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Integrating GIS and Field Geology in Interpreting the Structural Orientation of Miango and Environs, Jos Plateau of Nigeria

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ABSTRACT

Integrating GIS and field geological studies has provided the basis for a re-examination of the structural geology of the area, and has enhanced a new interpretation of the structural orientation of Miango and environs to be made. In addition to detecting structures(faults, fracture system), a number of important structures were mapped and analysed using the imagery, and the resulting map represents a modification from the existing publications. The analysed structures were interpreted in form of lineaments which show dominant trends of NE-SW, NW-SE, and N-S.Direction statistics and rose diagrams for all the interpreted linear features acquired in the study area by field geological observation were also prepared. The dominant trends of N-S, NW-SE and NE-SW respectively correspond to the general trend of Precambrian to Cambrian rocks in Nigeria, including rocks of the Basement Complex, as a result all the rock types are said to be Pan-African in age. These coincidence of structural orientation of landsat lineaments and field structures clearly brings to bear that their integration is highly significant in tracking geological structures relevant to mineralization and groundwater occurrence (fracture in the form of faults, shear zones, etc) within Miango area. They are complementary.

Key words: *Structural Orientation, GIS, Lineament, Rose Plot*

1. INTRODUCTION

Structures are the imprints of deformation on rocks which include joints, dykes, foliations, veins, folds etc. Such structural features exhibit variable trends in conformity with the general fracture pattern recorded in the Basement and Younger Granite province of Nigeria. These structures are believed to have resulted from intense regional tectonism that preceded and accompanied the emplacement of the Older Granites during the Pan-African Orogeny which produced a well defined and extensive N-S trend in North central Nigeria including the Miango area.

The origin of these structures cannot be totally related to tectonism and accompanying deformations, but they may have been due to tensional forces set up as a result of cooling. The objectives of the research work were to study the structural orientation of the crystalline rocks of Miango and environs. This can be achieved by

a. Lineament study using GIS to delineate geologic structures.
b. Geological and Structural geological studies of the area with the aim of identifying geologic structures observed in (a) above

1.1 Location, Accessibility and Areal Extent

The study area is located in Bassa Local Government Area, which is situated in the northern fringe of Jos, the Plateau State capital (Fig. 1). It lies between latitudes 9^0 49' 02''N and 9^0 52' 36''N and longitudes 8^0 39' 06''E and 8^0 43' 18''E(Naraguta 1:50,000 sheet 168 NW).

The main access route to the area is the Jos-Miango major road (Fig 1). The minor accessory roads and foot path as well as cattle tracts, which aided access to the interior parts of the area are linked to the major road. The minor roads and foot paths link different settlements and villages within the study area and this acted as major links to outcrops during field work mapping.

1.2 Relief and Drainage (Geomorphology)

The study area has a distinct and rugged topography with hills of different heights (Fig 1). The drainage pattern is mainly dendritic. It has various tributaries, rivers and streams most of which take their source from surrounding hills. This drainage pattern is typical of crystalline basement environment and depicts the homogeneity of the rock.

The area is drained by River Nge'll and other smaller rivers and streams. The river at the eastern part flow westwards though an aqueduct. The streams and rivers in the area are seasonal with the water having their highest flow in the rainy season around August and lowest flow during the dry season around March.

The relief of the study area is relatively high with highlands situated at the western, north western, southern and the north eastern parts.

The low lands are mainly on the central parts of the area with undulating landscapes. Both the plains and some of the hills have been extensively affected by weathering and erosion.

