RELATIONSHIP BETWEEN LINEAMENTS AND GROUNDWATER POTENTIAL: A CASE STUDY OF KUNYA SHEET 58SW, NORTHWESTERN NIGERIA

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ABSTRACT: Lineaments are natural surface elements such as joints, faults, folaitions or bedding planes interpreted directly from satellite imagery, geophysical maps or aerial photographs (Al-Nahmi *et al.*, 2016). The success of lineaments analysis is usually measured by the yield of the wells in close proximity to lineaments; wells on or near lineaments often exhibit higher yields (Musa, 2017). The relationship of lineaments and groundwater is studied by Mabee *et al*., 1994 and Sander *et al*., 1997. They agreed that, a high-density lineament indicates in general the presence of groundwater. Hung *et al*., 2002. suggested that fractured rocks could be analyzed by studying lineaments with the help of lineaments indices. Lineaments indices are defined as: lineaments frequency, length, and degree of intersection. Areas of high lineaments density, lineaments intersection and high lineaments connectivity in Kunya Sheet 58SW and environs as revealed by figures 4, 5 and 6 are mainly concentrated in the NE, SW, and NW of the study area.

KEY WORDS: Joints, Faults, Foliations, Satellite Imagery, Geophysical Maps, Aquifer

I. Introduction

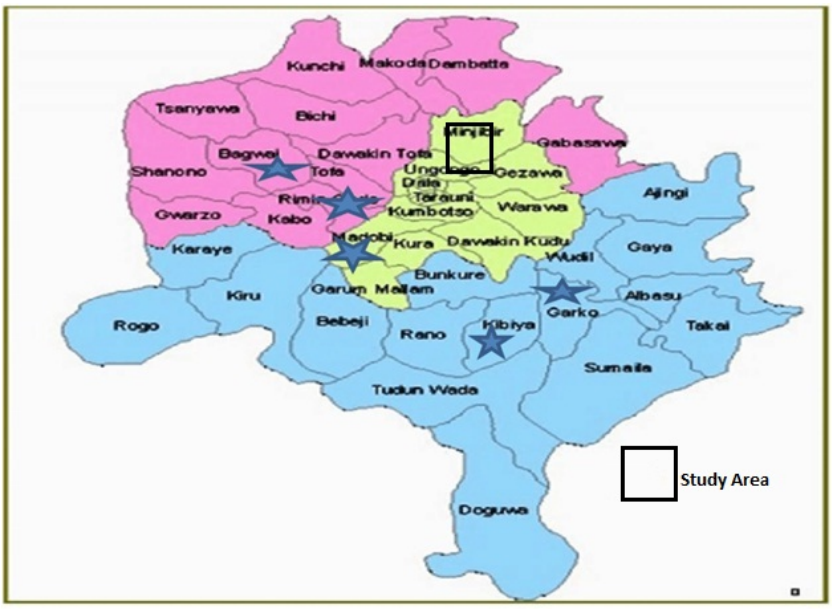
Water is undoubtedly the most precious natural resource that exists on earth. It comprises over 70% of the earth's surface; every living being on earth depends on potable water for survival, because water is life. Without this seemingly invaluable compound comprising of hydrogen and oxygen, life on earth would be non-existent. Underground water is one essential but necessary substitute to surface water in every society's usage. It's no doubt a hidden, replenishable resource whose occurrence and distribution greatly varies according to the local as well as regional geology, hydrogeological setting and to an extent the nature of human activities within the land. Underground water occurrence in Basement terrain is hosted within zones of weathering and fracturing which often are not continuous in vertical and lateral extent (Jeff, 2006).

However, in order to tap this resource, a hydraulic structure called Borehole is sunk into the ground, which when properly drilled, designed, and developed, will permit economic withdrawal of water from an aquifer. According to this research, shallow boreholes are those drilled to a depth of <60m, while deep boreholes are drilled to a depth of >70m, because many believed that fractures closes within 70m depth (Tahir, 2015).

