Bima Journal of Science and Technology, Vol. 8(1B) Apr, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i1.638

The Petrology of Granitoid Rocks of Kariya and Environs, Bauchi Province, Northeastern, Nigeria

Idris Ismail Kariya[1], Ahmed Isah Haruna[1], Abdulmajid Isa Jibrin[1], Yusuf Abdulmumin[1], E. E. Ntekim[2], Rilwan Abdulrauf[3], Hamza Yelwa Muhammed[1], Adamu Mukhtar Hassan[1],

[1]Department of Applied Geology, Abubakar Tafawa Balewa University, Bauchi.
[2]Department of Geology, Modibbo Adama University of Technology, Yola
[3]First Bank Nigeria limited

ABSTRACT

The study area received less attention from earlier workers which they consider the rocks as older granites that were barren, but this study show the rocks are part of migmatite Complex and horst mineralized pegmatites. Detailed field mapping and sampling was conducted in order to identify and record the physical features of the rocks. Petrographic studies were also carried out to elucidate their mineralogy and structural features. Field investigations and petrographic studies reveal that the rocks in the study area are metamorphic rocks based on certain structures observed, some of the structures include ptygmatic folding, crenulation cleavage, pinch and swell, undulus extinction and pleochroic halo which are characteristics of metamorphic rocks. Therefore, the area was found to be underlained by migmatite rocks which were classified as banded orthogneiss, straumatic, and nebulitic migmatites and some intrusion of younger granites. Tin, tantalite, tourmaline, lithium and corundum mineralization were inferred.

Keywords: Migmatite, Banded Orthogneiss, Straumatic, Nebulite, Bauchi Province, Ptygmatic folding.

INTRODUCTION

Kariya and environs is located in Ganjuwa local government area, Bauchi State, northeastern Nigeria. Situated within the basement complex of Nigeria where little or no research attention was given. This research work revealed that the rocks formed from series of orogenic cycles that have undergone metamorphism as a result of collision between West African Craton, Congo Craton and south of Tuareg shield Kroner and Stern, (2005), (Burke and Dewey, 1972; Black, 1980; Dada, 2006). The basement rocks of the study area consist of different varieties of migmatite rocks which were later intruded sporadically by the younger granites along the fractured zone commonly observed around Gadan Maiwa, Jangu and Kawarin Gasina areas. Pegmatite dykes, lodes and pegmatite sills were also observed in anisotropic areas while quartz ridges were also observed at Kariyan Gachi, Bakwi and Kariya towns.

Mehnert (1971) employs migmatite terminology based on their macroscopic appearance while Urban (1992); Schulmann *et al,.* (1994); Hasalová *et al,.* (2008) used the two major deformation events recorded in this gneiss-migmatite complex. The deformation phase D1 resulted in formation of steep, west dipping solid-state foliation S1, represented by compositional layering in the banded orthogneisses (Figure 1a). The D2 deformation led to the development of a large crustal-scale shear zone and was associated with reworking and folding of S1 compositional layering that is locally preserved in elongated relict domains (Fiure 1b).

With regard to the above findings, Hasalová *et al.* (2008) classified the migmatites into four

Bima Journal of Science and Technology, Vol. 8(1B) Apr, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i1.638

(4) groups based on structural deformation on the mineral assemblages as follows:

(a) The banded orthogneiss characterized by monomineralic banding, defined by recrystallized K-feldspar, plagioclase aggregates and quartz bands, alternating with layers rich in biotite, garnet, sillimanite and apatite.

(b) The straumatic migmatite which is marked by the onset of disintegration of the original monomineralic banding and is composed of plagioclase and K-feldspar aggregates with subordinate quartz. These aggregates are rimmed by biotite locally overgrown by fibrolitic sillimanite.

(c) The schlieren migmatite, which has K-feldspar– quartz-rich and plagioclase–quartz-rich aggregates. The original banding is distinguishable only from the modal content of the mineral phase dominant in these feldspar aggregates.

(d) The nebulitic migmatite that represents the most isotropic rock type, completely lacking relics of the original gneissosity. The migmatite occurs as irregular flat bodies or elongated lenses.

