Lineaments Characterization of Shira Complex, Bauchi State Nigeria

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ABSTRACT

In this study, a process of identifying and analyzing linear features on satellite imagery is used to understand the underlying geological structures like faults, joints, and fractures. This analysis involves extraction of the linear features, classifying them by orientation and density, to determine their tectonic significance. The case study area is Shira complex in Bauchi state Nigeria, the area is characterized by rough topography with outcrops of a volcanic rocks, granitic and migmatite-gneiss. Lineaments are widespread and dense around the complex, occurring in areas of high elevation, and slope gradient. Terrain roughness indices are high at the outcrops and lineament sites. Streams in the area exhibit variable flow and partly align with the lineaments. The high profile index observed have tectonic essence and are related to the occurrence of lineaments, strain domains, and high degree of rock weathering, erosion and human activities.

Subject terms: Geology, Structures and lineaments

INTRODUCTION

Following the recent complain from Shira community on the series of earth movement and sound in Shira town, Bauchi state. Earth movement and sound causing cracks on houses that created panic and uncertainty among the resident was heard on;

1. December, 2024 at 12:45am
2. 7th April, 2025 at 12:15am
3. 9th April, 2025 at 9:36pm
4. 11th April, 2025 at 09:03pm
5. 13th April, 2025 at 12:05am

The community is worried about the potential risk involved, there’s need to investigate the structures of the area so that the causes of the sound and cracks on the buildings within the community can be investigated further

So, to embark on this investigation a geologic structural investigation is needed to find out the factors responsible for such activities especially visible surface expressions, which can also be created by other processes such as human activity

Area of study

Shira is a Local Government Area in Bauchi State, Nigeria. Its headquarters is in Yana town, situated about 20 kilometers from Azare town along Azare-Yana road (figure 1).

