Communication in Physical Sciences, 2023, 10(1): 73-84

Petrographic Studies of Migmatite-Gneiss, Quartzites and Pegmatites Complex in Crusher Area of Lokoja, Kogi State, Nigeria

Ajogwu Cordelia Odinaka*, Mu'awiya Baba Aminu, Christopher Dalom, Aaron Enechojo Auduson, Yohanna Andarawus, Frankie Ojo Balogun, Nengak Musa, Ibrahim Yusuf Anzaku, Pam Dajack Dung, Andrew Changde. Nanfa, Okiyi, Ijeoma Millicent, Sadiq Mohammed Salisu and Tolulope Idiat Ogunsanya

Received: 11 August 2023/Accepted 30 September 2023/Published 02 November 2023

Abstract: *The studied Area is situated in Lokoja Local Government Area of Kogi state, this forms part of the Lokoja sheet on latitudes 07°49'N to 07°51'N and longitude 006°38E to 006°40'E and covers an area of 200km^2 on a scale of 1: 50,000. The study area is situated in the southern Bida Basin and the Basement complex of Nigeria. However, the major rocks encountered during the fieldwork was migmatitegneiss, porphyroblastic gneiss and pegmatite which is the parts of the migmatite-gneiss complex of the Nigerian Basement. Laboratory analysis (thin section) was conducted to determine the mineralogical composition of the rocks, the minerals include quartz, feldspars, micas and opaque minerals. The research area is characterized by overflowing groundwater which supplies streams and rivers for agricultural and domestic usage. Economically, the major economic minerals of the rocks include feldspar, quartz and micas. The feldspars if in large quantity will be mined for ceramic factories for the production of ceramics, tiles and fillers and enhancer in paint, plastic and rubber. Large clasts of quartz also occur in the pegmatite and can be mined and used to produce abrasive minerals. Quartz can be used in railway blasts, they serve as decorative stones, and they are also used in covering of walls and roofing. The quartzite and gneissic rocks in the study area can be blasted and cut into various sizes and shapes and thus be used for road construction and building design. A variety of uses for metamorphosed gneiss exist in buildings, such as ornamental stone applications etc.*

Keywords: *Quartz, Basement complex, migmatite-gneiss, Pegmatite, micas, opaque minerals, porphyroblastic gneiss and thin section.*

Ajogwu Cordelia Odinaka
Department of Geology, Federal University Lokoja, Kogi State, Nigeria.
Email: Cordeliaajogwu@gmail.com
Orcid id: 0009-0000-5489-3893

Mu'awiya Baba Aminu
Department of Geology, Federal University Lokoja, Kogi State, Nigeria.
Email:
muawiya.babaaminu@fulokoja.edu.ng
Orcid id: 0000-0001-5278-153X

Christopher Dalom
Department of Geology, Federal University Lokoja, Kogi State, Nigeria
Email: simon.christopher@fulokoja.edu.ng
Orcid id: 0000-0003-0989-7662

Aaron Enechojo Auduson
Department of Geology, Federal University Lokoja, Kogi State, Nigeria
Email: aaron.auduson@fulokoja.edu.ng

Andarawus Yohanna
Geology Department, Faculty of Science, Federal University Lafia, Nigeria.
Email:
yohanna.andarawus@science.fulafia.edu.ng
Orcid id: 0000-0001-8921-9647

Frankie Ojo Balogun
Geology Department, Faculty of Science, Federal University Lafia, Nigeria**.**
Email: frankiebalogon@gmail.com
Orcid id: 0000-00029632-3511

Nengak Musa
Geology Department, Faculty of Science, Federal University Lafia, Nigeria
Email: nengakmusa@gmail.com

Ibrahim Yusuf Anzaku
Geology Department, Faculty of Science, Federal University Lafia, Nigeria
Email:iy.anzaku@sciencefulafia.edu.ng
Orcid id: 0009-0000-3061-3578

Pam Dajack Dung
Department of Geology, University of Jos, Plateau State, Nigeria
Email: dajackpam82@gmail.com
Orcid id: 0009-0000-6304-1924

Andrew Changde. Nanfa
Department of Geology, Federal University Lokoja, Kogi State, Nigeria
Email: nanfa.changde@fulokoja.edu.ng
Orcid id: 0009-0000-3729-9497

Okiyi, Ijeoma Millicent
Department of Geology, Federal University Lokoja, Kogi State, Nigeria
Email: ijeoma.okiyi@fulokoja.edu.ng

Sadiq Mohammed Salisu
Abubakar Tafawa Balewa University Bauchi, Bauchi State**, Nigeria**
Email: sadiqmuhammedsalisu@gmail.com
Orcid id:0009-0002-5458-1747

Tolulope Idiat Ogunsanya
Department of Chemistry, University of New Hampshire, USA
Email:Tolulope.ogunsanya@unh.edu
Orcid id: 0000-0002-7362-2420

1.0 Introduction

Geological field mapping is a process of determining the full details of an area of interest and identifying all the geological features to create a detailed geological report which must show in a geological map. According to Ajibade *et al.* (1987), there are three main reasons why geological field mapping is done: academic purposes, government requests, and for exploitation of natural resources. Three stages should be essential in an effective geological mapping project: planning, data collecting, and reporting. Certain parameters must be considered when mapping geological landforms, structures and geothermal manifestation.

The geological mapping was carried out at the area Crusher area of Lokoja and its environs This report covers all the required geological details notes and information observed in the study area.

The fieldwork was embarked upon for the following reasons

(i) To study the various types of basement rocks, and their structures and also to study the features found in them.

(ii) To proffer the economic importance of the various rock types in the area.

The study area is situated on a Nigerian map with a scale of 1:50,000 sheets of Lokoja within (Crusher, Shagari village and Zango area, Lokoja, Kogi State, Nigeria. This region is located in Nigeria's North Central Area. (Odoma *et al.*, 2023). It is popularly called the Confluence State because the Confluence of rivers Niger and Benue is at its Capital Lokoja. The Study area lies between latitudes 07°49'N to 07°51'N and longitudes 006°38E to 006°40'E within the basement complex (Aminu *et al.* 2022b). The area is accessible through major roads and some minor roads which include secondary and tertiary roads that are motorable. It also has a large network of footpaths and animal tracks which was used during the fieldwork.

