mobile belts of Africa (modified after Ferre *et al*., 2002; Ajibade 2016; Akinola *et al*., 2022). (B) The geological map of the basement complex of northern Nigeria (modified after McCurry, 1971).

The western province, on the one hand, is characterized by narrow, sediment-dominated, N-S trending schist belts which are infolded into an Archean basement ("migmatite and tonalite-trondjhemite-granodiorite type orthogneisses and amphibolites". The schist belts are said to parallel the structures within the gneisses (Ajibade, 2016). On the other hand, the eastern province are characterized by medium – high grade metamorphic rocks (comprising migmatites and gneisses that have been intruded by granitic rocks), associated with limited relics of metasedimentary and metavolcanic rocks.

The Basement Complex of Northern Nigeria is documented in previous studies (McCurry, 1971; McCurry and Wright, 1977) and reported in both Garba (2009) and Suleiman *et al*. (2018). The Basement Complex of Northern Nigeria comprises three groups of rocks: high grade migmatites and gneisses (Birrimian age) that were impacted by intense granitization and metamorphism, the Younger Metasediments (Upper Proterozoic) composed of low grade metamorphic rocks that are infolded into and along with the older migmatites and gneisses during the Pan African orogenic event, and the Older Granite Series which were intruded during the Pan African Orogeny. McCurry (1971) discussed that the that Zaria and adjacent areas are underlain by Dahomeyean crystalline basement complex of gneisses and Birrimian (2,000 Ma), older metasedimentary relicts; infolded into the basement complex are Younger Metasediments (Katangan age; 800 – 1,000 Ma) which occur as N-S trending synclinoria that form remnants an earlier supracrustal cover. Late Precambrian to early Paleozoic syntectonic to late tectonic granites and granodiorites intruded both the basement rocks and its supracrustal cover. In terms of structure, McCurry (1971) identified North-South trend structures as typical of northwestern Nigerian basement characterized by two phases of intense deformation which resulted in tight isoclinal folding (uniform? low interlimb angle under intense compression) (i) one of which is east-northeast-west-southwest and (ii) North-South axes. McCurry also stated that the crystalline basement was reactivated and the supracrustal cover metamorphosed, effectively drawing two classes of progressive metamorphism that accompanied the deformations, which were separated and followed by static metamorphic phases. According to McCurry (1971) pressure – temeperature regimes were relatively constant during the metamorphism giving rise to a low pressure metamorphic facies similar to the Buchan type. She concluded that Migmatization of the basement complex accompanied the phase I of the deformation, followed by further differentiation during the phase II to produce homogenous gneisses and intrusive granites. Subsequent to the orogenic events were the formation of joints, fractures and faults, and a major NE-SW transcurrent fault system crosses the area.

Overall, the Nigerian Basement Complex, based on Ajibade (2016), can be summarized as comprising three rock groups: the migmatite gneiss complex, the low grade schist belt and the Older Granites. Erosion is postulated to have affected much of Nigeria during the early Palezoic – late Mesozoic times, removing much of the rocks of this age bracket, reaching as far as Ghana. In Late Precambrian and Early Paleozoic, Pan African Thermal and tectonic activities affected many of the Basement Complex rocks in Nigeria, resetting radioactive clocks to read around 480 Ma, but unmetamorphosed sediments of these ages do not seem to occur in outcrops (McCurry, 1971). Paleozoic sediments are present in Accra. However, the oldest sedimentary outcrops in eastern Ghana, Lome, Dahomey and western Nigeria are Cretaceous in age. Some studies (Whiteman, 1982) posited that the Basement Complex structures had little influences on the development of sedimentary basins in Nigeria. This is because the various basins in Nigeria appear to cut through or sometimes truncate the Basement trends.