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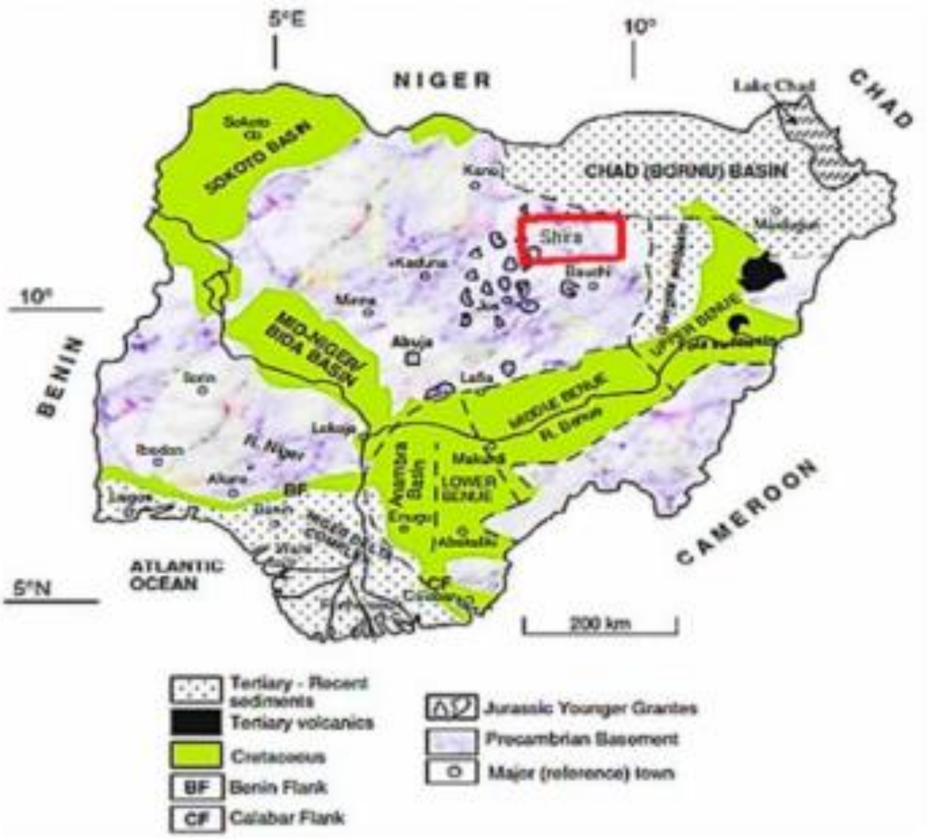
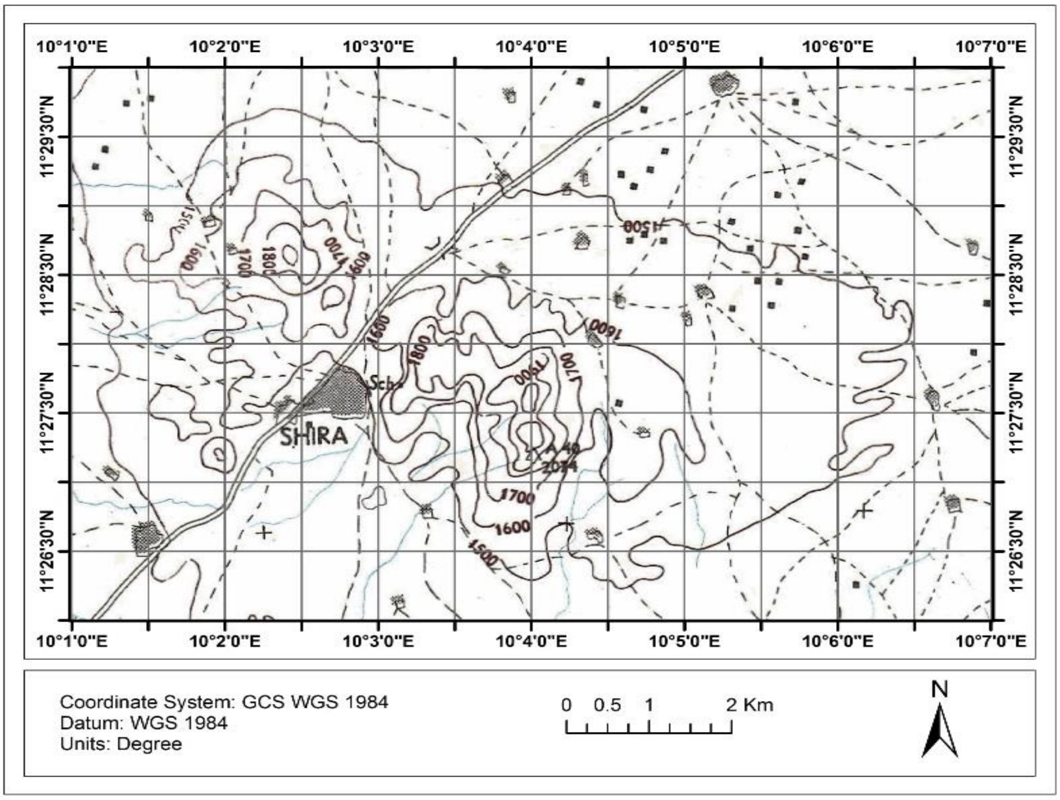
Figure 1: Geological map of Nigeria showing study area, after Obaje, 200



The area of study is located between latitudes 11°25'N-11°30'N and longitudes 10°00'-10°07'E. (Figure 2).

Fig. 2 Location of Shira



Aim and objectives

The aim of the research is to investigate the lineaments characterization of Shira complex.

The aim is achieved by mapping, measuring, and analyzing structural features of Shira complex, which is identified from satellite imagery.

Methods

The Satellite imagery data used in the research is acquired from LANDSAT-TM which covered an area located between latitudes 11°25'N-11°30'N and longitudes 10°00'-10°07'E. Geological mapping of the area to study the lithology of the rock types and sample the rocks types to measure the rock geometries and reconstruct their deformational histories, calculate the stress field that resulted to their deformation.

Justification and Contribution to Knowledge

i. The investigations of lineament characterization using Satellite imagery will help in understanding the underlying faults, fractures, and other structural elements that can help in understanding regional tectonic frameworks of the area.
ii. Lineament density map shows the total length of lineaments within a given area
iii. Examine the rock's physical characteristics and structure, which can influence the sound it produces.
iv. The research will guide the community on development of building and land-use planning that minimize earthquake risks