Lineaments favouring groundwater occurrences are tensional features which are directly related to the main direction of tectonic stress, a view supported by Caponella, (1989). In addition, according to Dainelli, (1989), in areas underlain by crystalline rocks, fracture zones and fracture crossing points are generally the ideal sites where groundwater may occur. The best sites for drilling boreholes are the highly weathered and high lineaments density areas with cross-cutting nature. These locations are where groundwater occurrence is most promising (Obiefuna *et al*., 2010).

II. Location of Study Area

The area investigated is situated about 42 km in the north eastern part of Kano metropolis, northwest Nigeria (Figure 1). It covers the southwestern part of Kunya Sheet 58 with Latitudes N12˚00′ to N12˚15′ and Longitudes E08˚30′ to E08˚45′. The study area covers a total area of 770km^2 and is accessible by major roads such as Kano to Gezawa and Gezawa to Minjibir to Kunya roads and through networks of footpaths.



Source: mapsofworld.com/kano

Figure 1. Map of Kano State showing the location of the study area

The area of study lies on the average altitude of 458m, and is generally undulating lowland. The highest point is about 472masl (Gunduwawa) and the lowest point is 428masl (Yadakunya A). The relief is greatly influenced by the geology; characterized by dome shaped, whaleback shaped and low laying outcrops.

The climatic condition in the study area is typically that of Sudan Savannah climatic zone of Nigeria, where two distinct seasons occurs i.e. dry and wet seasons. Dry season last for about seven months, October to April and wet season commence from May to late September. Mean annual rainfall in the area is 800mm (Olofin, 1987). The rainy season lasts for six months with temperature ranging from 26ºC to 33ºC. The driest weather is in November, December and January when an average of 0.00mm of rainfall is normally recorded. The wettest period is in August when an average of 228mm of rainfall is recorded.

The natural vegetation consists of the Sudan and Guinea Savannah both haven been replaced by secondary vegetation (Isa, 1984). Most parts of the study area are composed of farmed parkland, dotted with patches of shrub savannah. The few tall trees are mostly Acacia, Neem and Baobab which are scattered about in the study area but occurred densely along river course due to the presence of moisture for the vegetation to thrive (Tahir, 2015).

III. Geology of Study Area

The Kunya Sheet 58SW is underlain by two lithological units: rock of the basement complex, essentially coarse – porphyritic hornblende granite which are believed to be the oldest and sands and clays (Figure 2). The following sections described the units mapped.