In northern Nigeria (Fig. 1B), the crystalline basement complex consists of "quartzo-feldspathic biotite and hornblende gneisses, migmatites and high-grade metasedimentary relicts". The metasedimentary relicts are typically siliceous or calcareous bodies with sharp contacts with crystalline host rocks – these are regarded as the older metasediments; they are continuous with basement rocks of Dahomey and the Camerouns, probably of Birrimian and older. The much younger supracrustals (the Younger metasediments) are N-S trending belt characterised by micaceous schists, phyllites, quartzites and concordant amphibolites. Similar rock types (Kushaka Schist Formation) occur in Kusheriki area (SW of Zaria). In the Northwest, hornfelsic schists with intercalated calc-silicate rocks are found and continued northwards into Gusau and Dutsin Ma.

2.0 Methods

2.1 Material

This study employed field and laboratory techniques. The field approach includes mapping and sampling outcrop of crystalline rocks in Kabo area.

2.2 Field mapping

DOI: HTTPS://DOI.ORG/10.57233/IJSGS.V11I1.780 ISSNP: 2488-9229; ISSNE: 3027-1118
IJSGS FUGUSAU VOL.11(1) WEBSITE: https://fugus-ijsgs.com.ng

This was conducted using mainly Sheet 80 NE (scale 1:50,000) and little of Kabo NW of the NGSA map series. The location is bounded within latitude 11˚45′N and 12˚00′N and longitude 8˚15′E and 8˚30′E. The area is accessible via Gata and Madobi road / Kwankwaso road, through to Chalawa, Kafin Agur or Gulu.The localities covered include parts of Rimin Gata, Ungwar Rimi, Ungwar Dawa, Wangara, Kazode, Kafin Agur, Gulu, Yalwa, Kwankwaso (Kabo NE) and Durum (Kabo NW). Generally, the area is lowlying (Hausa plain) with maximum elevations just above 560 m above sea level (Garba, 2009). The field mapping involved reconnaissance and detailed mapping of outcrops in the area. The reconnaissance encompasses large scale traversing of the area and documentation of important outcrop locations using the base map, which was extracted from the Kabo Sheet 80 NE.

The field mapping involved careful observation and in-situ description of several outcrops. Emphasis was given to mode of occurrence, field relations with adjacent outcrops, structural (joints and faults) and macroscopic characteristics of the rocks. Hand specimens were described on the basis of texture, colour and mineralogy, and then labelled. Outcrop locations were then plotted on the base map. Lithological boundaries were delineated by observing changes in characteristics of outcrop units, nature of soil, vegetation and topography.

2.3 Thin section petrography

Thin sections of some samples of outcrop mapped and identified were studied for compositional and textural characteristics under petrographic microscope. The thin section petrography was used to support discussion of results. The thin section preparation followed procedure described in Omanayin *et al.* (2023), details of which is presented below.

Representative outcrop samples including gneisses and granites from the study area were used for the thin section study. The thin sections were prepared at the Geology Laboratory of the University of Jos. The procedure involved firstly, a few cm-thick rectangular slice of each rock sample was made with the aid of a diamond saw. Secondly, the slice of rock sample is glued onto a glass slide using epoxy solution. Thirdly, the glass slide-mounted rectangular sample is then sliced, thinned to mm-thick level, and then ground gently against a diamond lap until a translucent layer is achieved. The resulting thin section slide was ready for petrographic study under a petrological microscope.

Description and identification of minerals under the microscope were done using characteristics such as grain shape, colour and fracture, crystal form, cleavages, twinning and presence of inclusions that may be associated with the samples. These set of information together with screen grabs of the petrological view of the thin section slides were used to the discussion of results.

3.0 RESULTS AND DISCUSSION

3.1 Results

Representative results of the geological mapping and thin section petrography are summarised in Fig. 2, 3, 4 and 5. In Kabo NE, at Rimin Gata area, (Gata), the rocks are composed of medium-grained crystals, biotite rich porphyroblastic texture, and showing several joints and fractures (Fig. 2). This suggest post-emplacement stress event affected these rocks. The crushed rocks suggest episodes of dynamic metamorphism. Also, granitised migmatites and gneisses are widespread with black-white, biotite rich porphyroblastic, granite bodies with rod-like and prismatic crystals of quartz and feldspar surrounded by biotite (Fig. 3).