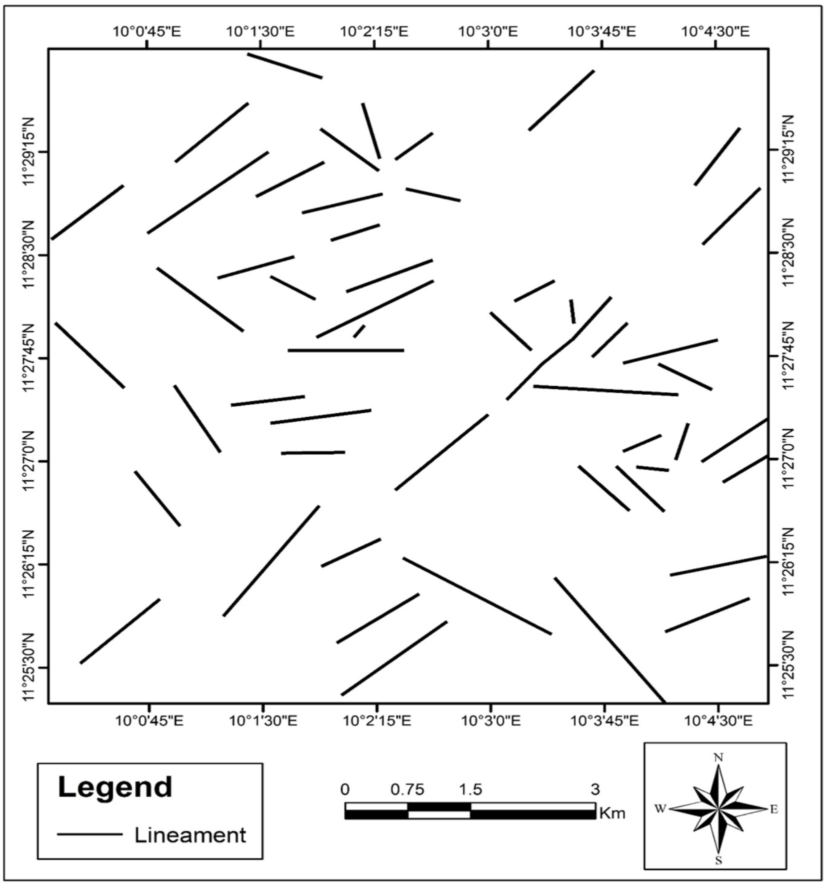
Geology of the Area

The geology of Shira was investigated by Woolley, 2001, which is part of the West African craton's crystalline basement (Rocci *et al.*, 1991). The three exposed hill complexes consist of one main ridge and two smaller secondary ridges which cover an estimated area of 152 km² with the largest outcrop of Sarkin na Dutse about 633.37m height above sea level, the two lower outcrops known as minor ridges are less exposed in the area are part of Shira Younger Granite Complex, which is composed of peralkaline syenites and granites. Key rock types include aegirine-arfvedsonite granite, birji granite, and Shira quartz syenite, often rich in dark, ferromagnesian minerals like arfvedsonite and aegirine. A related intrusion of granite porphyry is found to the southwest. The geology of the area varies from quartz syenite to granite with Biotite granite dominating the central portion of the sloppy area (Woolley, 2001). The area is dominated with granite and migmatite, and is sandwiched in some areas by the Kerri-Kerri sedimentary formation.

Results

The lineament extraction process identifies various lineament parameters, including the beginning and endpoint coordinates, direction, and length. In this study, edge enhancement filters were used to enhance linear features (Figure 3). Similarly, lineament and lineament length density maps are presented in Figure 4. Thus the result of the structural analysis revealed that numerous fractures and lineation occur at the northwestern and southeastern parts of the study area. The major orientations of the lineation are in the NE- SW, NW-SE and E-W directions. The length of all of lineaments were measured, computed and used to generate the rose diagram shown in Figure 6. The trend surface analysis of the structural features of the complex in relation to the lineaments based on the rose diagram revealed several trends of the lineaments in the NE-SW, NW-SE and E-W directions with the major and dominant structural trends being in the NE-SW and NW-SE directions.

Fig. 3: Lineaments orientation map



Analysis of lineament density reveal variable lineament density values across the study area (Fig. 4). Areas with high density are associated with the occurrence of outcrops, intersecting to abutting lineaments, and high lineament clustering. This indicates high degree of lineament connectivity Palamakumbura *et al.*; (1985*)*. The behavior is manifested as low medium and high lineaments density, where high lineament density is revealed by intersection and abutting relationships between lineaments, and a moderately to highly rugged terrain as represented with red colour. Several deformation-related features which indicate the occurrence of high strain domain that may enhance fracture density are also identified in the vicinity of the complex. These are variably oriented linear features which deform folded or dome-like, high elevation, rock blocks across the area. On the contrary, intermediate to low lineament density values observed in the eastern and western sections of the study area are due to the paucity of outcrops there as represented with ash and green colours respectively (Fig. 4). Hence, areas with high lineament density are likely to be the most deformed, while areas with low lineament density are expected to have lower degree of deformation.