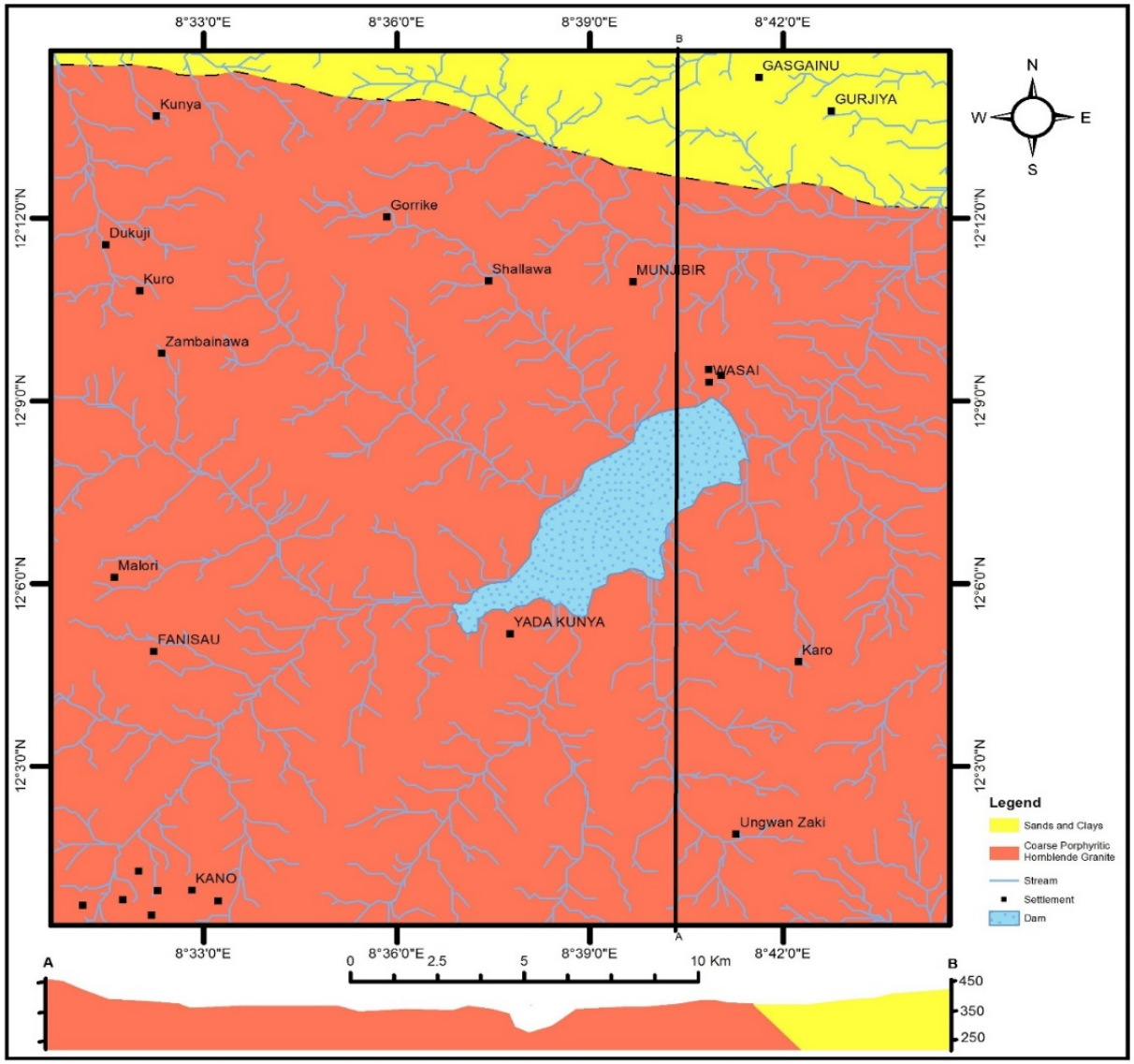


Figure 2: Geological map and cross – sectional view of A – B for Kunya Sheet 58SW

IV. Methodology

Structural lineaments were extracted from ASTER DEM. Manipulation was carried out in three GIS environments. **Erdas Imagine 9.2 GIS Environment** was used to obtain the shaded relief; **PCI Geomatica 10.0 GIS Environment** was used to automatically generate the lineaments. **ArcMap 9.3 software GIS Environment** was employed for the determination of coincidence between the two extracted lineaments and these points produced the lineaments that were digitized and utilized for the production of lineaments density thematic map.

The lineament map was prepared using the automatic line extraction from shaded relief image using PCI Geomatica 10.0. However, prior to automatic lineament extraction, shaded relief images were prepared using Erdas Imagine 9.2 software. Successive shaded relief images were created by varying the azimuth (Sun Angle) of DEM from 0^0 to: 45^0, 90^0, 135^0, 180^0, 225^0, 270^0, and 315^0. Solar Azimuth was set at 0^0, solar elevation at 30 and ambient light at 0.2 to ensure good contrast as shown by Abdullahi *et al.,* (2010). Two combined shaded relief images were created by respective overlay of shaded relief images with azimuth 0^0, 45^0, 90^0, and 135^0; and azimuth 180^0, 225^0, 270^0, and 315^0. ArcMap 9.3 software was used to determine the coincidence between the lineaments extracted from the two combined shaded relief images and these points formed the lineaments that were digitized and used for the lineament density thematic map.