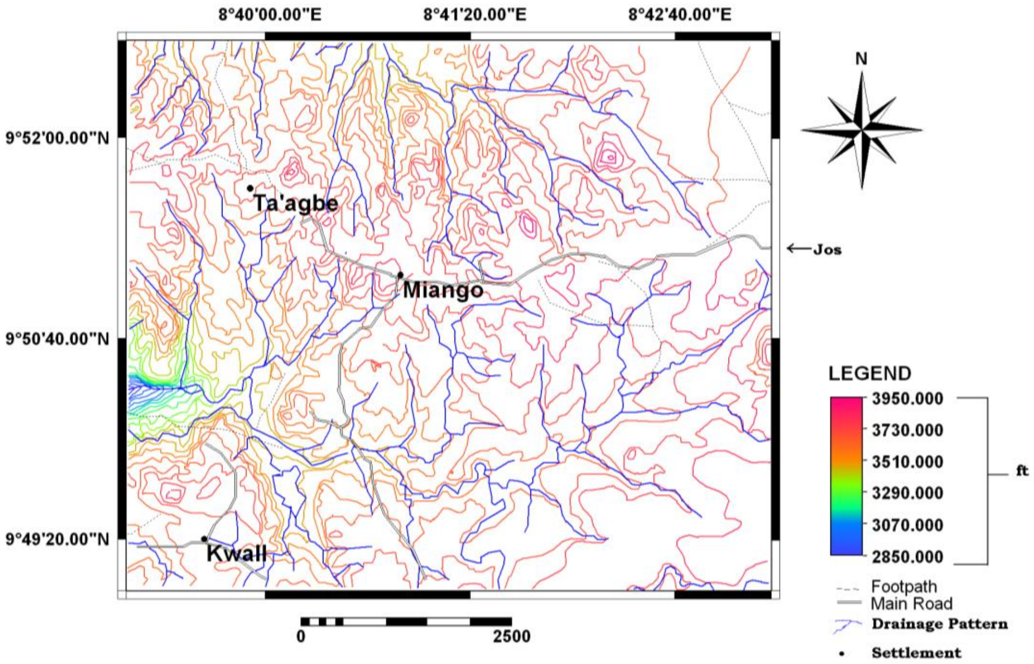

Fig.1: Relief and drainage map of study area

1.3 Regional Geologic Setting

The study area is composed of rocks of the Precambrian to mid Cambrian and Jurassic northern Nigeria crystalline shield (Schoeneich, 1991). The basement complex within this shield is of Precambrian to mid Cambrian age (600 ± 150 Ma) whereas the younger granites which are anorogenic and intrusive into the basement are of Jurassic age (150 Ma). The area is underlain by basement complex rocks which are mostly migmatites (fig.2) although exposure of these rocks is limited, they are seen outcropping at the north-eastern and north western part of the study area. The out crops are of low relief when compared with the porphyritic biotite granite and hornblende granite. The contact between the migmatites and the porphyritic biotite granite is gradational with structural conformity. Other rock units include older basalts located around the southern and central parts of the study area. The older basalts are generally small, eroded and partly decomposed remnants. The newer basalts which occur chiefly as flows within the basement especially at the north-eastern and south-eastern parts of the study area are dark coloured, fine grained and composed mainly of plagioclase feldspars, olivine and quartz.