The drainage pattern of the study area is dendritic. The rivers and their tributaries play a crucial role in the region. They collect and

carry water from the surrounding land, including rainfall and run-off, and transport it towards the Crusher (Meme) River which later proceeds and pours into the River Niger.

Fig 1: Drainage pattern of some parts of the crusher (Meme River)

The study area is primarily covered with grassland vegetation. There is a characteristic plain growth, which shows r relatively thick rainforest vegetation. Generally, the vegetation covered is the work of biological weathering which allows rocks to break into boulders. Most of these regions are covered by rainforests. The composition consists of large, tall-crowned trees mixed with a thick subsurface layer.

There is a large expanse of soil cover in this area. The soil cover varies from grey, dark to brownish. The soils in Crusher are fertile loamy soil with humus components, clay and laterite. There is frequent flooding in many areas throughout the wet season. Because of the thick dark loamy soil, farming is one of the main occupations of the indwellers. Crops grown in the area include; cassava, guinea corn, maize, groundnut, cucumber, melon seeds and watermelon among others. There is also evidence of weathering in this area. The presence of boulders and some weathered particles are evidence of biological and physical weathering.

The scope of the research work is to carry out a detailed geological mapping and to carry out the petrographic study of the Crusher area on a map scale of 1:25000 and an era extent of $25km^2$, with the objectives of identifying various rock types, petrographic characteristics and spatial distribution of different rock, lithology, structural geology, economics geology/mineral resources and hydrogeology of the area. It involves the recognition, description and identification of geological features of outcrops with special peculiarities for a better understanding of the geology of the study area.

The study area is an urban area which ranges from linear to dispersed settlement. The land in Crusher is mostly used for agricultural purposes and the rearing of animals such as cows, and cattle by the Fulani's. Their woods are used for timber and sometimes burn down to blast rocks and for hunting. Geological materials are being mined such as Quartzite and feldspar etc.

Lokoja and its environment happen to be one of the most studied areas in North central Nigeria. Quite a number of expert and qualified geologists have worked extensively on the study area.

Based on some research findings, rocks can be divided into three groups and the Igarra-Kabba-Lokoja belt is a prominent rocks in the western Nigeria (Ajibadee *et al*., 1987; Christopher *et al*. 2022).

1.1 The basement complex of Nigeria

The study location is entirely crystalline and falls within the Basement Complex of Nigeria (Aminu *et al*., 2022b). Most of the relevant literature published about the study area and Basement Complex of Nigeria were generally reviewed and cited.

Radiometric ages indicate that the basement complex of Nigeria is polycyclic and is believed to be the result of at least four major orogenic cycles of deformation, metamorphism and

remobilization corresponding to include rock of Liberian (2700±200Ma), Eburnean (2000±200Ma), Pan African (600±150Ma) by Grant, 1972.

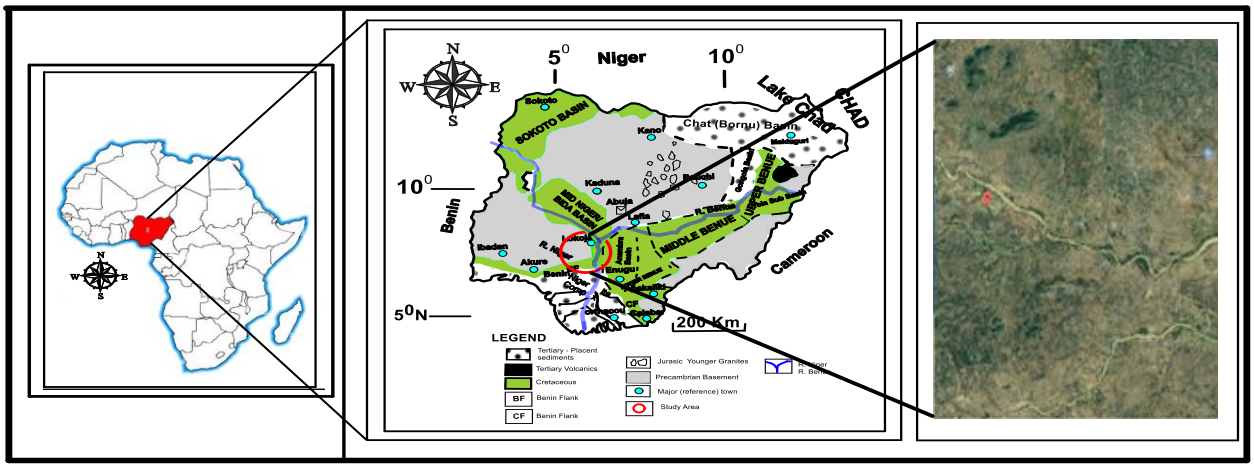


Fig. 2; Geological map of Nigeria showing Lokoja which is the studied Area (Modified after Obaje 2009; Aminu *et al*., 2022a; Ibrahim *et al*., 2023;).

3.0 Materials and Methods

Fig. 3 presents a flow chart illustrating the schems and steps adopted for the study. To achieve the aim and objectives of the study, a literature review of the previous work such as desk review was done on the study area, other method includes description, observation, sampling of the rock type and plotting the sample points on the base map was used as a guide for this research.

3.1 Desk study and field study

Relevant materials have been used during the literature review from the internet and publications to know about the geological structures and to have more idea about and the rock types.

Places suitable for geological field mapping were selected, located and observed by hand specimen, structures such as the orientation of the outcrops, Dip and Strikes were also observed and readings were also taken. Samples were collected and labelled at each location, and the direction of river flow was also taken and settlement coordinates.

3.2 Laboratory analysis

Out of the 10 samples collected from the field, four (4) samples were sorted and prepared for thin section production. A petrographic microscope was used to view the produced thin section under crossed polarized light and plain polarized light PPL, minerals observed were described accordingly.

These methods were achieved using the following Instruments Global Positioning System GPS, Bruton Compass, Hammer and Tape. A global positioning system was used to take location coordinates.