V. Result and Discussion

The Basement Complex is believed to have responded to series of tectonism during the Pan – African Orogeny or even earlier. The important structural features mapped in Kunya Sheet 58SW are; the joints, aplitic dykes, faults, and veins. The regional strike direction of the lineaments are dominantly N – S, representing the final imprints of the Pan – African Orogeny. Other trends are mainly in the NNW – SSE direction though few minor features trending NE – SW were also mapped. Major streams in the study area such as the Jakara and Getsi Streams are controlled by these fructures. Two sets of lineament trends were observed ; a predominant NNW - SSE trending lineament and a less predominant set trending NE – SW as observed from the Rose diagram (Figure 3).

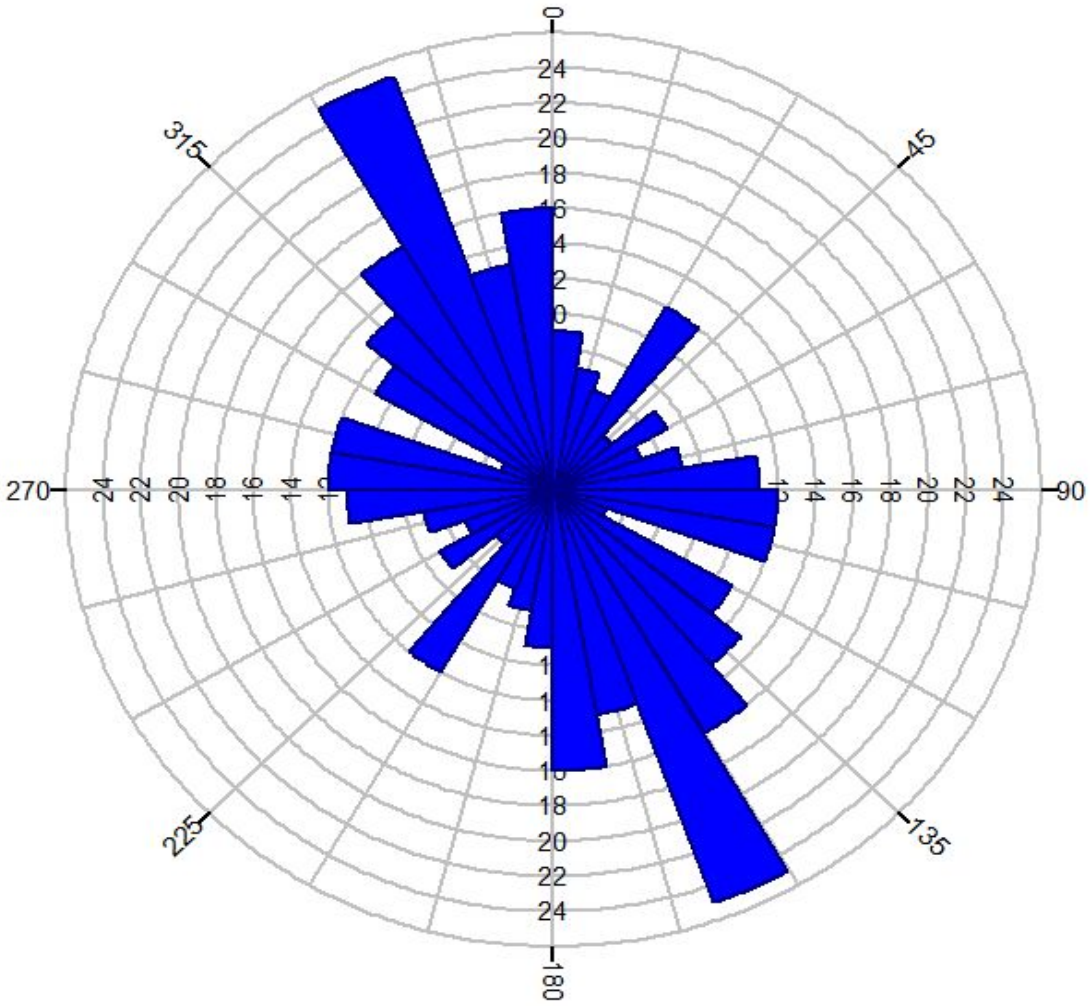


Figure 3: Rose diagram (Azimuth frequency) showing lineaments trends in Kunya Sheet 58SW