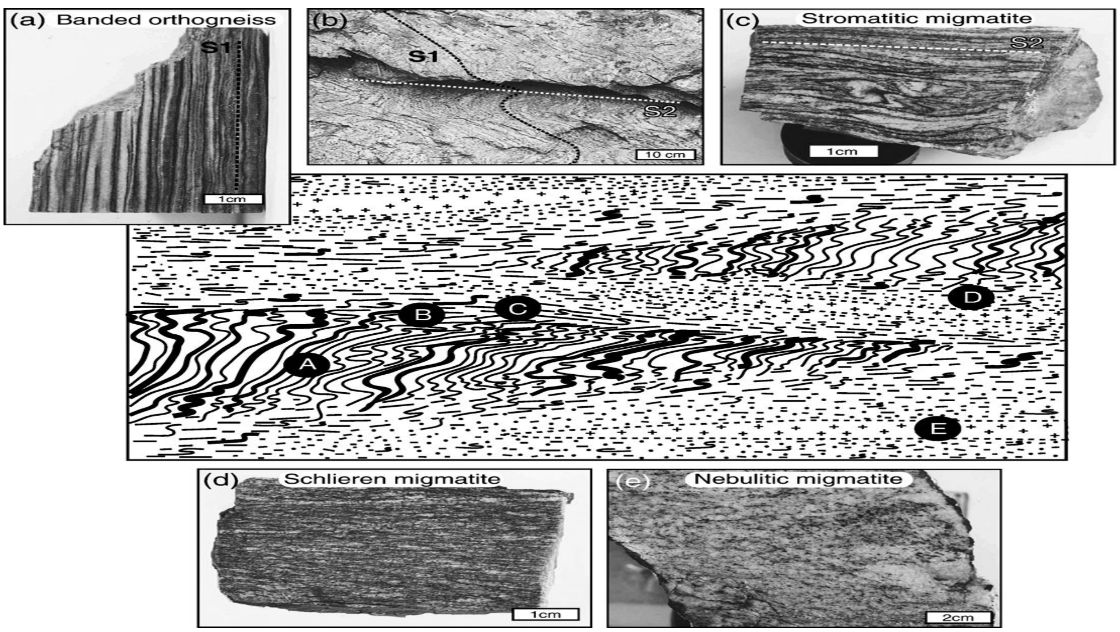


Figure 1: Sketch showing the individual gneiss and migmatite types and their relationships within an outcrop. Banded orthogneiss with distinct S1 compositional layering (a) is folded and transposed (b) to the straumatic migmatite (c) that passes gradually to the schlieren migmatite (d) and finally to the completely isotropic nebulitic migmatite with no relics of gneissosity (Adapted from Hasalová et al., 2008).

REGIONAL GEOLOGICAL SETTING

The term 'Pan-African' was coined by WQ Kennedy in1964 (Kroner and Stern 2005) on the basis of an assessment of available Rb-Sr and K-Ar ages on mobile belts formed in Africa *500* Ma ago. The term Pan-African is now used to describe tectonic, magmatic, and metamorphic activity of Neoproterozoic to earliest Paleozoic age. Kroner and Stern (2005) described eastern part of the belt consists of a high-grade granite gneiss terrain of the Nigerian province partly consisting of Paleoproterozoic rocks which were migmatised at 600 Ma. This deformation and metamorphism are considered to have resulted from oblique collision of the Nigerian shield with the west African Craton basement, followed by anatectic doming and wrench faulting Kroner and Stern, (2005) figure 2. The Nigerian basement complex forms part of the Pan-African mobile belt and lies between the West African and Congo Craton and south of Tuareg shield (Burke and Dewey, 1972; Black, 1980; Dada, 2006).

Ajibade *et al.,* (1989) geologically divided the Nigerian basement complex into the western and eastern provinces and geographically into three viz; the western Nigerian basement complex, the eastern Nigerian basement complex and the northern Nigerian basement complex.

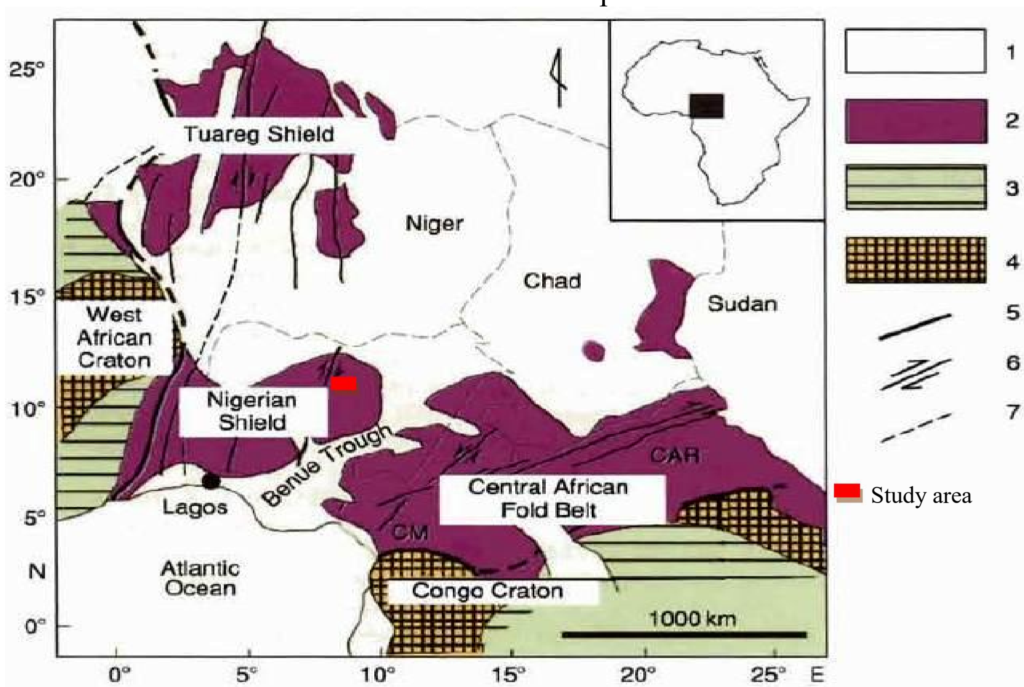


Figure 2: A Sketch map showing Pan-African domains in West central Africa. 1, Post-Pan-African Cover; 2, Pan-African domains; 3, pre-Mesozoic platform deposits; 4, Archaean to Palaeoproterozoic cratons; 5, craton limits; 6, major strike-slip faults; 7, state boundaries. CAR, Central African Republic; CM, Cameroun. Adapted from Kroner and Stern (2005).

These basement complexes occupy three geographical regions in the country (figure 3). The western Nigerian basement complex constitutes the southwestern part of the country and extends into the Republic of Benin. The eastern Nigerian basement complex, believed to be a westward extension of the Cameroon basement complex into Nigeria, occupies three regions (Hawal Massif, Adamawa Massif and the Oban Massif) along the country's eastern border with Republic of Cameroon (Okezie, 1974; Ajibade *et al.*, 1989; Elueze, 1999; Haruna, 2016). The northern Nigerian basement complex covers an extensive area north of rivers Niger and Benue and is composed of schist belts in the western part and large masses of granitoids in the central and eastern parts intruded by the younger granites around Jos. The three basement regions are separated from one another by Cretaceous to Recent sedimentary basins Haruna (2016). The granitoids of

Bima Journal of Science and Technology, Vol. 8(1B) Apr, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i1.638

Bauchi are part of a large volume of crystalline rocks in the eastern margin of the northern Nigerian basement complex also intruded by the younger granite of Zaranda and Burra-Ningi-Warji-Gwaram-Shira ring complexes (Haruna, 2016). The basement rocks occupy about half of the land mass of the country (Black, 1980).