Consequently, the variable lineament density and lineament distribution patterns in the study area may be due to lithological or structural controls (Nelson,1985). The preferential clustering of the fractures in the study area as confirmed on the lineament density map indicates that the area was more evidently deformed than surrounding areas i.e., a high strain domain or that the rocks in the central area/core were more sensitive to brittle deformation. Watkins *et al.*; (2015), suggest that enhanced straining will cause increased fracture intensity. The center of the study area, where outcropping rocks were identified corresponds to exposed sections of the younger granite complex, which has been suggested to be better deformed more than the surrounding migmatite country rock (Oyedele, 2015). This deformation likely represents imprints of emplacement tectonics, which generally predisposes the granitic outcrops in the study area to higher degree of deformation unlike the surrounding areas where observation suggests lower degree of deformation. The study suggests that the variable lineament density and lineament distribution in the study area are dictated by the rock type and degree of deformation. In addition, the abundance and paucity of outcrops in the area corresponds to the distribution of lineaments in these areas. Hence, the distribution of lineaments in the Shira complex is primarily controlled by the emplacement of volcanic rocks distribution.

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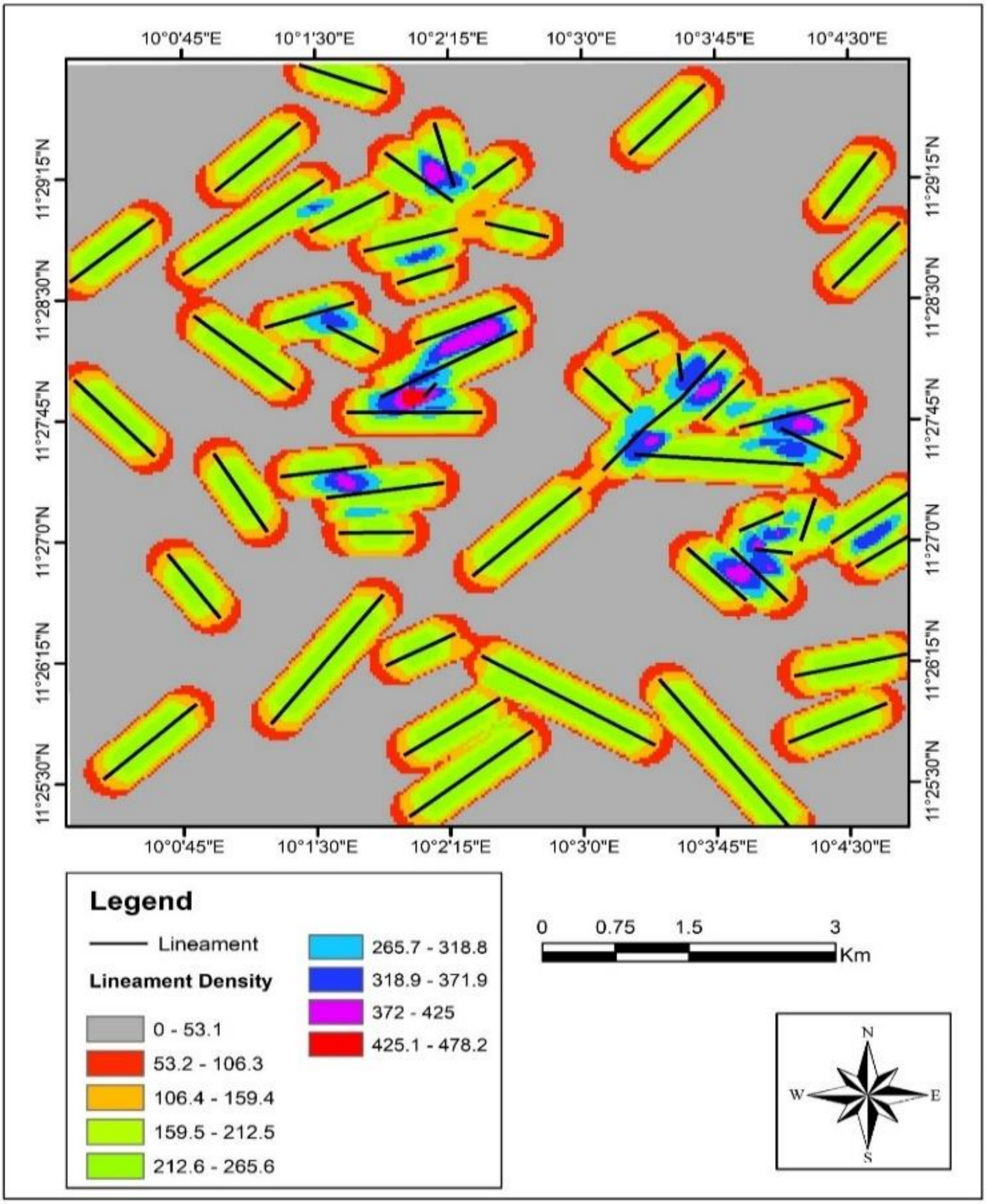
Fig. 4: Lineament density map