The lineaments in the study area vary in length from few millimetres to tens of centimetres. For instance, at Gunduwawa village, the joint mapped is almost vertical in orientation and approximately 122.40cm in length (Plate I). Most of these joints are open while others are infilled with quartz and feldspar, forming veins. Some of the open ones are weathered and sustain light vegetation or water courses.

Plate I : N – S trending and almost vertically dipping joint in coarse – porphyritic hornblende granite. Locality : Gunduwawa Town (N12˚ 01′14.9″ E08˚38′41.5″)

Plate 2: Part of Quartz vein in coarse – porphyritic hornblende granite from the study area

Groundwater potentials in hard rock areas is greatly influenced by the presence of lineaments, which may serve as a conduit for groundwater movement (Obiefuna, 2010).

Generally, producing wells are located in areas of greater lineaments density, lineament intersections and high degree of lineaments connectivity (Lattman, 1958). Areas of high lineaments density, lineaments intersection and high lineaments connectivity in Kunya Sheet 58SW and environs as shown on the maps (Figures 4., 5 and 6) are mainly concentrated in the NE, SW, and NW of the study area. These are areas with line density values in range of 2.14 to 3.21 and which are coloured red and purple in the lineaments density map. These areas have greater potentials for groundwater propecting for their high concentration of lineaments. Other areas with line density values in range of 1.43 to 2.14 can also serve as good for groundwater prospecting (Figure 4).