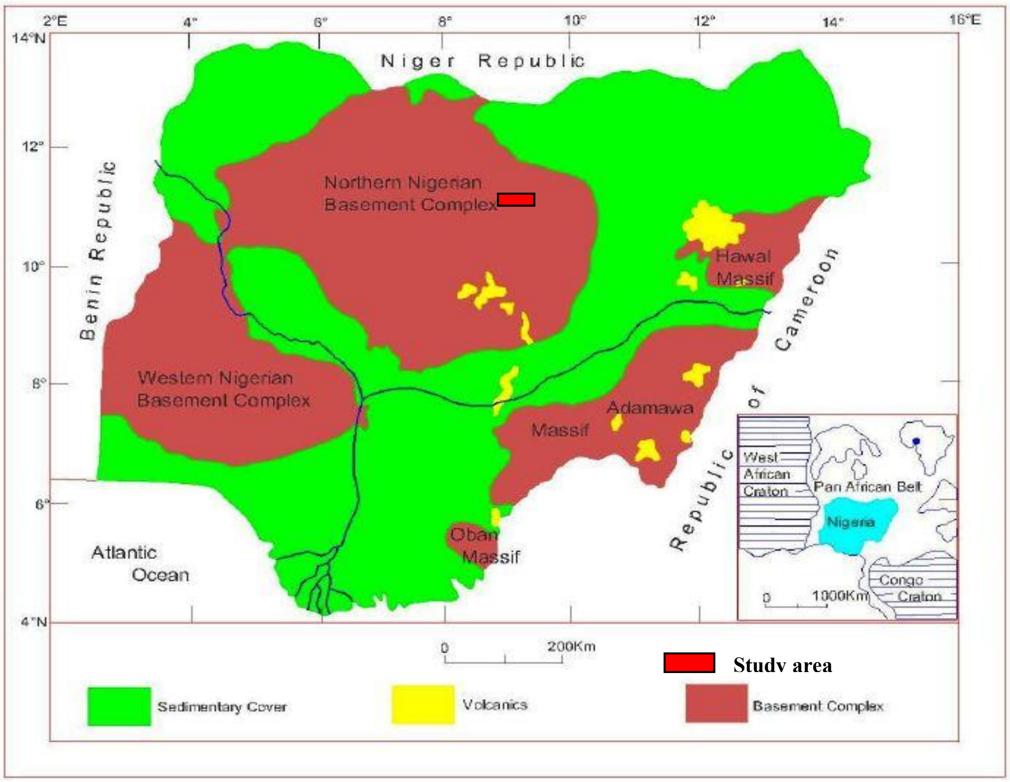


Figure 3: The Nigerian Basement Complex Provinces (after Haruna, 2016).

The migmatite–gneiss complex (MGC) is generally considered as the basement complex sensu- stricto (Rahaman, 1988; Dada, 2006) and migmatite-gneiss-quartzite complex (Rahaman and Ocan, 1978). It is the most widely spread of the component units in the Nigerian basement with heterogeneous assemblage of migmatites, orthogneisses, paragneisses, and a series of basic and ultrabasic metamorphosed rocks Dada, (2006). Evidence of Pan African reworking have been seen in petrographic studies displaying medium to upper amphibolites facies metamorphism, Rahaman (1988). The migmatite–gneiss complex has ages ranging from Pan-African to Eburnean. Lithologically, similar rocks in other parts of Nigeria especially in the northeast and southeast, have given only Pan-African age (Tubosun, 1983).

MATERIALS AND METHODS

Various materials were used during the research:

Topo Map of the study area was used to demarcate the area of interest and all possible features were noted on it. Relevant field materials were used in collecting the samples and measurement were taken for structure observed during the field work.

Field Method

Traversing method was used at the beginning of the field work to identify the area of study and compare with the information acquired from Topo-map as reconnaissance. Thirteen different samples at different locations were collected from the field for petrographic studies and hand specimen description.

Petrographic analysis: Was carried out at Abubakar Tafawa Balewa University Bauchi. Thirteen different samples were selected for petrographic studies. After preparing the slides high powered electronic microscopic was used to identify mineral contents and possible microstructures within the rock samples.

RESULTS AND DISCUSSION

The study area consist of three main varieties of migmatite observed during field work and petrographic studies which include: Banded orthogneiss, schlieren cum-diatexite migmatites. The banded orthogneisses were exposed at Filin Shagari and Gadar Maiwa towns, whereas schlieren cum-diatexite at Natsira, Mai-alewa and Kariya towns. The field work carried out show that the study grades from low grade migmatite from western part into medium to high grade migmatites to the central and eastern part.

The occurrence and associations of the various rock types observed in the field are signatures of their genesis. Hand specimen of various rock types sampled at different locations were observed in the field and interpreted based on major rock forming minerals (mineralogy), colour, structures and textural characteristics.

In figure 5a, the rock observed was dark in colour, medium to fine grained and formed as low-level outcrop along the stream channels. The rock is characterized by monomineralic banding with thin films of light-colored minerals. The rock is referred to as banded orthogneiss.

The rock unit in plate 1b has alternation of leucosomes and melanosome (light and dark colors) with low relief. The foliation planes are well developed in the mafic part of the rock and in some places; some metamorphic structures were observed e.g. ptygmatic folding, crenulation cleavages, vein reflection and vein refraction, indicating effect of shear stress. The banding is less than that of banded orthogneiss and the monomineralic minerals were disintegrated by light color minerals forming alternation of light and dark color minerals. It means that the migmatite graded from banded orthogneiss into straumatic as a result of increase in quantity of felsic materials into mafic, thus forming larger bands of mafic and felsic mineral. This rock unit is termed straumatic migmatite. Most of the rocks in the study area suffered from regional metamorphism in which some rock units clearly display the effect of shear movement as seen in figure 5c.