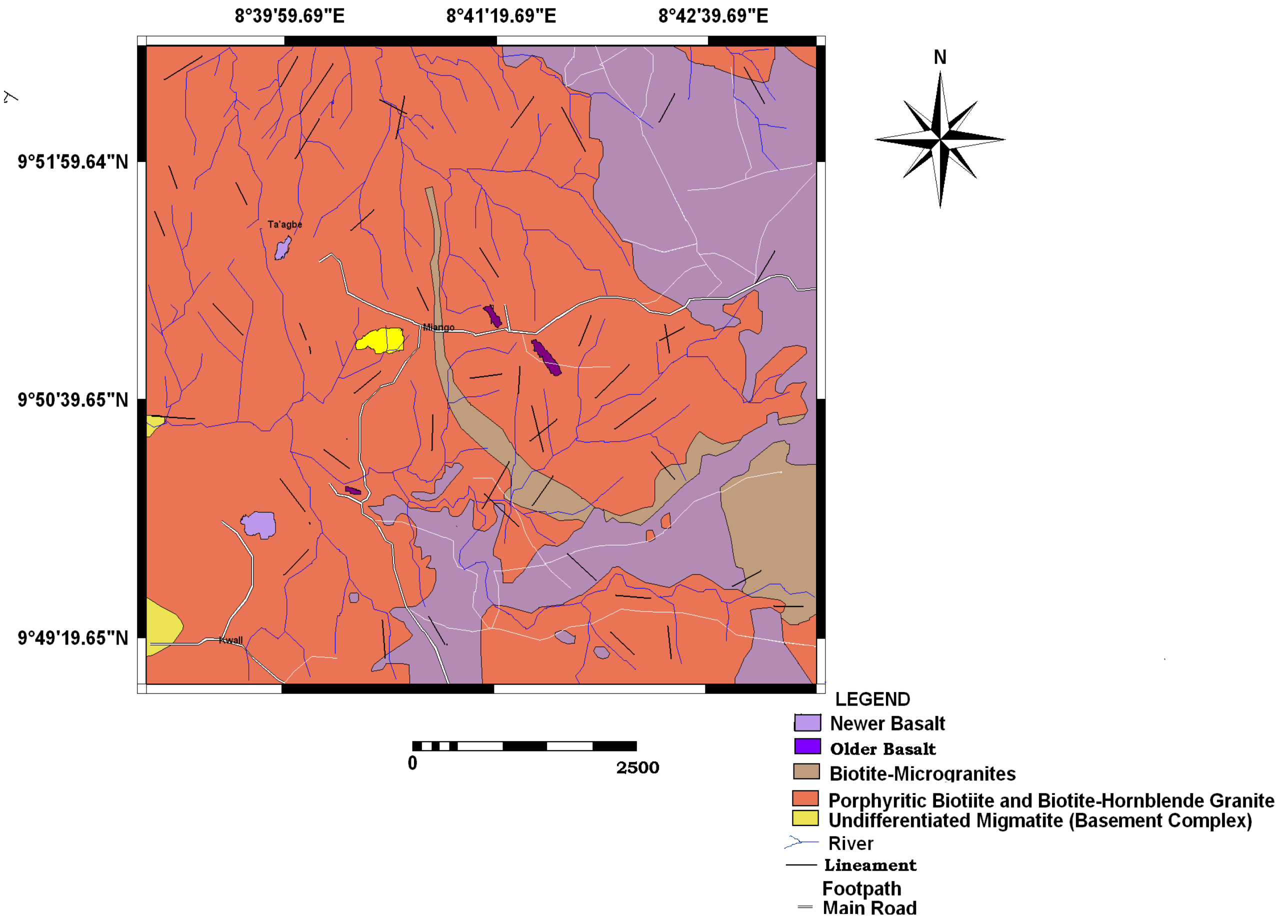

Fig.2: Geologic map of study area

2. MATERIALS AND METHODS

2.1 Landsat Image Identification

Satellite images are measurements of reflected solar radiation, energy emitted by the earth itself or energy emitted by radar system that is reflected by the earth. These images consist of arrays of pixels (picture elements) which are ordered in rows and columns and each pixel has a digital number (DN) that represents the intensity of radiation of the earth's surface. An image data may consist of many spectral bands usually in blue, green and red bands of the visible light and infrared bands, and each band is created by the sensor that collects energy in specific wavelengths of the electromagnetic spectrum,. For these images to be useful as data sources for particular applications, they have to be processed so that the desired features can easily be extracted. Therefore the main objectives here are to rectify the image and visualize it for information extract and optimum interpretation.

For this study, the Landsat 7 ETM + image data was used. Table 1 summarizes the application of the Landsat spectral bands. Band 7 of this image data., according to this table is useful for the discrimination of minerals, rock and structural types (Lillesand and Kieffer, 1994). Images acquired in this band have high information content, i.e. there is large variation in the spectral response of materials in the environment. This is because Band 7 is the least affected by atmospheric attenuation compared with the reflected infrared bands. Landsat 7 also carries a panchromatic band (Visible through near infrared) with 15-m resolution for "sharpening" of multispectral images.

Figure 3 illustrates the image of this band over the study area. The enhancement of the image was achieved using the image histogram equalization with 10% stretching interval. The stretched image was sharpened through the use of directional filters in order to emphasize the linear features. The enhanced image(Fig. 3) shows increased contact and sharpness between geologic feature and improve the recognition of subtle differences.

Table 1: Applications of Landsat spectral bands (Global Land-Observing Program, 2003).

S/N	Band Designation	Spectral Bands Used
1	Blue-green	Useful for bathymetric mapping and distinguishing soil from vegetation and deciduous from coniferous vegetation
2	Green	Emphasizes peak vegetation, which is useful for assessing plant vigor
3	Red	Discriminates vegetation slopes
4	Reflected IR	Emphasizes biomass content and shorelines
5	Reflected IR	Discriminates moisture content of soil and vegetation; penetrates thin clouds
6	Thermal IR	Useful for thermal mapping and estimated soil moisture
7	Reflected IR	Useful for mapping hydrothermally altered rocks associated with minerals deposits.