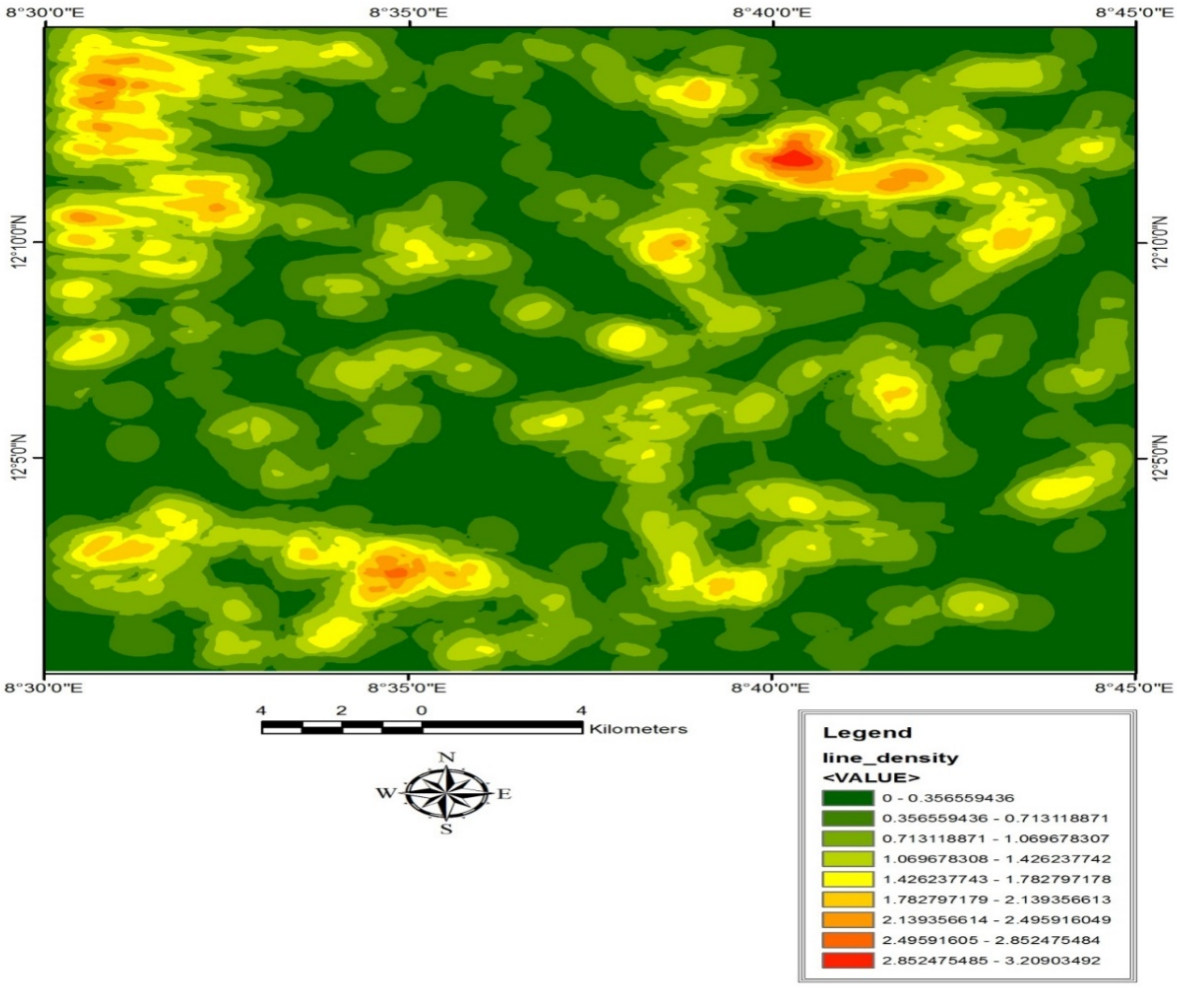


Figure 4: Lineaments density map of Kunya Sheet 58 SW

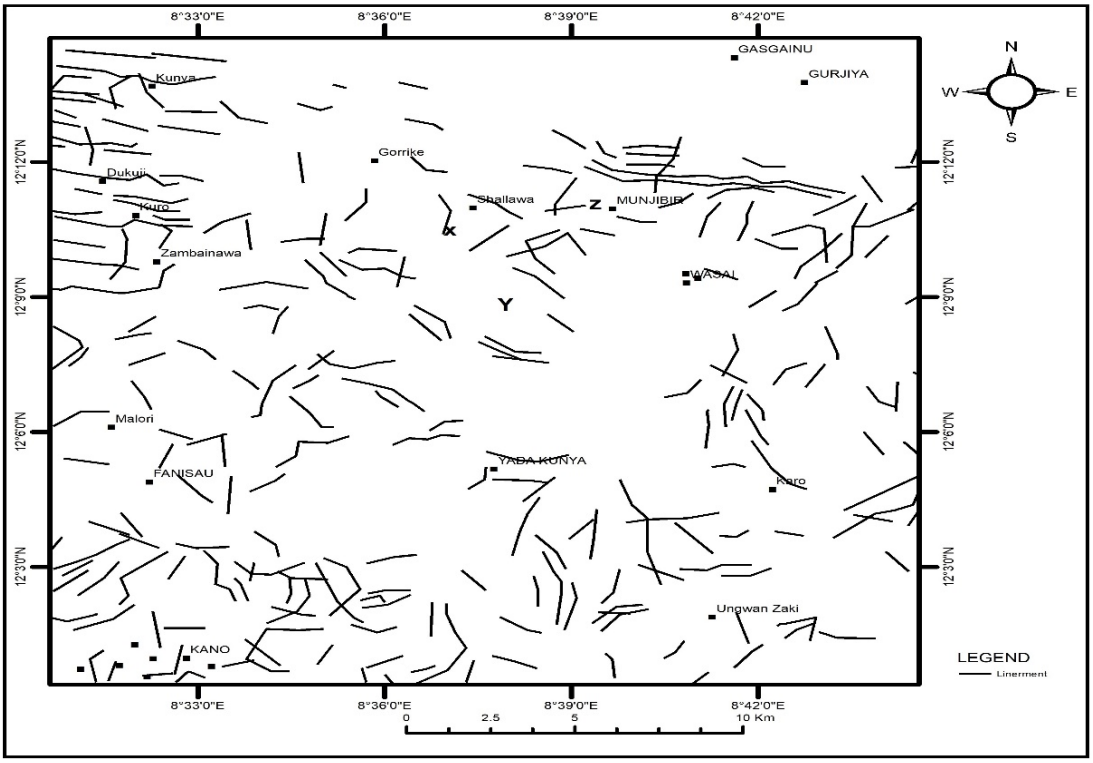


Figure 5: Lineaments map of Kunya Sheet58 SW