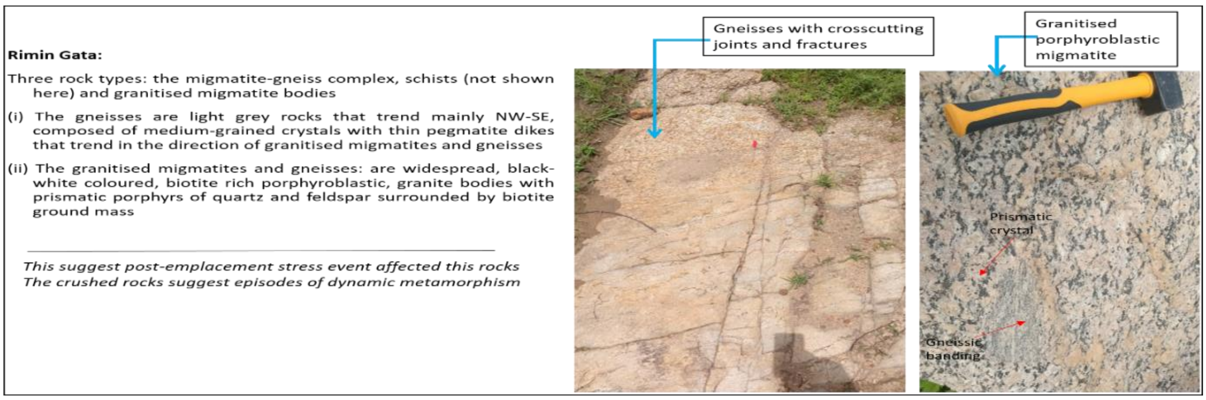


Figure 2. Examples of Migmatite-gneiss Complex in Gata Area Showing Typical Characteristics such as Porphyroblasts with Prismatic Crystals.

DOI: HTTPS://DOI.ORG/10.57233/IJSGS.V11I1.780 ISSNP: 2488-9229; ISSNE: 3027-1118

IJSGS FUGUSAU VOL.11(1) WEBSITE: https://fugus-ijsgs.com.ng

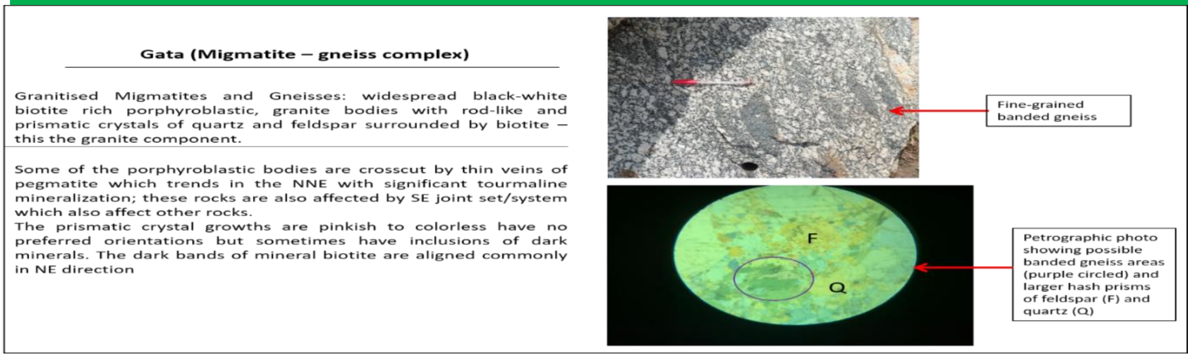


Figure 3. Fine to Medium Grained Gneiss with NE Trending Dark Bands and Petrographic Characteristics Shown with Annotations (Hash Prisms of Feldspar, F circled, and Quartz, Q.