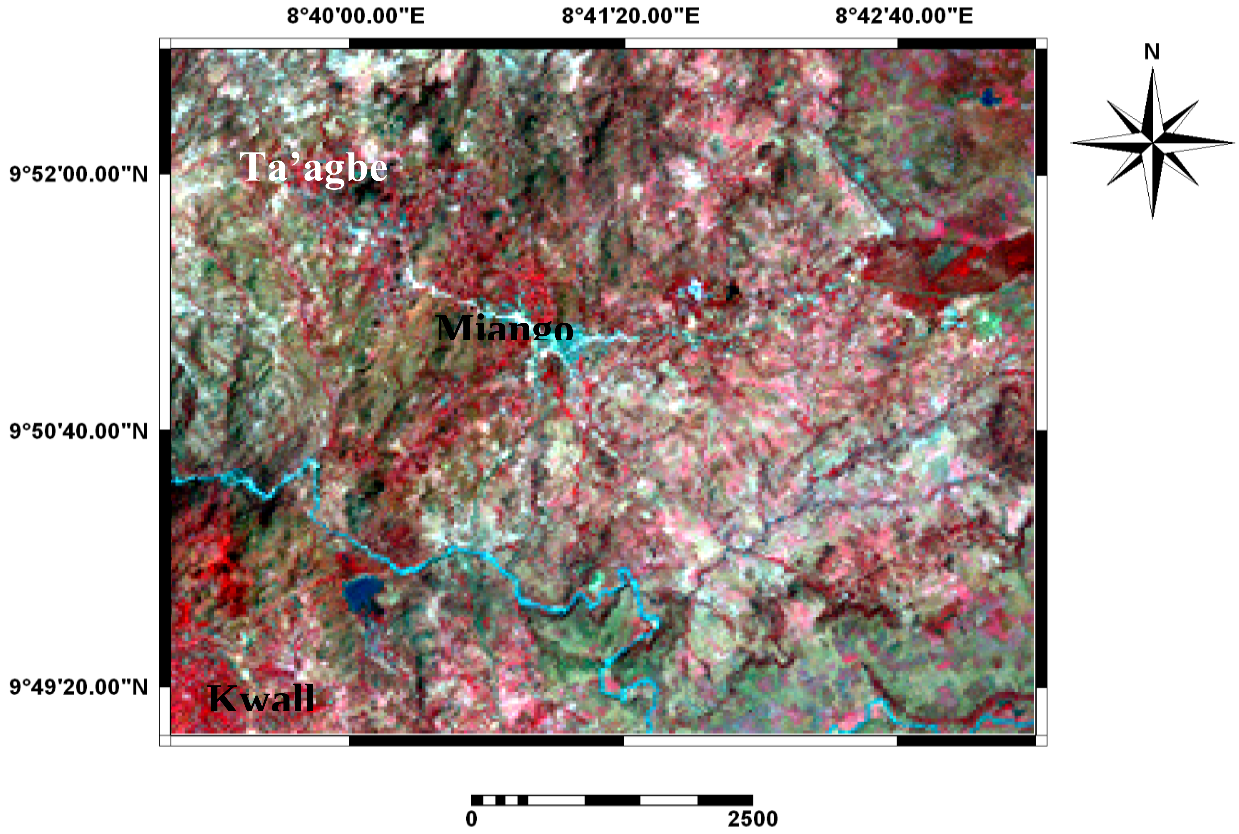

Fig.3: Landsat image of study area

3.2 Field Geological Observation

Fractures and Joints

Fractures represent any break in a rock whether or not it causes displacement due to mechanical failure by stress. It includes cracks, joints and faults.

Joints on the other hand are fractures on rocks in which there is no relative movement along the fracture planes. They are linear structural features resulting from the fracturing of brittle rocks. They are the most common structural features observed within the study area (plate 4). The strike reading of the joints on the porphyritic biotite granite show trends of NE – SW, N-S while migmatites indicate a trend of E-W. (Figs. 4 and 10).