The geologic map of the study areas was produced figure 4 showing the rocks within the study area which help in synergizing the field work and the petrographic studies.

DOI: 10.56892/bima.v8i1.638

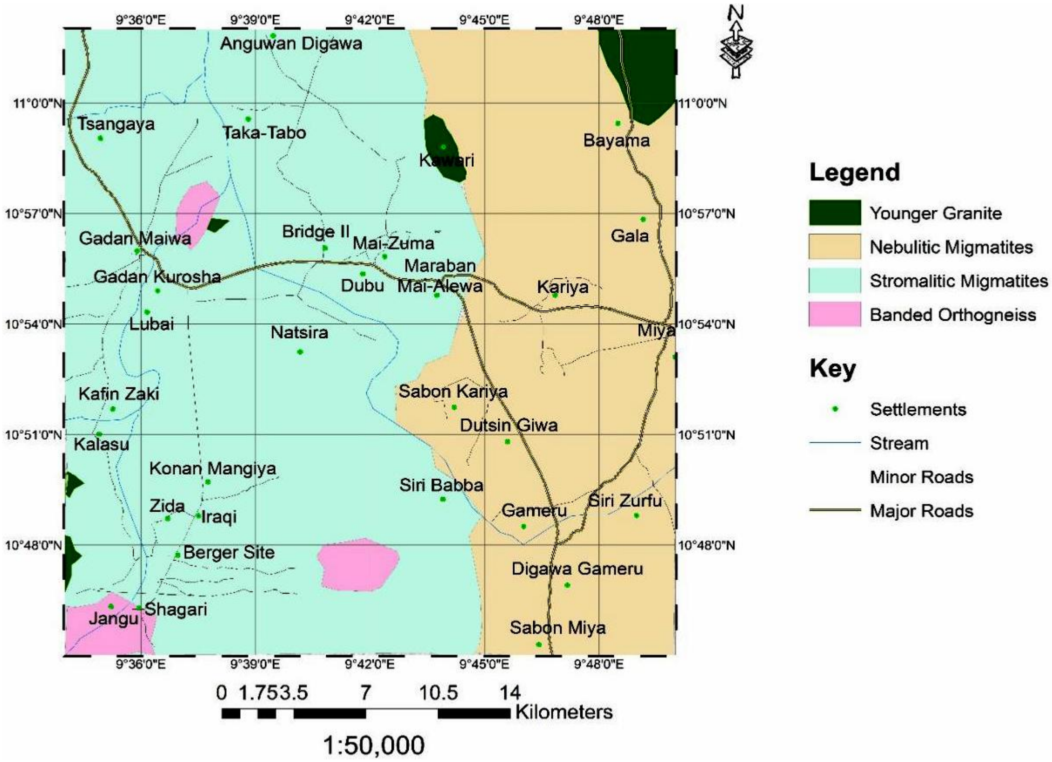


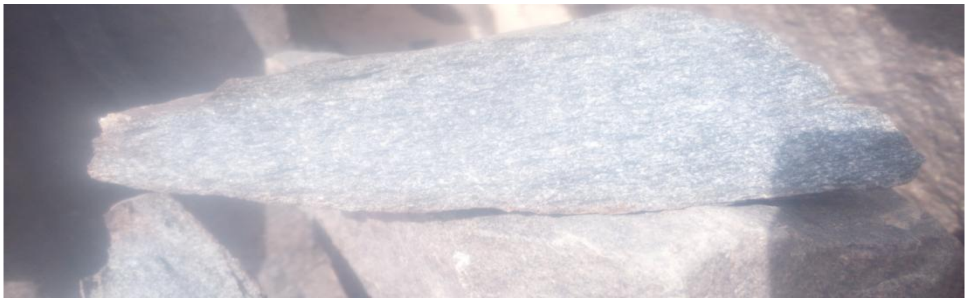
Figure 4: Geologic map of the study area.

In some place dykes, veins and fractures cross cut each other and some are parallel (figure 6b), some show vein reflection where the fluids are homogeneous and vein refraction if the fluids are heterogeneous. Some pegmatites are discordant and tabular, with some felsic rocks intruded concordantly along a foliation plane, while some intrusion of biotite granites occurred sporadically along discordant planes (figure 7). Textures observed ranges from coarse, medium to fine grained. Rocks observed during the field work have relief ranging from low to medium to high especially towards the isotropic areas. The field structures observed are the signatures of their tectonic history that affected the area. The general trends of dykes range from N242W to N352W and S108E to S148E and some N02E to N05E and foliation planes measured are E-W.

The pegmatites which were found to be LCT-type (Lithium, Cesium and Tantalum) are the useful structures hosting mineralization. Pegmatite occurred as load and dykes as seen in some locations. Location GMB01A and KRO4A the pegmatites are hosting dead beryl at Gadar Maiwa and Kariya towns, GMB01A and NT01A & NT02A bears black tourmaline (schorl) at Natsira town and locations GMB01B, KR04A and KRO1 hosting tantalite; lithium, rutile and amethyst minerals at Kariya and Gadar Maiwa towns.