At Ungwar Rimi, the quartzite schist belt here is extensive, several metres wide (7m), and trends mainly NE-SW direction (Fig. 4 and Fig. 5). The quartzite is also rich in feldspar. It appears that this mineralized rocks have been mined in the past.

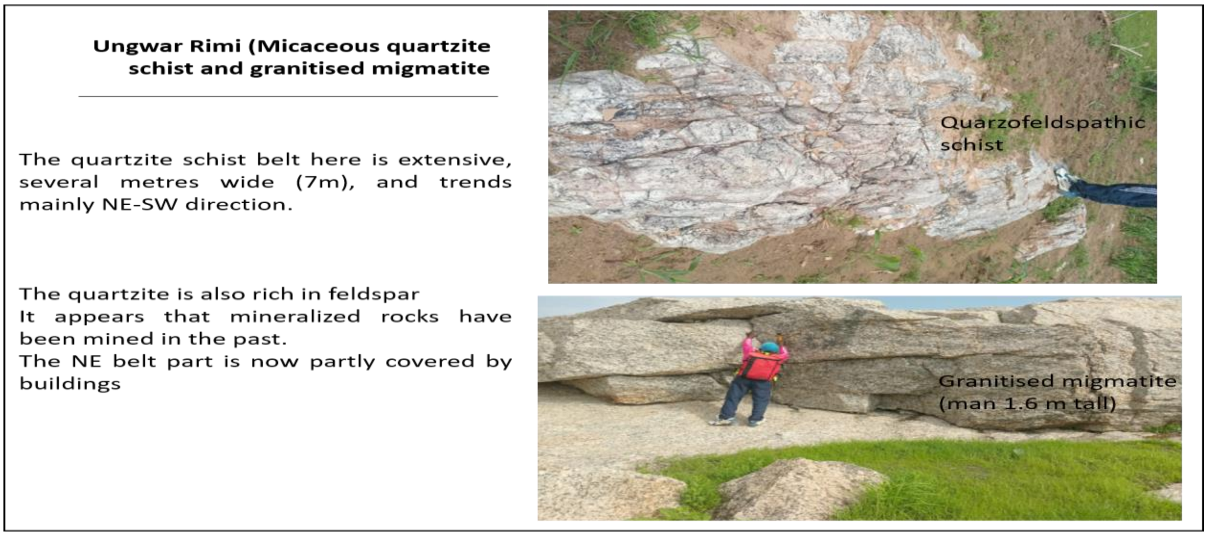


Figure 4. Photos of Quartzofeldspathic Schist Belt (NE-SW trending) and Granitized Migmatitic-gneiss Bodies at Ungwar Rimi Village, Kano. The Rocks Trend Mainly in Northeast Direction.

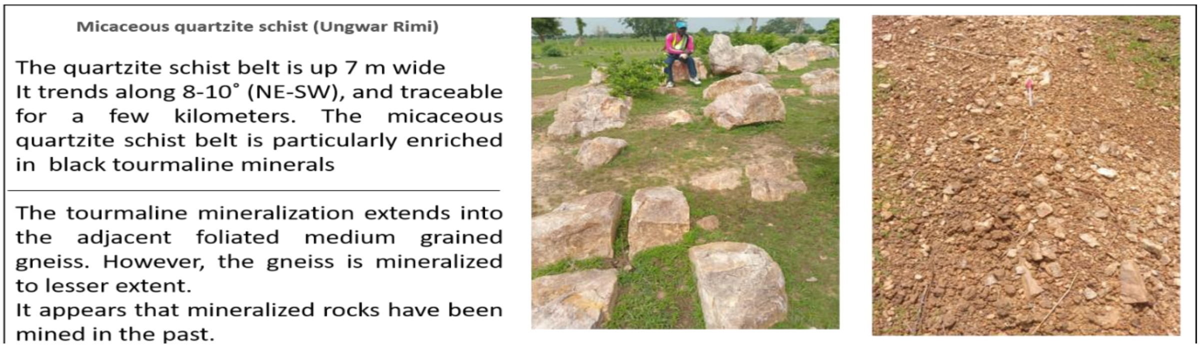


Figure 5. Quartzite Schist at Ungwar Rimi Village, Revealing the NE-SW Trending Micaceous and Quartzitic Schist in Kano. The Rock Trends Mainly in Northeast Direction