The Landsat-TM data of the study area was digitally processed and enhanced to color composites, and classified images complemented by digitized geologic maps of the study area. Drainage patterns and textures, bare rocks and vegetated areas were enhanced in single band images. The color composites were used as background data for both supervised and unsupervised image classification. The Landsat-TM data obtained was further subjected to various image enhancement and transformation routines. For image enhancement, three bands (RGB) colour composites were created. Figure 5 show typical composite maps generated in the study area.

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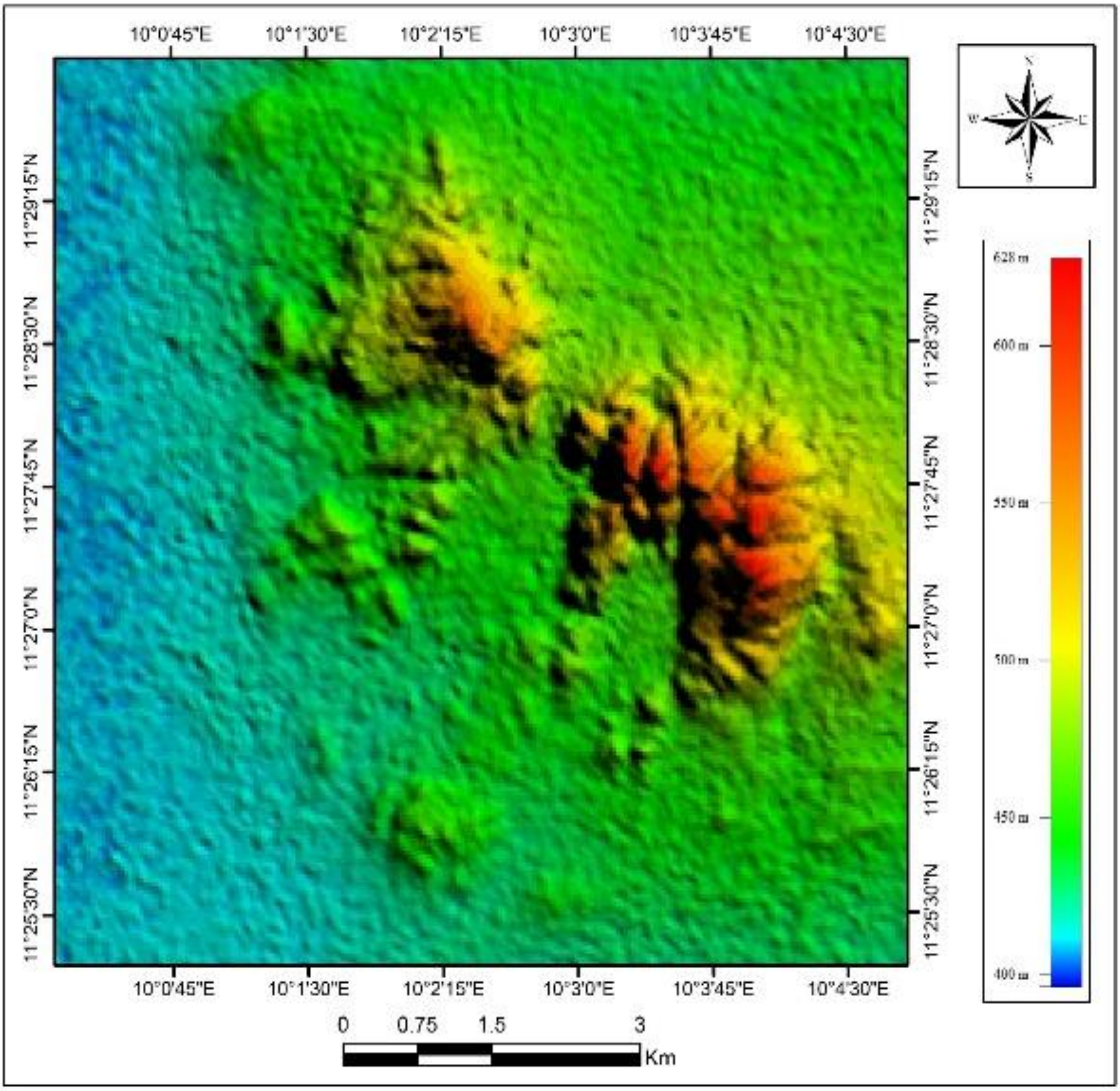
From the generated colour composites, yellow colour corresponded to higher elevation of the volcanic rocks while the green colour represents the intermediate topography and the blue colour corresponds to the lower topography of the basement complex rock as represented on figure 5. In addition, the correlation of the lineament map and the volcanic rocks distribution revealed that the emplacement of the lavas and the granitic rocks may have been controlled by ring fracturing and large-scale cauldron subsidence (Ananaba, and Ajakaiye, 1987). Besides, the granitic bodies are generally fractured and fissured with these weak zones which influenced the creation of quarry in the area and also used as pathways for the greisenisation fluids for mining activities.