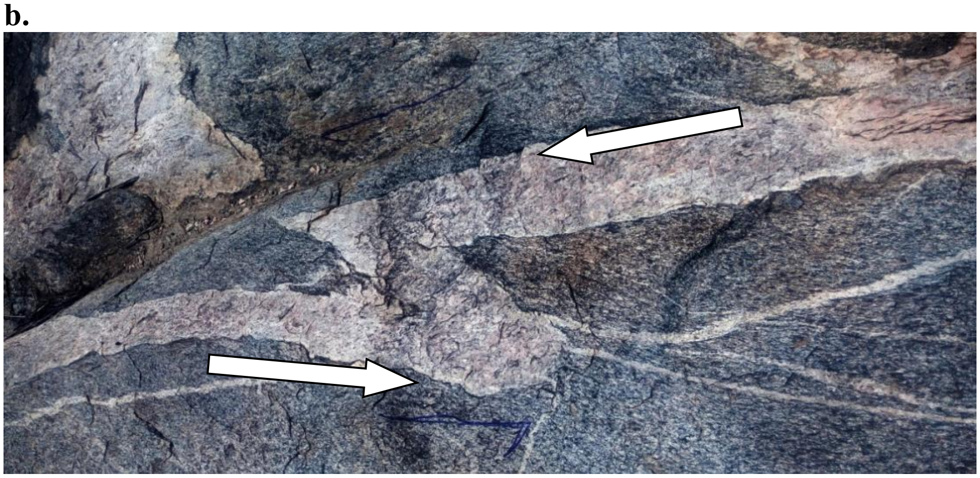
Bima Journal of Science and Technology, Vol. 8(1B) Apr, 2024 ISSN: 2536-6041

DOI: 10.56892/bima.v8i1.638



a.

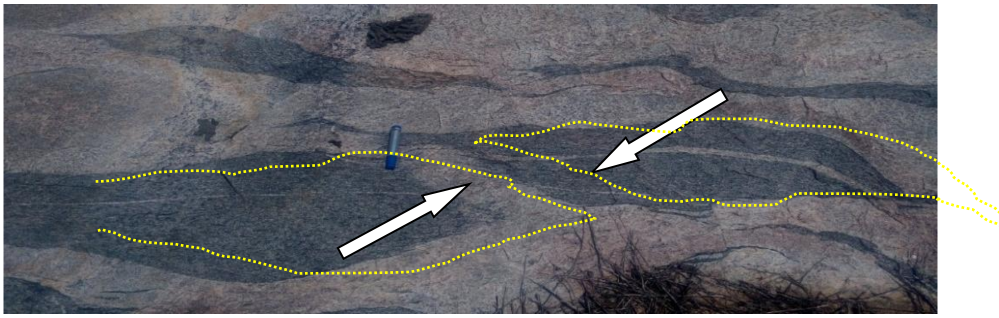
b.



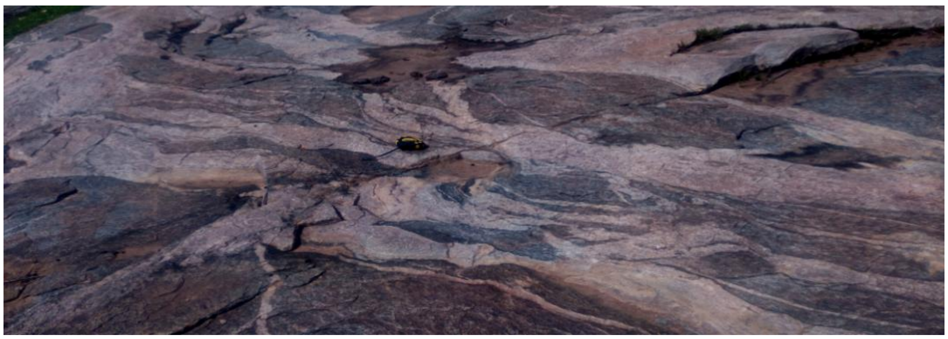
c.

Figure 5: Field view of banded orthogneiss (a), straumatic migmatite (b), shearing in migmatite rock (c).

Bima Journal of Science and Technology, Vol. 8(1B) Apr, 2024 ISSN: 2536-6041
DOI: 10.56892/bima.v8i1.638



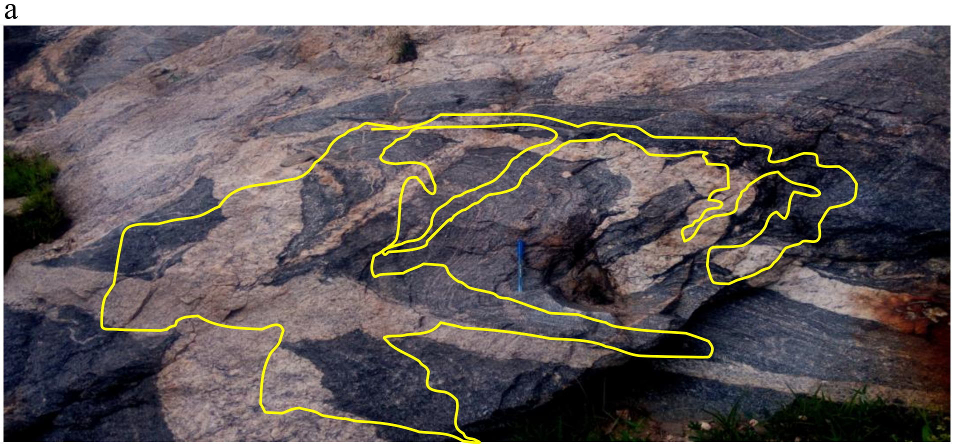
a



b.

Figure 6: Field view of pinch and swell (a), cross cut (b), flow structure in migmatite rock

a



b

Figure 7: Field views of (a) pegmatite dyke; (b) effect of shear stress causes contortions.

DOI: 10.56892/bima.v8i1.638

Based on field work conducted it was observed that the study area was underlain by metamorphic rock, specifically migmatites formed from high grade regional metamorphism. The migmatites rocks within the study area graded from banded orthogneisses, straumatic and nebulitic migmatites as classified by Hasalová 2006.