Compass clinometers were used to determine parameters such as bearing altitudes as strike and dip directions by aligning the magnetic meridian to point on NORTH-SOUTH (**N-S)** direction.

A hammer was used to collect outcrop fresh samples by breaking it into pieces.

A sample bag was used to collect all the samples, characteristics of different rock types such as mineralogy, color, and grain sizes were recorded on field notes. While other analysis was taken to the laboratory.

3.3 Field description and petrographic analysis

The study area lies between latitude 07 49’ 0’’ to 07 51’ 30’’and longitude 006^0 38’ 30’’ to 006^0 40’30’’ see Fig. 4 below. The mapped

area is Basement terrain, and River tributaries, the various rock types encountered include mainly Migmatites gneiss with an intrusion of Pegmatite and Quartzite. Some part of the rock has been weathered. The mineral composition observed on these outcrops includes: feldspar, quartz, mica, and biotite. Structural observation includes cleavage, foliation, fracture and joint, and secondary fold due to tectonism and is asymmetric.

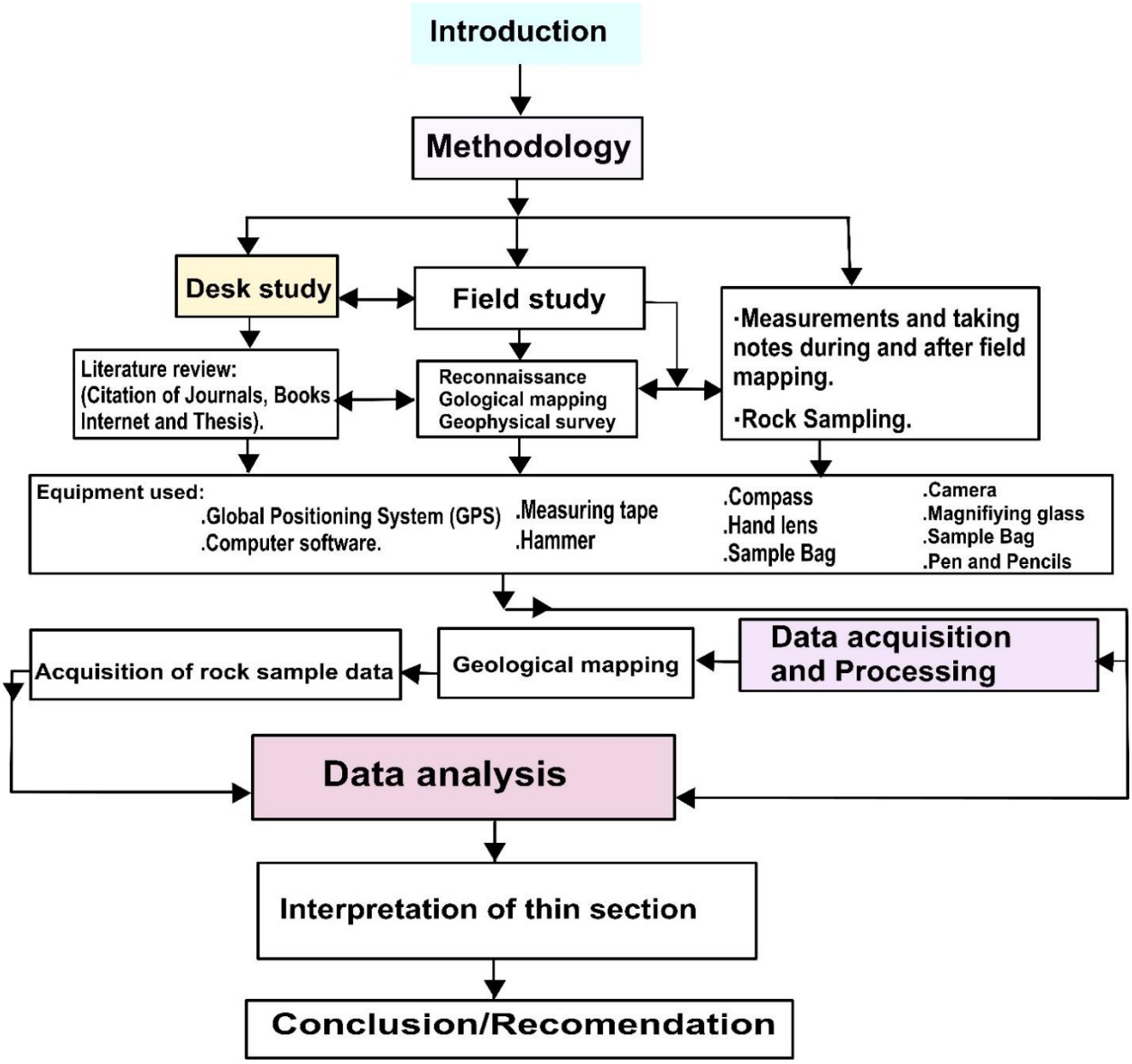


Fig. 3 : Research methodology of the research (Modified after Aminu *et al*., 2022a; Ibrahim *et al*; 2023; Akagbue *et al*., 2023)

3.3 Field discription of migmatite gneiss

Migmatite gneiss is the most widely spread rock type in the research area and forms as gneiss, occurring with migmatites and pegmatitic intrusions. They are highly visible, with large flat-lying rock formations as well as in cuts across rivers, roads, and stream channels. see Figs. 5 to 8 below as highly weathered rocks. The general trend is NW-SE. They are predominantly quartz and feldspar,

giving it a light appearance and a lesser quantity of ferromagnetic minerals, mostly of medium grain texture. The ferromagnesian mineral is mostly biotite or hornblende. They contain veins, either pegmatites or quartz-felspathic veins.

At this location, N 7^0 50' 39.4" and E $6^0$39'21.2" Sample point 5 (see Fig. 4) massive outcrop with feldspathic intrusions light and dark colouration, which signifies Feldspars, quartz and micas that is of medium grained sizes

The photomicrographs reveal the sutured grain boundary between microcline cross Hatching, Orthoclase, quartz and Muscovite crystals using (X10).