Figure 5: A color composite map of Shira complex



Shira Complex show the directional orientation of structural features, such as joints or dikes, which are influenced by the underlying geological forces. Shows peaks of directional data along these trend lines, reflecting the regional tectonic stress that guided the flow of magma and the subsequent fracturing of volcanic rocks. Figure 6 diagram produces six (6) numbers of trends with one primary (1^0) trend of N320^0 W with one secondary (2^0) trends of N55^0 E with one tertiary (3^0) trends of N350^0 W and two quaternary (4^0) N65^0 E, N335^0 W and one pentagonal (5^0) trends of N315^0 W.

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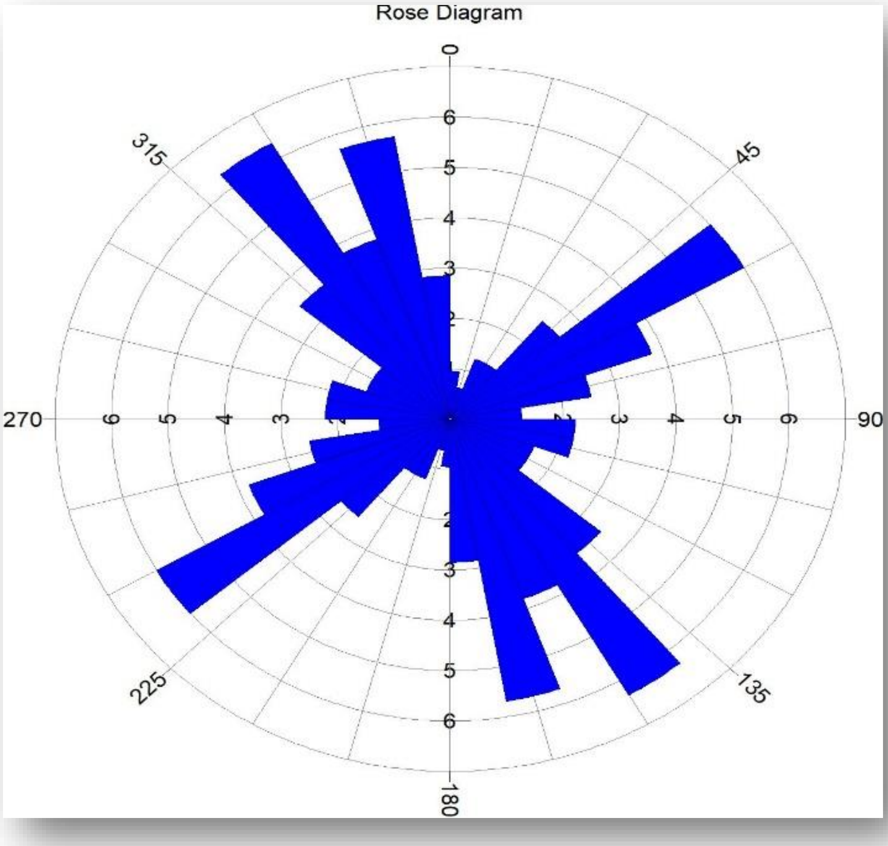
Figure 6: Rose Diagram