At Kazode and Durum (towards Kabo NW), the migmatites show foliation with several folding in places. The folding is mainly tight isoclinal folds with inter limb angles between 0˚ and 30˚ and occurrence of some chevron folds (Fig. 6). The basement rocks here also show fabrics especially among the gneisses, a dark to greenish needles of fine grained biotite and hornblende exhibit mineral alignments (Fig. 6).

DOI: HTTPS://DOI.ORG/10.57233/IJSGS.V11I1.780 ISSNP: 2488-9229; ISSNE: 3027-1118

IJSGS FUGUSAU VOL.11(1) WEBSITE: https://fugus-ijsgs.com.ng

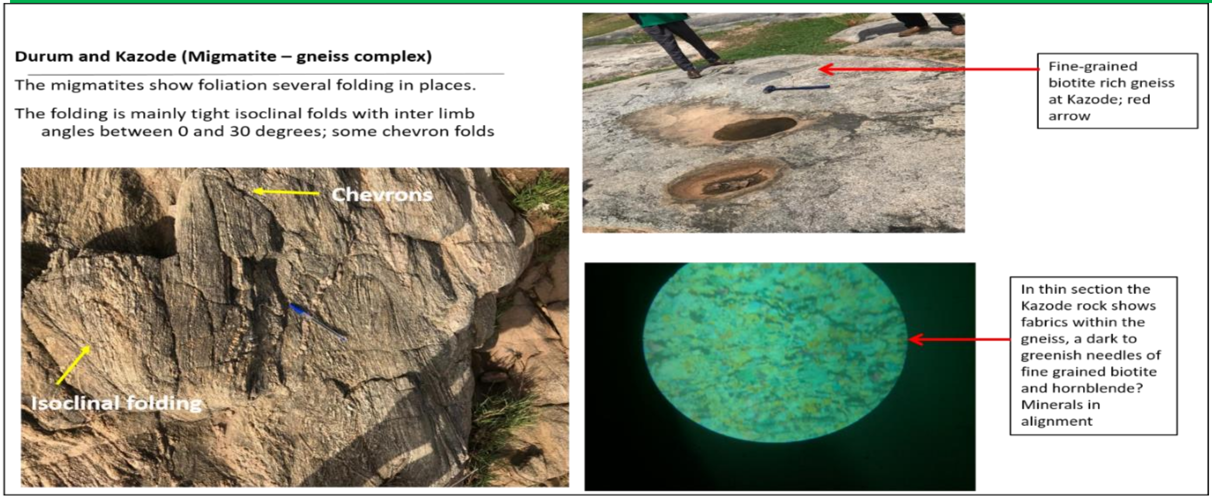


Figure 6. Foliated Migmatite with Tight Isoclinal and Chevron Folds in Kazode Area of Kano. The Petrography revealed dark to greenish needles of Hornblende in Clear Alignment.

4.0 DISCUSSION

Overall, (i) Coarse – medium grained gneisses with near horizontal that trends mainly NW-SE, (ii) the quartzite schist belts, and (ii) porphyroblastic migmatite/gneisses with rodlike, NW-SE trending porphyroclast of quartz and feldspar set in a fine grained mass biotite/hornblende. The fourth lithology, porphyritic biotite and biotite hornblende granite was additionally recognized by Suleiman *et al*. (2018), which is added here for the sake of review and discussion of the geological map.