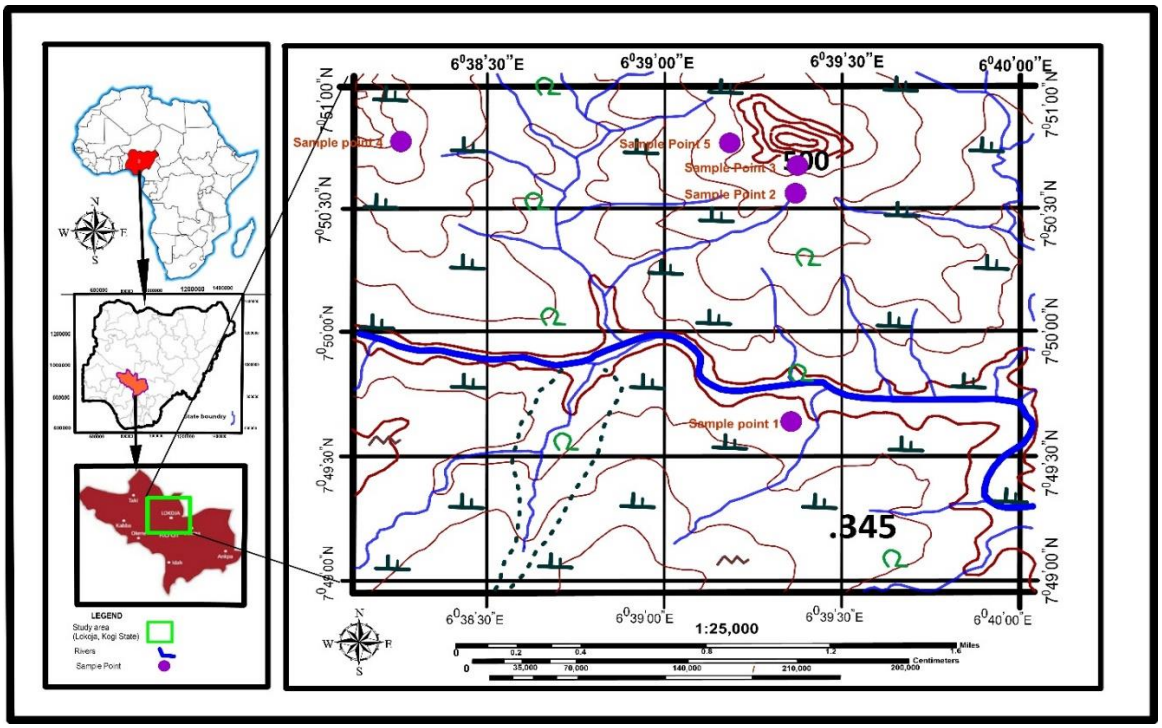


Fig. 4: Map of the studied area showing the sample points (Modified after Nanfa *et al*., 2022; Ibrahim *et al*., 2023, Abdulbariu et al 2023a).

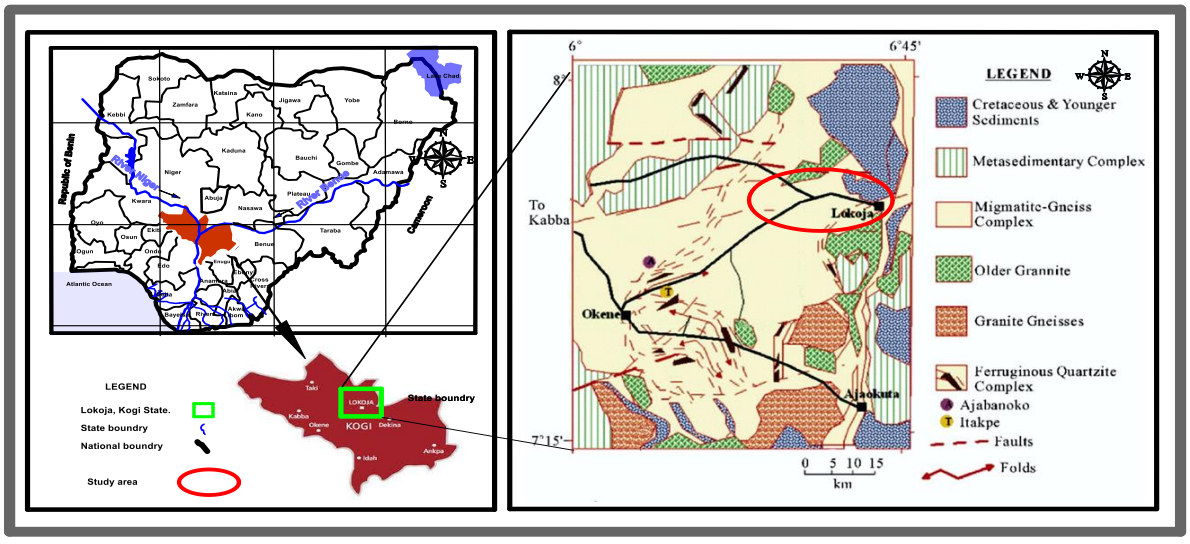
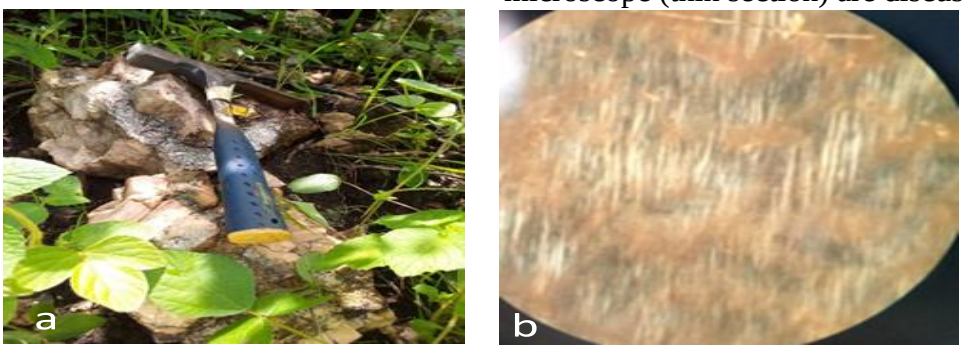