Deformation structures observed also confirmed that the rock units in the study area are migmatites. These structures (deformation) include; ptygmatic folding, crenulation cleavages, pinch and swell, foliation, dykes and veins in which some are deflected; these structures are as a result of shear stress that affected the area (figure 6).

Petrography

Petrographic studies were done using electronic microscope and camera, where the slides were viewed both under plane polarized light and cross polarized light. Certain features were observed and identified under magnification 4x10 (40µm). Since the area was metamorphic terrain, for this research work, petrographic studies will give more emphasis on metamorphic structures and relate it with the structures observed during the field work.

Under plane polarized light the biotite show spindle shapes (figure 8a); under cross polarized light wavy extinction undergone by quartz was observed in (figure 8b). In figure (8c& d) ptygmatic folding was observed in both plane and cross polarized lights with quartz displaying undulus extinction under cross polarized light (figure 9d).

Evidence of shear stress was observed under cross polarized light in (figure 9b) which results into the formation of boudinage (pinch and swell) on brittle minerals (quartz); undulus extinction of quartz (figure 9b). A pleouchroic halos was also observed on some slides especially (figure 9a) under plane polarized light with some biotites being stretched since they are ductile minerals and under cross polarized light wavy extinction displayed by quartz (figure 9b).

In pegmatite the feldspar display carslbad twinning and show evidence of shear stress vindicated by ground masses of crushed quartz (figure 9d).

In figure 10b quartz minerals and plagioclase feldspar displaying polysynthetic twinning was observed; deep blue colouration of muscovite with alteration of pinkish colouration under cross polarized light, quartz and plagioclase feldspar was observed in (figure 10d) the rock is pegmatite.

DOI: 10.56892/bima.v8i1.638

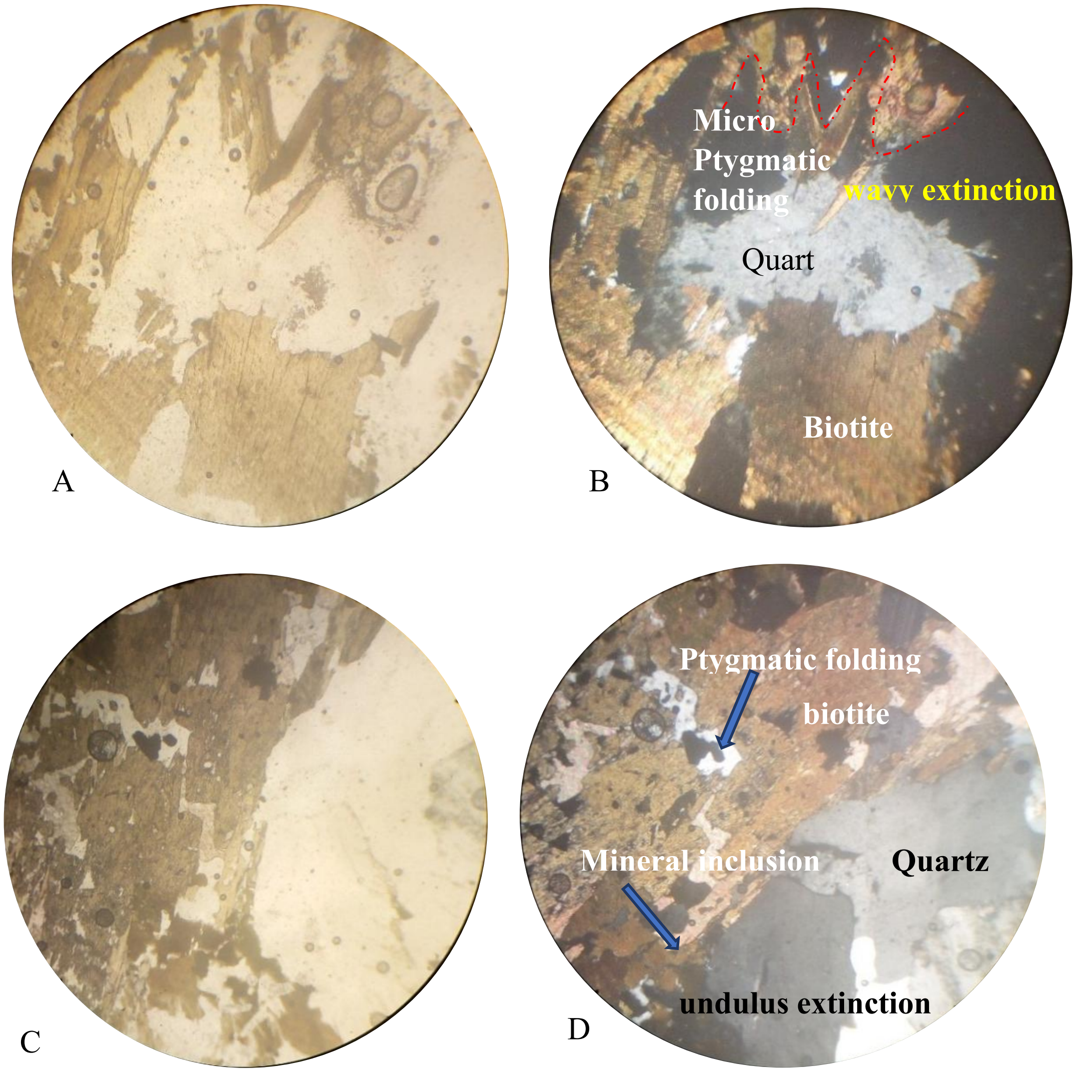


Figure 8. Sample 3a (migmatite) showing elongated biotite minerals (a), undulus extinction of quartz (b) inclusion of minerals along ptygmatic folding, quartz and biotite (c & d).