A surface geological map representing the distribution of basement outcrop in the studied Kabo area was constructed (Fig. 7).The distribution of the rock types suggest predominance (>60%) of migmatite gneiss complex comprising mainly porphyroblastic "migmatite and gneiss" which are deformed and intruded by porphyritic biotite-rich granites within the Kabo region. Lesser occurrence of biotite rich granite (common mostly in the northwestern and northeastern margins of the area) and minor schist belts are infolded into the migmatitite gneiss complex. We found the granite bodies often cut through the migmatite-gneiss complex; they exhibit preferred mineral alignment, suggesting that they are probably granitization products of the migmatite-gneisses, and later metamorphosed and deformed. Deformation such as shearing and folding are appeared to be more common and intense in the South West and West of the study area (Fig. 7). Observed structures include tight isoclinal folding and fracture. Evidence points to the fact that porphyroblastic, probably granitised bodies overlies the migmatite – gneisses; the granoblastic gneisses with rod-like and prismatic porphyroclasts are commonly aligned NE-SW. Indications are that migmatite-gneisses are older emplacement; they are followed by granitic intrusion; then followed by metamorphism that resulted in partial melting, crystal growth and realignment. Networking of fractures suggest probably different stresses that affected the whole area because it affect both rock types. These conclusions are consistent with previous studies (McCurry, 1971; McCurry and Wright, 1977). The crushed rocks suggest episodes of dynamic metamorphism.

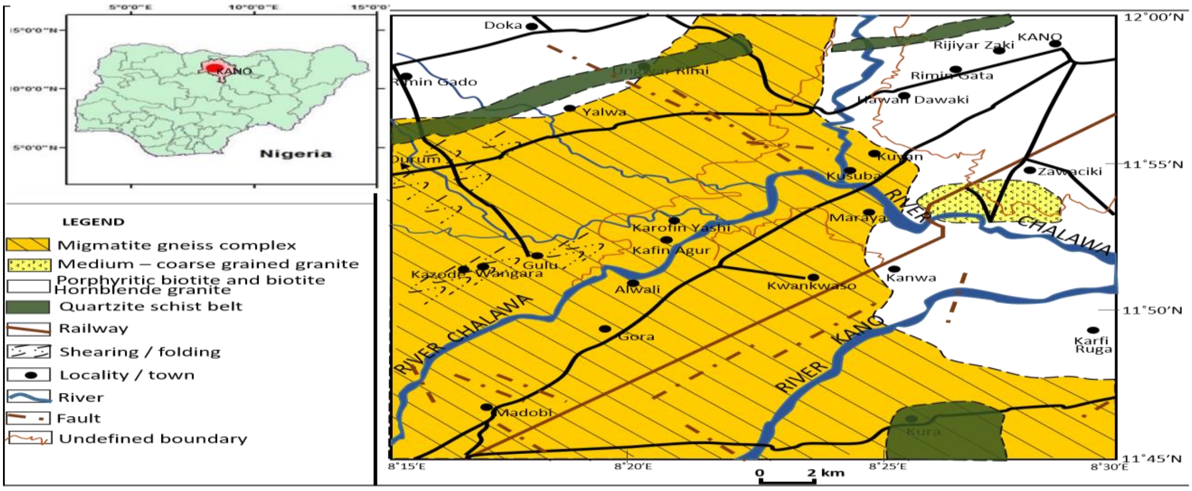


Figure 7. The geological map of the Kabo area of Kano, northwestern Nigeria based on this study. Deformation are more pronounced in the West and NW of the area. Indications of faults are supplemented with data presented in Suleiman *et al*. (2018)

Therefore, we confirm that the rock types just discussed above are part of the system affected by Pan-African orogenic cycles. Possible contribution from the Liberian orogenic events has also be envisaged in the Kabo area based on the various lineament trends (Suleiman, 2018). The Pan African orogeny (550 Ma) is said to be characterized by both NE-SW and NW-SE lineaments (Genik, 1992). This distribution correlate well with the findings of Suleiman *et al*. (2018), who interpreted the regions occupied mainly by the migmatitite gneiss complex as representing positive and negative anomalies that suggest "shallow, highly magnetized intrusions and metamorphosed igneous rocks buried underneath respectively. It is therefore extrapolated here that the high positive amplitude anomalies correlate with migmatites, biotite-granites and the granite-gneiss suites. Additionally, Suleiman *et al*. (2018) observed that the trends of the upward continued anomalies are aligned along NE-SW, NW-SE, E-W and NNW-SSE directions, which suggest an inferred NNW-SSE trending anomalies which might have been masked by short wavelength anomalies on the Reduced to Equator (RTE) residual map.