Fig. 5: A map of the study area showing Migmatite-Gneiss complex and the studied area (Modified after Baba Aminu *et al*., 2023; Abdulbariu et al 2023b)

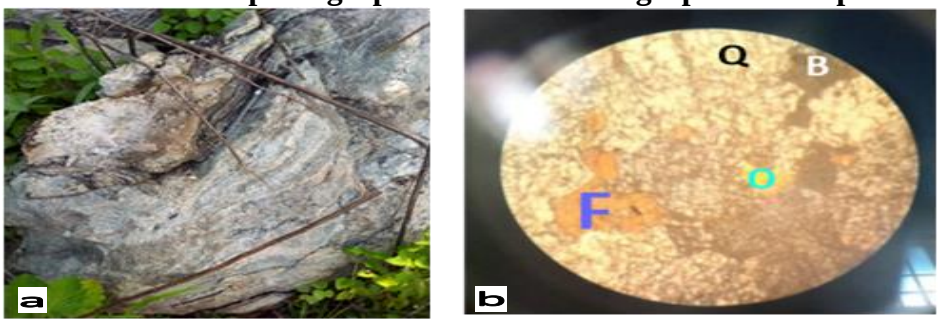
3.2: Petrographic analysis

Petrographical properties of rock under a microscope (thin section) are discussed below.



Field photograph (a) Photomicrograph (b)

Fig. 7a and 7b: Field photograph and Photomicrographs of feldspathic vein



Field photograph of migmatite gneiss. Photomicrograph of migmatite gneiss

Fig. 8a and 8b: A field photograph and A photomicrograph of the same outcrop

This migmatite gneiss from this location N 7^0 50' 48.2" and E $6^0$38'15.0" Sample point 4 (see Fig 8a and 8b) is foliated and folded with medium to coarse-grained textures, presence of both light and dark-colored minerals. The microscopic analysis reveals the presence of the following minerals; Quartz, feldspars, biotite and Opaque minerals using cross-polar (X10)

Q=20%, F=10%, O=30% and B=40%

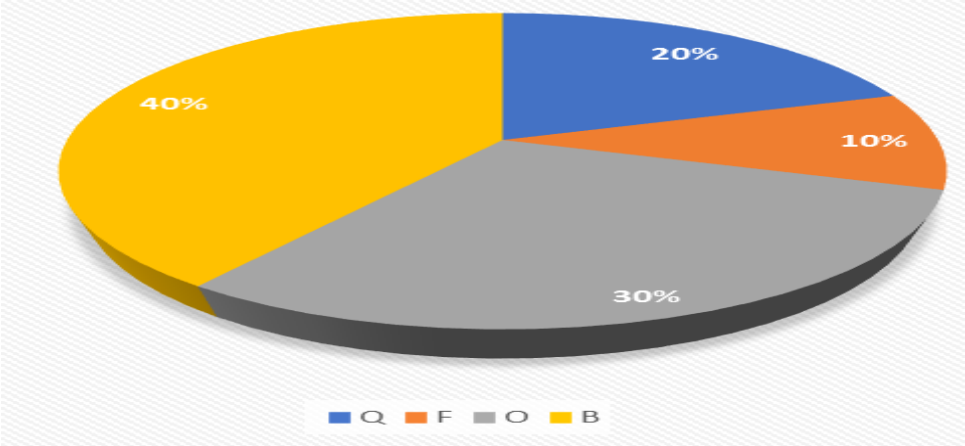


Fig. 9: A pie chart representing the percentages of quartz, feldspars, biotite and Opaque minerals from Fig. 8a and 8b (taken from sample point 4 of Fig. 4).

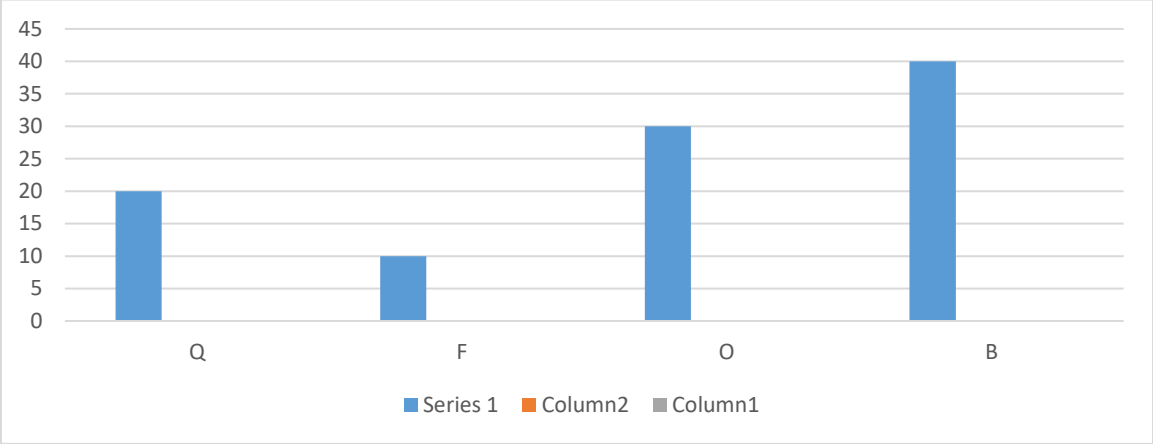


Fig. 10: A bar chart representing the percentages of quartz, feldspars, biotite and Opaque resulting from sample point 4 fig. 8a and 8b (taken from sample point 4 fig. 4.