DOI: 10.56892/bima.v8i1.638

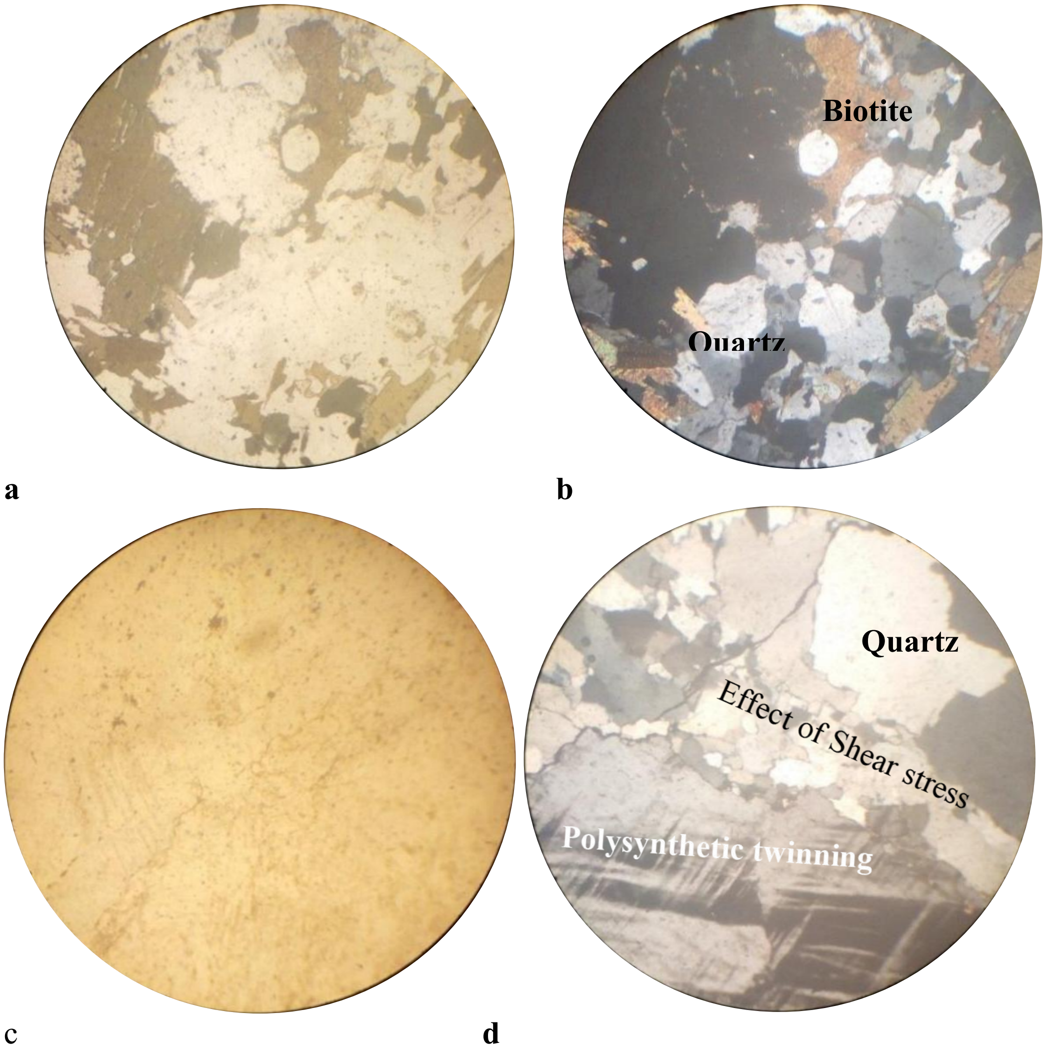


Figure 9: Sample 5 (migmatite) showing pleochroic halo quartz and elongation of biotite minerals (a & b) and sample 10a (pegmatite) showing wavy extinction, polysynthetic twinning (plagioclase feldspar) and quartz, evidence of shear stress (d).