DISCUSSION

Structural interpretation in the study area revealed four structural trends in the NE-SW, NW-SE, N-S and E-W directions with the dominant trends being in the NE-SW and NW-SE directions. Generally, the fractures in the Nigerian Basement complexes and associated areas are oriented in four principal directions: E-W, NE-SW and NW-SE Bala, et al.; 2000, Chukwu-Ike and Norman 1997. The E–W fractures are discernible locally, having been overprinted by latter events. The E-W fractures are very prominent and are often conformable with other geological trends. They have been identified on “imageries” as depressions and prominent scarp surfaces and appear to have determined the causes of the major N-S flowing streams. They are traceable across most part of the country. The E-W fractures are also found on both sides of the River. These fractures are products of brittle deformation and are marked in the field by considerable shearing and brecciating. There is no doubt that the fractures are of regional extent as similar structures have been identified in the Tuareg area of Niger Republic. Furthermore, each complex often exhibits a centripetal arrangement of successive phases along a linear direction. The spatial arrangement of the totality of the complexes suggests the basement control of the igneous activities and the reactivation of the existing lines of weakness during the Mesozoic. Thus, within the younger granite province, in addition to the E-W, NE-SW, and NW-SE fracture systems, ring fractures were developed and granitic complexes themselves were fissured and mineralized also the granitic bodies were fractured such that fissures and crushed zones developed in them serve as pathways for the greisenisation fluids. High lineament frequencies are obtained in areas where basement rocks outcrop or are closer to the surface (i.e. area with thin overburden) whereas low lineament frequencies are characteristics of areas with deeply buried basement rocks.

CONCLUSION

This study has demonstrated that Landsat-TM has a lot of research potentials for geological application. This work revealed that E -W, NE-SW and NW-SE are well developed principal structural trends both on the crystalline basement complex as well as the cretaceous and younger sediments. This indicates that these fractures may have been active since geological times. The structural trends were found to be controlled by structures in the underlying Precambrian rock of the Basement complex. Sound from rocks is caused by impacts, internal stresses, and material properties that allow them to vibrate and resonate. Striking a rock converts impact energy into sound waves, while natural phenomena like internal stress from formation or tectonic forces can cause them to "ring" when struck. Weathering conditions can stress and fracture rocks, which can sometimes trigger a ringing sound as the internal stresses are released. Finally, the sound is also influenced by the rock's internal structure, density, and crystalline makeup, and the quarry activities taking place in the area which influenced the earth movement and sound that is causing cracks on houses that created panic and uncertainty among the resident of Shira town.

Summary

The geology of Shira was investigated by Woolley, 2001, which is part of the West African carton's crystalline basement (Rocci et al., 1991). The three exposed hill complexes, which consist of one main ridge and two smaller secondary ridges which cover an estimated area of 152 km² with the largest outcrop of Sarkin na Dutse about 633.37m height above sea level, the two lower outcrops known as minor ridges are less exposed in the area are part of Shira Younger Granite Complex, which is composed of peralkaline syenites and granites. Key rock types include aegirine-arfvedsonite granite, birji granite, and Shira quartz syenite, often rich in dark, ferromagnesian minerals like arfvedsonite and aegirine. A related intrusion of granite porphyry is found to the southwest. In this study, a process of identifying and analyzing linear features on satellite imagery is used to understand the underlying geological structures like faults, joints, and fractures. This analysis involves extraction of the linear features, classifying them by orientation and density, to determine their tectonic significance. The case study area is Shira complex in Bauchi state Nigeria, the area is characterized by rough topography with outcrops of a volcanic rocks, granitic and migmatite-gneiss. Lineaments are widespread and dense around the complex, occurring in areas of high elevation, and slope gradient. Terrain roughness indices are high at the outcrops and lineament sites. Streams in the area exhibit variable flow and partly align with the lineaments. The high profile index observed have tectonic essence and are related to the occurrence of lineaments, strain domains, and high degree of rock weathering, erosion and human activities.