Plate 5: Joints on the porphyritic biotite granite of Miango area

Foliation

The term foliation is a general term sometimes used as essentially synonymous with cleavage, but it is applied most generally to mineral alignment in metamorphic rocks and sometimes in igneous rocks (older granites). Thus, salty "cleavage" and "schistosity" are special types of metamorphic foliation characterized by the types of fabric or mineral arrangement commonly found in slates and schists. Foliation is mostly used for metamorphic fabric like migmatite gneiss.

Foliation is formed as a result of static pressure that act on the pre-existing rock changing the platy mineral such as mica and amphiboles contained in the rock structurally to a new form. The presence and degree of foliation in a rock helps in knowing the rock type and condition under which the rock was formed.The dominant trend is NE-SW for both the porphyritic granite and the migmatites.

Plate 6: Foliation on the Migmatite of Miango area

Veins

These are tabular or sheet like bodies of mineralization which were introduced into fissures and joints within the study area. They are brought about by the infilling of fractures by mineral fluid before recrystallization. Most of the veins are quartz veins, although, some are fine grained felsic materials. In some places the size of the quartz vein is as thick as 17cm. Plate 6 shows a typical quartz vein within the area. The dominant trend is N- S, NE-SW.

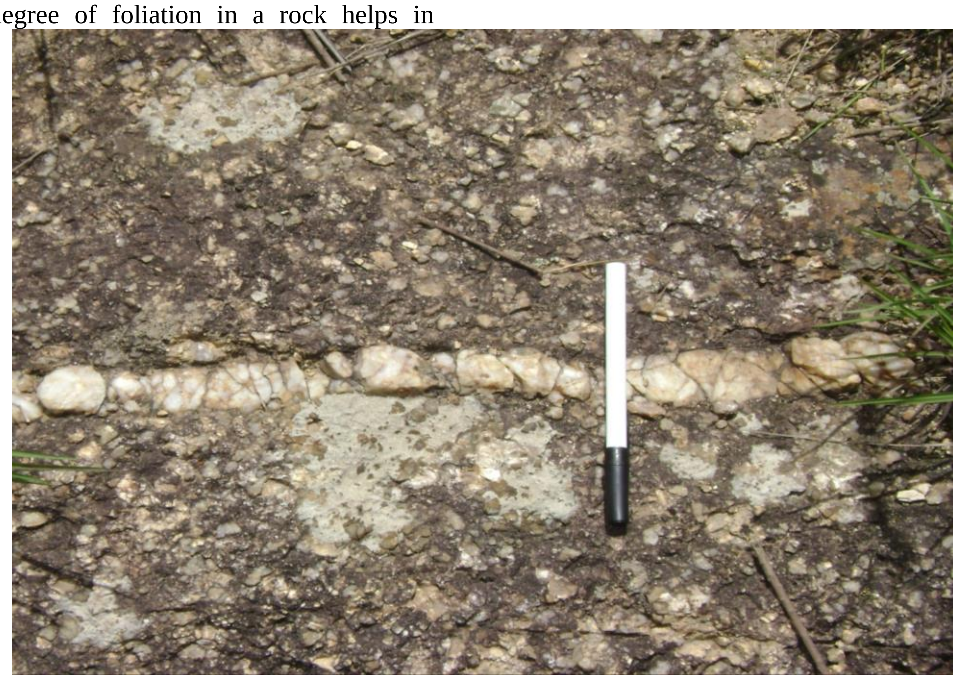

Plate 7: Quartz Vein in part of Miango area

3. RESULTS AND DISCUSSION

3.1 Lineament Interpretation

The lineaments were extracted and analyzed with respect to the local geology and drainage pattern (since natural water courses are invariably structurally controlled) of the study area. These were assembled to give the lineament map of the study area (Fig.4)This method of representation shows the distribution of lineaments over the study area and it is useful in the sense that it offers a quick glance of the spatial distribution and density of lineaments and so provides a useful database in mineral exploration, geophysics, hydrogeology, water borehole drilling, road and dam location and alignments, environmental planning as well as potential hazard monitoring and control (Odeyemi et al, 1999).

Analysis of Landsat image indicates NE-SW, NW-SE and N-S trends to the majority of lineaments. These coincide with the general trends of geologic structures of the study area.