The SW and W distribution of faults inferred in the area suggest different episodes of stress on the rock bodies. This interpretation is also in accordance with those of Suleiman *et al*. (2018), where it was inferred the prevalence of NE- SW, NW – SE and E – W subsurface lineament trends with the less common NNE – SSW, WNW – ESE and ENE – WSW trends are indicative of different stress regimes at different geologic phases for rocks in the study area. This is in agreement with earlier thought (Kroner and Stern, 2005) that the Pan-African, rather a single orogeny, was a prolonged orogenic cycle reflecting the opening and closing of large oceans as well as accretion and collision of buoyant crustal blocks. Our results here are also consistent with those of Akintoye *et al*. (2023) in North-central Nigeria.

Physical evidence of mineralization of economic significance (e.g., tourmaline, quartz) was observed in the area (e.g., Fig. 6). We therefore interpret that the positive sign of mineralization together with interpreted lineaments serve as possible mineral exploration targets. Minerals of high magnetic content, such as magnetite and ilmenite have been considered likely to occur in commercial quantities.

5.0 Conclusion

The crystalline basement rocks of Nigeria comprises three main lithological groups: the Basement Complex, the Younger Granites and the Tertiary-Recent Volcanics) that were to have been affected by Pan African (~550 Ma) thermo-tectonic events. The Basement Complex (Precambrian), consisting mainly of gneisses- and migmatite-complex with schist belts, granites and some minor rock-types, is characterized by a complex history and geochronology that require further understanding. This study presents the results of field mapping and thin section petrography of rocks in Kabo area with the objectives of providing new insights into the geology and mineralization trends in the region of northwestern Nigeria. The following conclusions were drawn from the study:

(i) The Kabo area comprises coarse – medium grained gneisses, quartzite schist belts, porphyroblastic migmatite/gneisses with porphyroclast of quartz and feldspar set in a fine grained mass biotite/hornblende, and porphyritic biotite and biotite hornblende granites.

(ii) Porphyroblastic migmatite/gneisses which trend mainly NW-SE with porphyroclast of quartz and feldspar set in a fine grained mass biotite/hornblende predominate the Kabo NE area with minor occurrences of infolded schist belts as well as granitised bodies.

(iii) Tight isoclinal folding and fracture are evident in porphyroblastic migmatitite gneiss. The distribution of the migmatite – gneisses characterized by prismatic porphyroclasts are indications that migmatite gneisses are older emplacement followed by granitic intrustion and then metamorphism that resulted in partial melting, crystal growth and realignment.

(iv) Network of fractures are evident and suggest that different episodes of stresses affected the whole area because these structures are present in all the rock types.

(v) Mineralization potentials exist in the region, and the interpreted lineaments could be useful as possible mineral exploration targets. This represents important exploration takeaway in this study.

ACKNOWLEDGMENT

Appreciation goes to Maryam Muhammed Isah for the companionship and support she gave the first author throughout the field work and development of this manuscript. Thanks to the anonymous reviewers of our manuscript.

REFERENCES

Abdulmalik, N. F., & Ahmed, I. I. (2024). Lithological and Structural Mapping of Basement Rock Units in the Ikara North-Central Basement Complex, Nigeria. UMYU Scientifica, 3(4), 182-217.

Ajibade, A. C. (2016). The Nigerian Schist Belts and the Evolution of the Basement. Nigerian Mining and Geosciences Society (Season of Rahaman 2016), p. 88-91.