RECOMMENDATIONS

More work has to be done to investigate the causes of sound in this area, techniques like seismic wave analysis, which measures how sound travels through the rock, and acoustic and vibration sensor systems, which can correlate sound with specific rock properties. Another method is to analyze the rock's physical properties and its environmental conditions to determine why it makes a particular sound, such as stress levels. Aeromagnetic data interpretation on the area need to be conducted to investigate Magnetic susceptibility and depth determination of the structures in the area.

REFERENCES

1. Akanbi, E. S., Ugodulunwa, F.X.O. and Gyang, B.N., (2012). Mapping Potential Cassiterite Deposits of Naraguta Area, North Central, Nigeria using Geophysics and Geographic Information System (GIS). Journal of Natural Sciences Research. Vol.2, (8).
2. Ananaba, S. E. and Ajakaiye, D.E., (1987). Evidence of tectonic control of mineralization of Nigeria from lineament density analysis: A Landsat study; Int. Jour. Rem. Sensing; vol.1, (10), pp. 1445-1453.
3. Bala, A. E., Batelaan, O., and De Smedt, F., (2000). Using LANDSAT 5 Imagery In the Assessment of Groundwater Resources in the Crystalline rocks Around Dutsin-Ma, Northwestern Nigeria. Journal of Mining & Geology Vol.36 (1), pp.85-92.
4. Chukwu-Ike, I.M., and Norman, J.W. (1997). Mineralized crustal fractures shown on satellite imagery of Nigeria; Inst. of Min. and meta-transactions; vol.86; pp. 55-67.
5. [13] Falconer, J.D., 1921. The Geology and Geography of Northern Nigeria, Mac Millan Press, London; pp. 135-136.
6. Nelson, A.E. Major tectonic features and structural elements in the northwest part of the Greenville Quadrangle, Georgia (USA). US Geol. Surv. Bull.1643, (1985).
7. Opara, A.I., Onyewuchi, R.A., Selemo, A.O.I., Onyekuru, S.O., Ubechu, B.O., Emberga, T.T., Ibim, D.F., and Nosiri, O.P., 2014b. Structural and tectonic features of Ugep and Environs, Calabar Flank,

Southeastern Nigeria: Evidences from aeromagnetic and Landsat-ETM data; Mitteilungen Klosterneuburg; vol.64, no.7; pp.33-54.

8. Oyedele, A. A. Use of remote sensing and GIS techniques for groundwater exploration in the basement complex terrain of Ado-Ekiti, SW Nigeria. Appl. Water Sci.9, (2019).
9. Palamakumbura R, Krabbendam M, Whitbread K, Arnhardt C. Data acquisition by digitizing 2-D fracture networks and topographic lineaments in geographic information systems: further development and applications. Solid Earth. 2020; 11:1731–1746. doi: 10.5194/se-11-1731-2020. [DOI] [Google Scholar]
10. Ramasamy, S.M. (2010). Significance of surface lineaments for gas and oil exploration in parts of Sabatayan Basin, Yemen. Journal of Geography and Geology,2(1), 119-128.
11. Rocci, G., Bronner, G., and Deschamps, M. (1991). Crystalline basement of the West African craton. In: DALLMEYER, R.D. & LECORCHE, J.P. (eds) The West African orogens and circum-Atlantic correlatives. Springer. Berlin, 31-61.
12. Samaila, C. A and Solomon, N. Y., 2011. Groundwater Potential on the Jos-Bukuru Plateau, North Central Nigeria, using lineaments from gravity measurements; Journal of Water Resource and Protection, vol. 3; pp.628-633.
13. Udoh, A.N., 1988. Remote sensing imageries of Nigeria, north of 70401: In: Oluyide, P.O.et. al., (eds). Precambrian Geology. Geological Survey of Nigeria, Publ., pp.99- 102.
14. Watkins H, Butler RWH, Bond CE, Healy D. Influence of structural position on fracture networks in the Torridon Group, Achnashellach fold and thrust belt, NW Scotland. J. Struct. Geol. 2015; 74:64–80. doi: 10.1016/j.jsg.2015.03.001. [DOI] [Google Scholar]
15. Woolley, A. R. (2001). Alkaline rocks and carbonatites of the World: Africa, London, The Geological Society, 372 p.