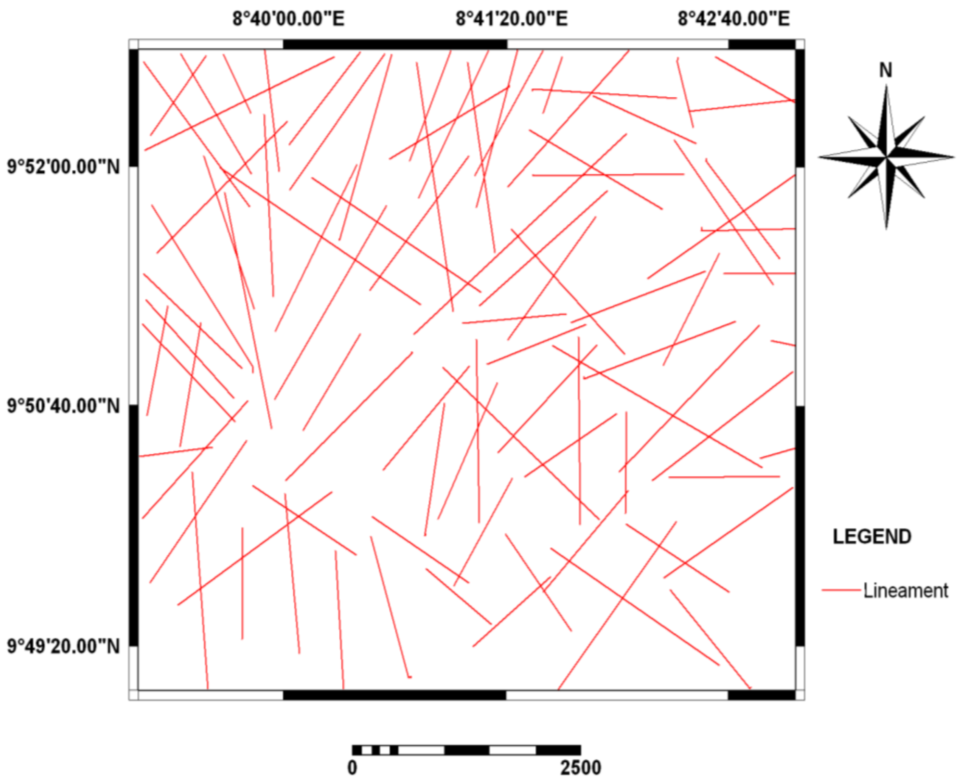

Fig. 4 Lineament map of study area

3.2 Field Structural Interpretation

The field data generated were interpreted using rose plots. The dominant trends of N-S, NW-SE and NE-SW respectively correspond to the general trend of Precambrian to Cambrian rocks in Nigeria, including rocks of the Basement Complex, as a result all the rock types are said to be Pan-African in age(Fig.5-10) .

These structural features could have different relative periods of tectonism and metamorphism in the study area. The rock structures exert important influence upon the activities and pattern of rivers. This could be related to the courses of river channels in the study area.

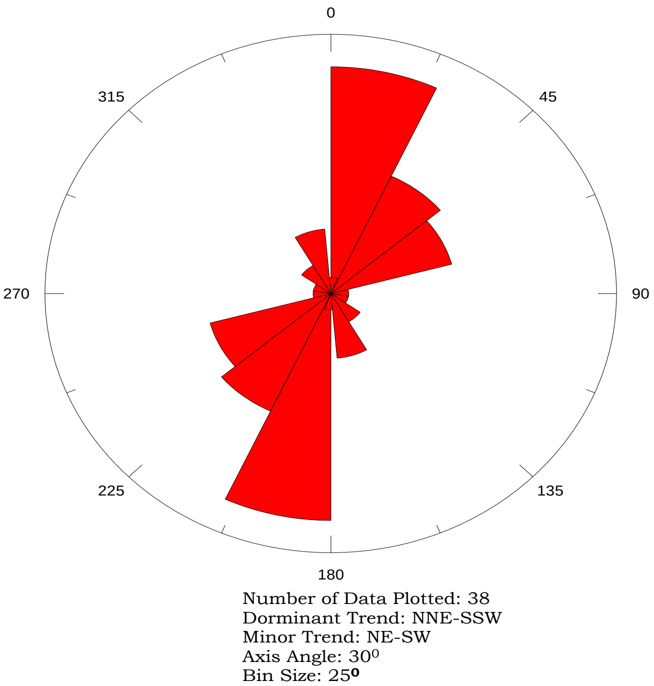

Fig.5: Rose Plot of strike of foliation on porphyritic biotite granite within the northern part of study area