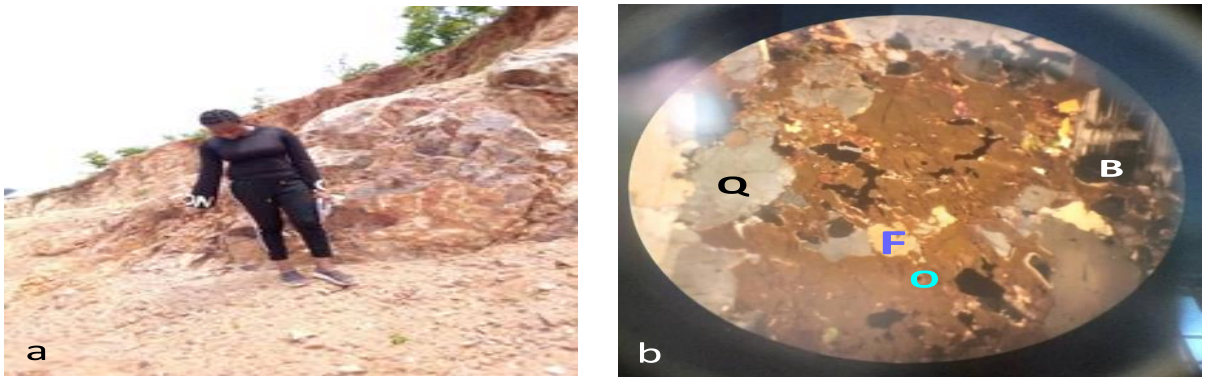


Fig. 11a and 11b: Field photograph of gneiss and the photomicrograph.

The migmatite gneiss from this location **N 7^0 50'41.1"** and **E 6^0 39'28.4 (sample point 3)** ranges from fine to medium-grained and some have been weathered to clay, with gray colouration. The photomicrographs show the presence of feldspars, quartz, biotite, opaque minerals and feldspars turning into clay.

Q=55%, B=20%, C20% and O=5%

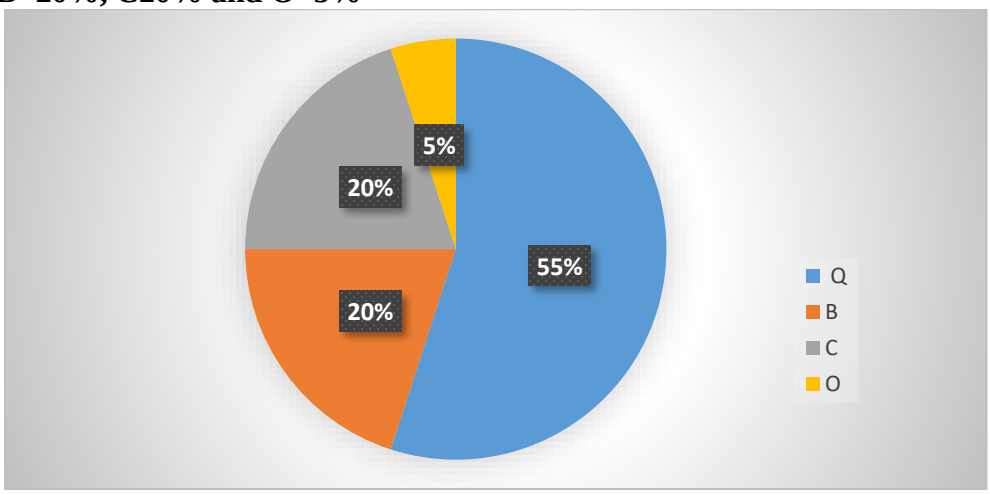


Fig. 12: A bar chart representing the percentages of quartz, feldspars, biotite and Opaque resulted from sample point 3 (from Fig. 11a and 11b)

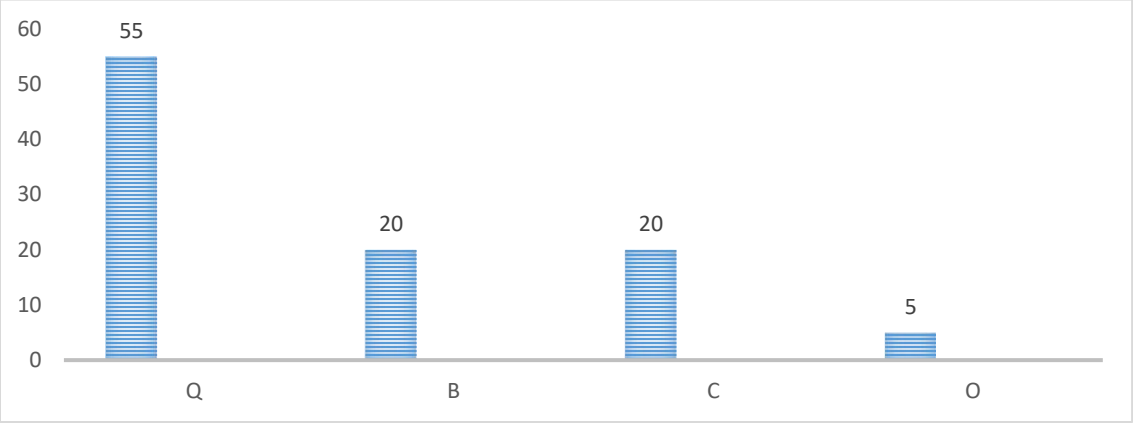
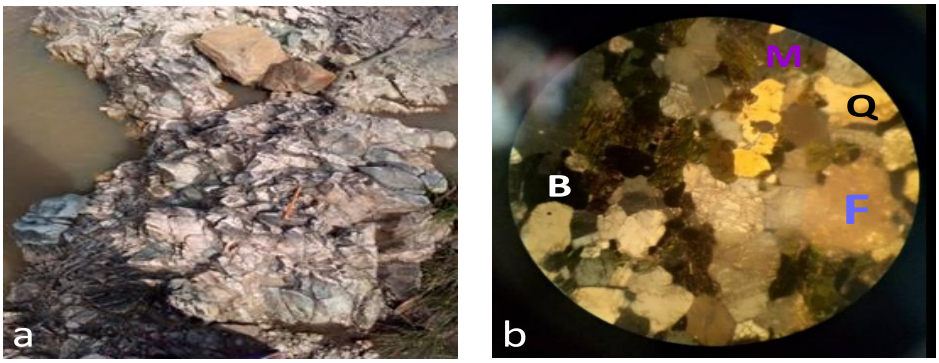


Fig. 13: A bar chart representing the percentages of quartz, feldspars, biotite and Opaque resulted from sample point 3 (from Fig 11a and 11b)



. 14a and 14b: Field photograph and photomicrographs

Pegmatite is an intrusion with coarse-grained textures due to slow cooling and may turn to clay when weathered, there are joints and fractures. It is exposed around the riverside at this location **N 7^0 49' 35.4"** and **E $6^0$39'28.9"** . The photomicrographs reveal that the mineral composition includes Biotite, Feldspars, Quartz and Muscovite. Sample point 1 from Fig. 14a and 14b (see also Fig.4)
Q=10%, F=50%, B=30 and M=10.