DOI: 10.56892/bima.v8i1.638

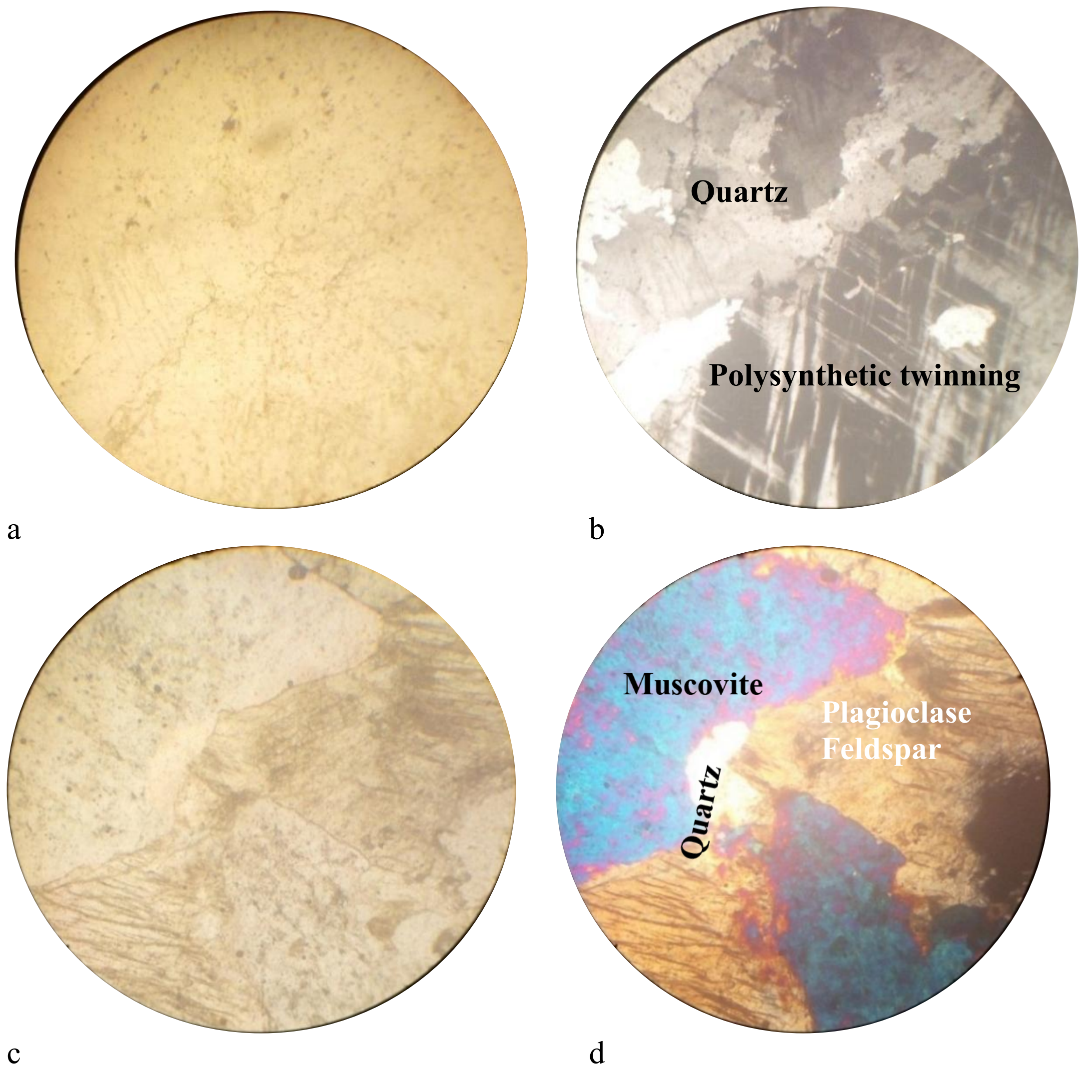


Figure 10: Sample K01 (pegmatite) showing Carlsbad twinning (Feldspar) and quartz (b), Sample K02 (pegmatite) showing muscovite navy blue, Feldspar and Quartz minerals (d).

CONCLUSION

Based on the research work carried out on the granitoids of Kariya and environs the following conclusions were made:

1. The migmatites in the study area are classified into**;** banded orthogneiss, straumatic and nebulitic migmatites.
2. The rock units in the study area have mineralogical composition of biotite, quartz, plagioclase, alkali feldspars, sillimanite and opaque minerals.
3. The pegmatites are mineralized hosting dead tourmaline, beryl lithium and tantalite.

Acknowledgements: The Author wish to acknowledge all staff of Applied Geology, My supervisor in person of Professor A.I. Haruna, Directorate of Research Innovation and Development, ATBU Bauchi, Dr. A.I. Jibrin, Rilwan Abdulrauf, Abdullahi Bunasai Ningi, friends and family.

REFERECES

Ajibade, A. C. (1979). The Nigerian Precambrian and the Pan-African

Orogeny. In: The Precambrian Geology of Nigeria P.O. Oluyide (Eds.); *Proceedings of the first symposium on the Precambrian Geology of Nigeria. Geological Survey of Nigeria, pp. 45-53.*

Ajibade, A. C., Woakes M. and Rahaman M. A. (1989). Proterozoic crustal development in the Pan-African regime of Nigeria.

Black, R. (1980) Precambrian of West Africa. Episodes, 4, 3-8.

Burke, K.C. and Dewey, F.J. (1972) Orogeny in Africa. In: Dessauvagie, T.F.J. and Whiteman, A.J., Ed., African Geology, Ibadan University Press, Ibadan, 583-608.

C. A. Kogbe (Rev. Ed.). Geology of Nigeria 57-69. Elizabethan publication company, Lagos, Nigeria.

Dada, S.S. (2006) Proterozoic Evolution of Nigeria. In: Oshi, O., Ed., Elueze, A. A., 1999. Petrochemical variations and petrogenetic trends of some iron Ores in southwestern Nigeria. Mineral wealth, 110: 59-68

Haruna, I. V. (2016). Lithology and field relationships of the Bauchi granitoids northeastern Nigeria. *International researchers Journal of earth sciences 4(6), 30-41.*

Hasalová P., Lexa O., Stipska P., Hrouda F., Ulrich S., Haloda J. and Tycova P. (2008). From orthogneiss to migmatite: Geochemical assessment of the melt infiltration model in the Gföhl Unit (Moldanubian Zone, Bohemian Massif). *Journal of Metamorphic Geology*.

Kroner, A. and Stern, B. (2005). Pan-African Orogeny north African Phanerozoic Rift valley. *Encyclopedia of geology vol.1*, Elsevier, Amsterdam.

Liegeois J. P. and Black R. (1987). Alkali magmatism subsequent to collision in the pan-African belt of the Adrar des iforas. In: Fitton, J.G., Upton, B.G.J (Eds.). *Alkaline igneous rocks,* 30, 381-401. The geological society, Blackwell Oxford.

Mehnert, K. R. (1971). Migmatites and the Origin of Granitic Rocks. Elsevier, Amsterdam.

Okezie, C.N. (1974) Geological Map of Nigeria, Scale 1:2,000,000. Geological Survey of Nigeria, Abuja.

Rahaman, M.A. (1988) Recent Advances in the Study of the Basement Complex of Nigeria. In Precambrian Geology of Nigeria, Geological Survey of Nigeria, Kaduna South, 11-43.

Rahaman, M.A. and Ocan, O. (1978) On Relationship in the Precambrian Migmatite-Gneiss of Nigeria. Journal of Mining and Geology, 15, 23-30.

Schulmann, *et al.,* (1994). Steady state flow and rheology of deformed Erzgebirge granitoids. Journal of the Czech Geological Society, volume 39, issue 1, 96.