Ajibade, A. C., Woakes, M., & Rahaman, M. A. (1987). Proterozoic crustal development in the Pan-African Regime of Nigeria. Proterozic Lithospheric Evolution, 17, 259-271.

Ajibade, A. C., & Wright, J. B. (1989). The Togo-Benin-Nigeria Shield: evidence of crustal aggregation in the Pan-African belt. Tectonophysics, 165(1-4), 125-129.

Akinola, O. O., Ghani, A. A., & James, E. (2021). Petrography and geochemical characterization of a granite batholith in idanre, southwestern nigeria. Sains Malaysiana.

Akintoye, G. S., Bassey, N. E., & Udoh, A. C. (2023). Geological Analysis of Gravity Data Over Part of Nigeria's NorthCentral Basement Complex. Journal of Mining and Geology, 59(1), 87-98.

Ejiga, E. G., Yusoff, I., Ismail, N. E. H., Lawal, M., & Yelwa, N. A. (2022). Application of scaling geology in magnetic basement mapping around the Middle Benue Trough in Northcentral Nigeria. Physics of the Earth and Planetary Interiors, 331, 106914.

Ferré, E., Gleizes, G., & Caby, R. (2002). Obliquely convergent tectonics and granite emplacement in the Trans-Saharan belt of Eastern Nigeria: a synthesis. Precambrian research, 114(3-4), 199-219.

Garba, I. (2009). Hydrogeological map of Kabo Sheet 80NW topographical sheet 1: 50,000. Bayero Journal of Pure and Applied Sciences, 2(2), 207-217.

Genik, G. J. (1992). Regional framework, structural and petroleum aspects of rift basins in Niger, Chad and the Central African Republic (CAR). Tectonophysics, 213(1-2), 169-185.

Lawal, M., & Hassan, M. H. A. (2023). Sedimentary and stratigraphic characteristics of the Maastrichtian Dukamaje formation of southern Iullemmeden Basin: Implications for the paleogeography of the Upper Cretaceous trans-Saharan seaway. Journal of African Earth Sciences, 200, 104878.

Lawal, M., Ayomaya, S. A., Ojero, J. O., Muhammad, A., Yelwa, N. A., Bello, J., & Bello, A. (2017). Integrated Geology and Geochemical Analysis of Eruku Basement Complex, Southwestern Nigeria. Nigerian Journal of Basic and Applied Sciences, 25(1), 63-72.

McCurry, P. (1971). Pan-African orogeny in northern Nigeria. Geological Society of America Bulletin, 82(11), 3251-3262.

McCurry, P., & Wright, J. B. (1977). Geochemistry of calc-alkaline volcanics in northwestern Nigeria, and a possible Pan-African suture zone. Earth and Planetary Science Letters, 37(1), 90-96.

Omanayin, Y. A., Lawal, M., Bolaji, I. B., & Muhammad, A. (2023). Field and Petrographic Studies of Basement Complex Rocks in Saigbe and Environs, North-Central, Nigeria. Nigerian Journal of Basic and Applied Sciences, 31(1), 49-59.

Ominigbo, O. E. (2022). Evolution of the Nigerian basement complex: Current status and suggestions for future research. Journal of mining and Geology, 58(1), 229-236.

Suleiman, A., Aku, M. O., & Sanusi, Y. A. (2018). Analysis and interpretation of high resolution aeromagnetic data over Kabo town and its adjoining areas, in Northwestern Nigeria. Bayero Journal of Pure and Applied Sciences, 11(1), 145-152.

Wallis, S. R., Yamaoka, K., Mori, H., Ishiwatari, A., Miyazaki, K., & Ueda, H. (2020). The basement geology of Japan from A to Z. Island Arc, 29(1), e12339.

Whiteman, A. (1982). Nigeria: its petroleum geology, resources and potential. Graham and Trotman, London, 381 pp.