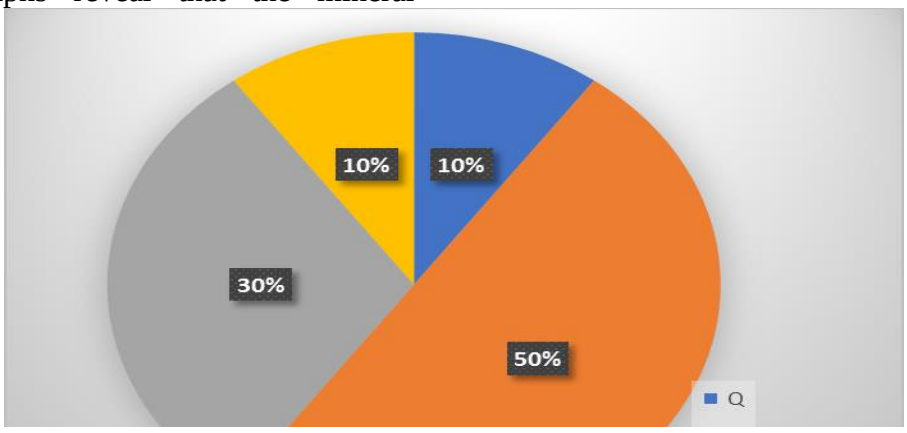


Fig. 15: A bar chart representing the percentages of quartz, feldspars, biotite and Opaque resulting from sample point 1 in Fig. 14a and 14b.

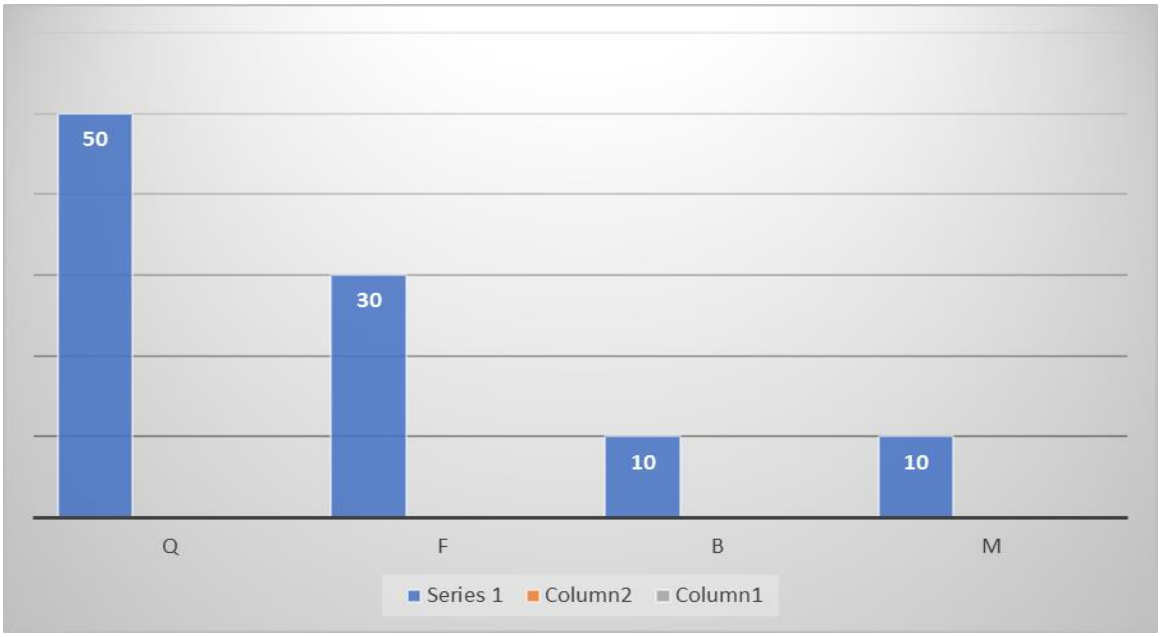


Fig. 16: A bar chart representing the percentages of quartz, feldspars, biotite and Opaque resulted from Fig. 14a and 14b (sample point 1 in Fig. 4)

3.3 Economy geology

The rocks found in these areas are highly economical and include: quartzite, migmatites gneiss and pegmatites. The major economic minerals of the rocks include feldspar, quartz and micas.

(i) The feldspars: if in large quantity will be mined for ceramic industries for the production of ceramics, tiles and as fillers and extenders in paint, plastic and rubber. Large clasts of quartz also occur in the pegmatite and can be mined and used to produce abrasive minerals.

(ii) Quartz can be used in railway blasts, they serve as decorative stones, and they are also used in covering walls and roofing.

(iii) The quartzite and gneissic rocks in the study area can be blasted and cut into various sizes and shapes and thus be used for road construction and building design.

(iii) Metamorphosed gneiss: is a versatile building material, such as ornamental stones, and gravestones.

The rocks in the research area, as revealed by field and structural mapping, are part of a main complex of migmatite/migmatized gneiss.

From field deposition of metamorphic rock, ranging from fine-medium and coarse grain, the suite is locally associated with pegmatite. The final geological map of the study area demonstrated that the area has been impacted by an orogenic cycle, as evidenced by two generations of folded, massive, and foliated quartzite. The rocks of the area show a predominantly N-S and NE-SW planar structure and a minor NW and E-W structural trend defined by gneissose foliation. The N-S, NE-SW, and E-W indicate ductile metamorphic deformations that are likely pre- or syn-pan African events that contribute to the widespread formation of gneissose structures in the basement rocks, while the NW-SE brittle deformational structure is infilled by pegmatite and the quartz veins appear to be post- or syn-pan African.