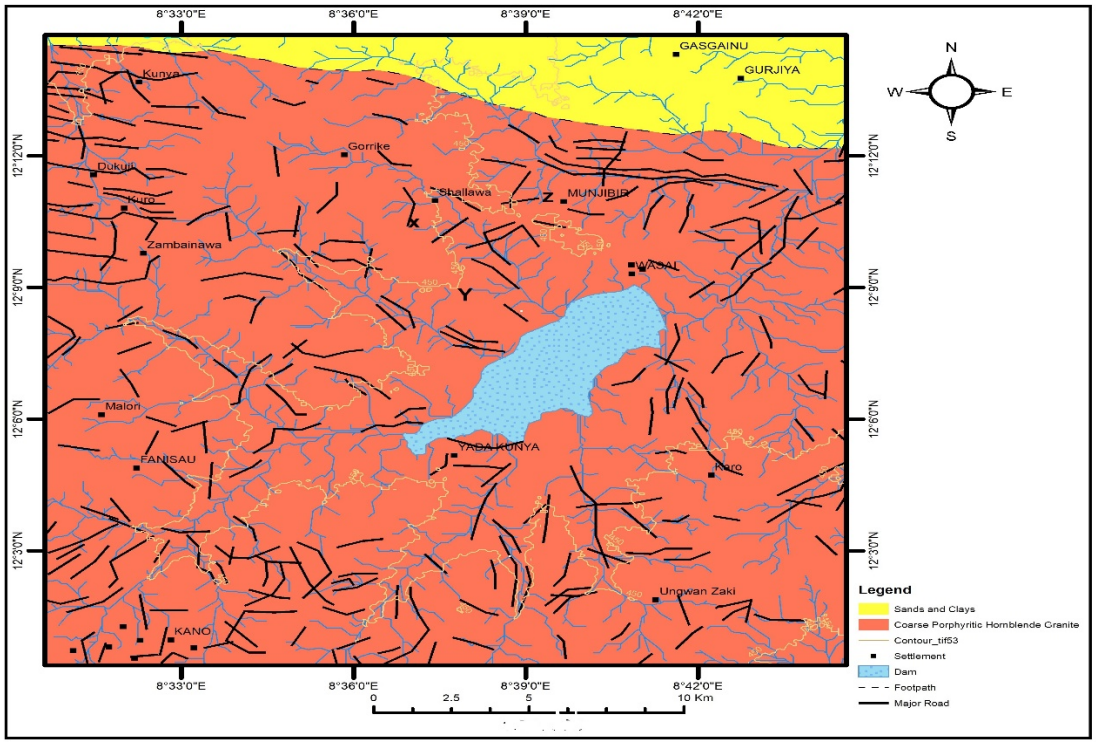


Figure 6: Lineaments Map of Kunya Sheet 58SW superimposed on the geological map of the area. Note: The streams in the area are structurally controlled.