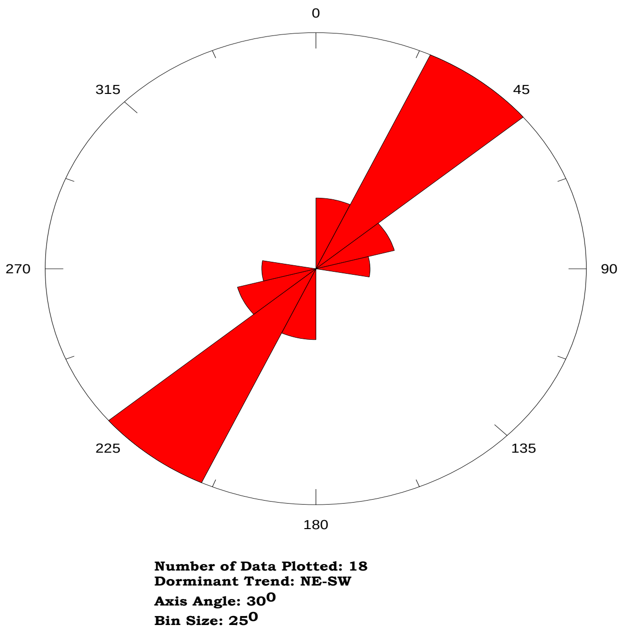

Fig.6: Rose plot of foliation on Porphyritic biotite granite within the Central part of study area.

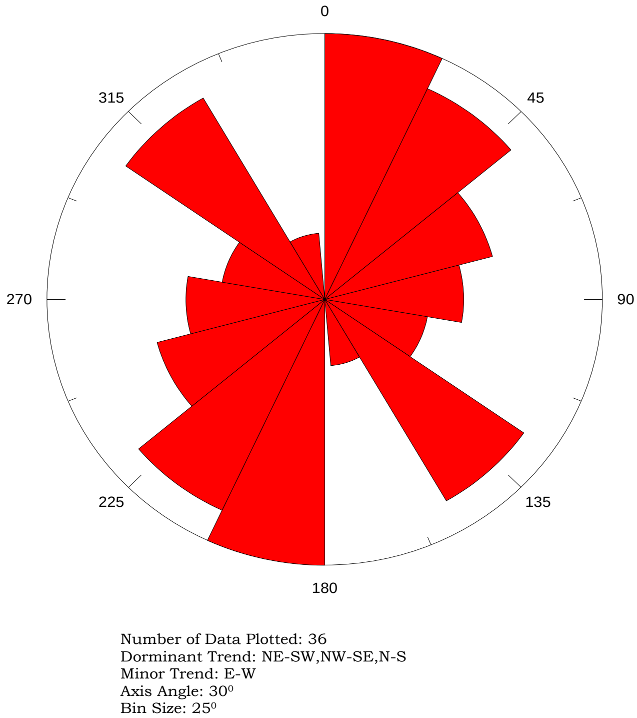

Fig.7: Rose plot of joint strike on porphyritic biotite granite within the southern part of study area.

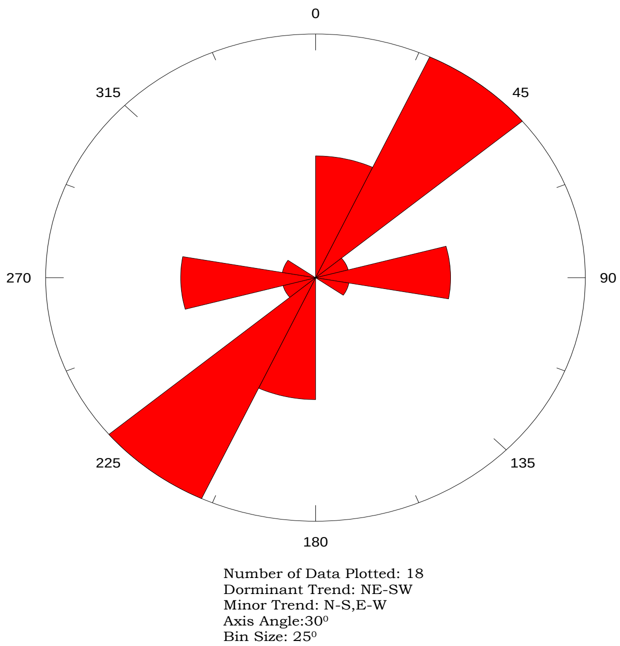

Fig.8: Rose plot of joints on porphyritic biotite granite within the southern part of Miango area.