4.0 Conclusion

The field and structural mapping of the study area shows that the major rock groups are migmatite, quartzite, and gneisses, which have been intruded by a series of feldspar, quartz, and pegmatite. Structural evidence shows that the area is typical basement terrain with rocks of diverse nature, complexly deformed with the development of foliations, and folds with the presence of both planar and linear structures. Structural evidence also shows that most structures include joints, pegmatitic and normal folds, quartz feldspar veins, and pegmatite veins.

The Nigerian Geological Survey Agency should Organize mapping activities for all geological students across the globe and also help to educate students on the important of geological mapping in all their branches. Motorable roads or tracks should be constructed to ease access into the structures and it has been observed that the rivers are not suitable for drinking water, therefore Geophysical surveys and studies should be conducted to delineate the water bearing zones and to know where the boreholes should be drilled to ease the villagers from scarcity of water.

4.0`Reference

Abdulbariu, I., Izge, J. H, Baba Aminu, M., Ayinla, H. A. (2023a) Application of Vertical Electrical Sounding (VES) and Two-Dimensional (2-D) Imaging Methods for Groundwater Exploration and Basement Configuration at GOFAMINT Church Camp, Ibadan, Southwestern Nigeria. Science Forum, Journal of Pure and Applied Science.2023b;23(2023):336-356

Abdulbariu, I., Omeneke, A. L., Baba Aminu, M., Dung, P. D, Salisu, S. M, Odinaka, A. C., Akagbue, B. O., Ibrahim O. I and Ayoola, A. H. (2023b) Application of Vertical Electrical Sounding (VES) for the Determination of Water-Bearing Zone in Karaworo, Lokoja Kogi State, Nigeria. *Journal of Geography, Environment and Earth Science International* Volume 27, Issue 11, Page 47-73, 2023; Article no. JGEESI.108341ISSN: 2454-7352. https://doi.10.9734/JGEESI/2023/v27i11726

Ajibade A. C. Woakes, M, and Rahaman, M. A, (1987). Proterozoic crustal development in the pan-africa regime of Nigeria. America Geophysical Journal, pp.259-271. Washington DC, USA: American Geophysical Union.

Akagbue, B. O., Ibrahim, M. N., Ofure, O. F., Ekugbe, O. U., Amaobichukwu, C. T., Kyrian, O., Baba Aminu, M., Dung, P. D., Salisu, S. M., Babale., S. I. &Ilelah, K, G. (2023). Comprehensive assessment and remediation strategies for air pollution: current trends and future prospects; A case study in Bompai industrial area, Kano State, Nigeria. *Communication in Physical Sciences,* 10, 1, pp. 1-13.

Aminu, M. B., Nanfa, C. A., Hassan, J. I., Yahuza, I., Christopher, S. D., & Aigbadon, G. O. (2022a). Application of electrical resistivity for evaluation of groundwater occurrence within Adankolo campus and environs, Lokoja North Central, Nigeria. *European Journal of Environment and Earth Sciences,* 3, 1, pp. 14–22. https://doi.org/10.24018/ejgeo.2022.3.1.235

Aminu, M. B., Christopher, S.D., Nanfa, C. A., Ahmad T. D., Andarawus, Y., Nengak, M., Tobias, S. (2022b). Petrography and heavy mineral studies of lokoja formation along Mount Patti North Central Nigeria: Implication for provenance Studies. *European Journal of Environment and Earth Sciences.* 3, 2, pp. 36-51

Baba Aminu, M., Nanfa, C. A., Aigbadon. G. O., Christopher, S. D., Friday, I. E., Yohanna, A., Ibrahim, A., Salisu, S. M., Dung, P. D., Paca, F. S. & Tobias, S. (2023). Geology, geochemical and petrographic studies of Lokoja sandstone

facies: implication on source area weathering, provenance and tectonic settings. *Communication in Physical Sciences.* 9, 4, pp. 465-482.

Christopher, S. D., Ayoola. H. A., Aigbadon. G. O., Baba Aminu, M., Nanfa A., C. & Lydia A. (2022). Heavy mineral analysis of the cretaceous Lokoja Formation Exposed around Karara- Banda area, North Central Nigeria**.** *Quest Journals Journal of Research in Environmental and Earth Sciences*, 8, 11, pp.: 40-49

Grant (1972). The geochronology of Precambrian basement complex rocks from Ibadan, southwestern Nigeria. *Earth Planet Sci. Lett.* 101, pp. 29-38.

Nanfa, C. A., Aminu, M. B., Christopher, S. D., Akudo, E. O., Musa, K. O., Aigbadon, G. O., &Millicent, O. I. (2022.). Electric resistivity for evaluating groundwater potential along the drainage zones in the part of Jos North, Plateau State, Nigeria. *European Journal of Environment and Earth Sciences.* 3, 6, pp. 59-68.

Ibrahim, A., Baba Aminu, M. & Okechukwu A. K. (2023). Frequency-Domain Electromagnetic and VLF Data with an application to modeling of basement structures: A case study within Ibadan Area, Southwestern Nigeria. *(IJRIAS)*, 8 6, pp. 156-175 June DOI: https://doi.org/10.51584/IJRIAS.2023.8616

Odoma, A. N., Simon D. C., Baba Aminu. M., & Changde, A. N. (2023). Application of Pebble Morphometry and Sedimentology in Studying Provenances and Deposition Environments of the Lokoja Formation in the Southern Mid-Niger Basin as Exposed in Parts of Lokoja and its Adjoining Areas. *Science Forum* (*Journal of Pure and Applied Sciences*). 23*, pp. 85-68.*

Obaje N.G., (2009). *Geology and Mineral Resources of Nigeria. Springer Dordrechi Heidelberg London*, pp, 55-68.

Oyawoye M.O. (1972). *The basement complex of Nigeria in African Geology* edited by T.F.J Dessau Vagie and Whiteman, A.J, University of Ibadan 66-102.

Compliance with Ethical Standards
Declarations

The authors declare that they have no conflict of interest.

Data availability

All data used in this study will be readily available to the public.

Consent for publication

Not Applicable.

Availability of data and materials

The publisher has the right to make the data public.

Competing interests

The authors declared no conflict of interest.

Funding

There is no source of external funding.

Author's contribution: All the authors have contributed equally by attending the field work and data interpretations.