VI. Conclusion

Lineaments mapped in the study area includes: Dykes, Quartz veins, Faults and Joints. They are predominantly trending in the N – S direction, what marked the final imprint of Pan – African Orogeny. Other trends are mainly in the NNW – SSE with few trending in the NE – SW. These zones of high lineaments density, high lineaments intersections and high lineaments connectivity shown in Figures 4, 5 and 6 above, are probably areas of good groundwater prospects as infiltration is expected to be high in those areas. Two major aquifer units are present in the study area: the fractured crystalline aquifer which is overlain by more unconsolidated overburden aquifer. Groundwater occurs in the pore spaces of the weathered overburden aquifer as well as in fractures in the fractured crystalline aquifer. The later aquifer unit is mostly indirectly recharged by drawing its water from the former aquifer. Hence, both aquifer types are in hydraulic connection. The over burden unit contains significant resources of water.

REFERENCES

1. Abdullah, A., Akhir, J. M., and Abdullah, I., (2010) Automatic Mapping of Lineaments Using Shaded Relief Images Derived from Digital Elevation Model (DEMs) in the Maran - Sungi Lembing Area, Malaysia, The Electronic Journal of Geotechnical Engineering, Vol.15, Bund. J, pp. 949-957 http://www.ejge.com/2010/Ppr10.066/Ppr10.066w.pdf

2. Al-Nahmi, F., Alami, O.B., Baidder,L. and Hilali, A. (2016) Using Remote Sensing for Lineaments Extraction in Maghrabah Area – Hajjah, Yemen. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* XL II – 2/W1: 137-140

3. Caponella, F. (1989) Remote sensing image interpretation for Groundwater Surveying in Remote sensing /Application for water Resources. Report of the 13th UN/FAD/UNESCO International Training Course; RSC-Series, pp. 50 -292

4. Dainelli, E.P. (1989) Airborne photographic methods. Remote sensing application to water resources. Report of the 13th UN/FAO/UNESCO International Training Course; RSC Series 50, pp. 11-31

5. Hung, L.Q. Dinh, N.Q. Batelaan, O. Tam, V.T. and Lagrou, D. (2002) Remote sensing and GIS based analysis of cave development in the Suoimuoi Catchment (Son La-NW Vietnam). *Journal of Cave and Karst Studies*, 64(1): 23-33

6. Isa, M. (1984) Hydraulic Properties of Aquifers in Kano State. Unpublished M.Sc. thesis, Ahmadu Bello University, Zaria, pp. 25 – 48

7. Jeff, D. (2006) "Forum for groundwater" htt://www.waternet.co.za/groundwater/ (3) December 2006

8. Lattman, I. H. (1958) Techniques of Mapping Geologic Fracture Traces and Lineaments on Aerial Photographs. *Photogrammetric Engr., 19(4): 568 – 576*

9. Mabee, S.B, Hardcastle, K.C., and Wise, D.U., (1994) A method of collecting and analyzing lineaments for regional-scale fractured-bedrock aquifer studies. Ground Water 32 (6): 884-894

10. Mapsofworld. Com/ kano (2002) Political map of Kano State, Nigeria

11. Musa, A.I. (2017) Groundwater potential assessment of part of Kazaure area (Sheet 35 Kazaure SE), northwestern Nigeria. Unpublished M.Sc. thesis, Department of geology, Ahmadu Bello University, Zaria, Nigeria. Pp. 18 - 46

12. Obiefuna, G.I. Adamolekun, S.S., and Ishaku, J.M., (2010) Determining potential areas of groundwater occurrences using remote sensing techniques: A case study of Mubi area, Northeast, Nigeria. *Continental Journal Applied Sciences* 5:15 – 24

13. Olofin, E.A. (1987) Some aspects of physical geography of Kano region and human response. M. Sc. lecture note, series number 1. Geography Department, Bayero University, Kano

14. Sander, P. Minor, T.B. and Chesley, M.M. (1997) Groundwater exploration based on lineament analysis and reproducibility tests. Ground Water 35(5):888–894

15. Tahir, A.G. (2015) Aquifer Characteristics and groundwater potentials of Crystalline Basement Complex of Kano State. Unpublished M.Sc. thesis, Ahmadu Bello University, Zaria, pp. 33 – 56