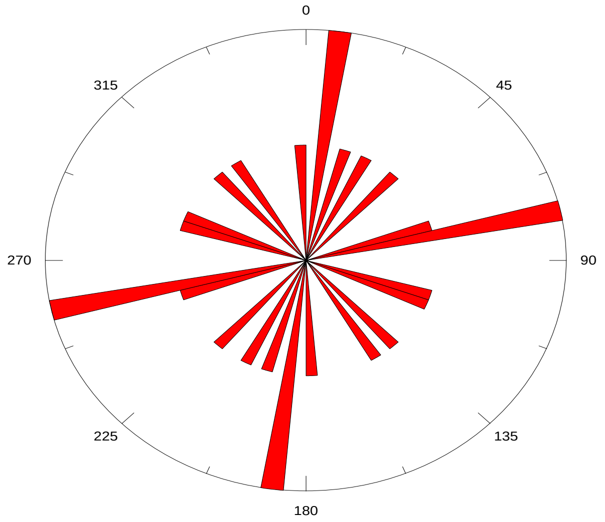

Fig 9: Rose plot of strike reading of foliation on migmatite in Miango area

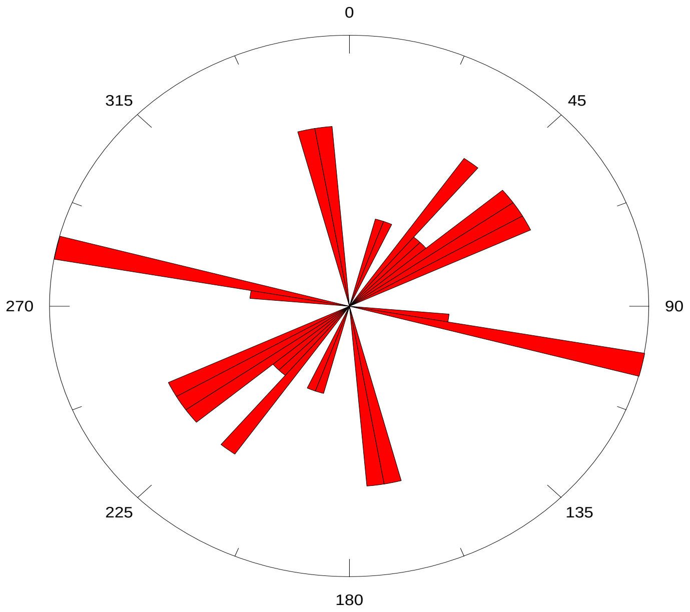

Fig 10: Rose plot of joints on the migmatite in Miango area

4. CONCLUSION

The structural orientation in the study area has greatly controlled the geological setting, relief and drainage, geological boundaries and trend of younger rocks. Generally, the nature and extent of structures depends on the duration and intensity of deformation.

The trends of the field observation also confirm what is obtainable on the Landsat Image of the study area.The geological structures relevant to mineralization and groundwater occurrence (fracture in the form of faults, shear zones, etc) within Miango area are predominantly tectonic in origin. And the presence of tectonic structures is an indication of deformative stresses, both on regional and local scales. The geological structures were investigated as lineaments. A lineament refers to a linear topographic feature possibly related to an underlying structure such as a fault, fracture zone or lithologic contact (Scalon, et al., 2002). Generally, regional linear or curvi-linear features expressing deep-seated geological structures are usually visible on remote sensing image products such as aerial photographs or satellite imageries.

It should be mentioned that some lineaments, mapped from the remote sensing data were not present in the geologic maps, which suggest that this image lineament interpretation provides new geologic perspectives even in an area which has been well mapped because of mineral and Water exploration.

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