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Vol. 1(3) 25 November, 2013, Pp. 13-24
www.academiascholarlyjournal.org/ijasrr/index_ijasrr.htm
ISSN: 2360-9338©Academia Scholarly Journals
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LANDSAT-7 INTERPRETATION OF LINEAMENTS OVER THE SOUTHWESTERN PART OF ADAMAWA STATE, NORTHEASTERN NIGERIA

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Accepted October 09, 2013

This research work was carried out to map and interpret lineaments of the southwestern part of Adamawa state, northeastern Nigeria using LANDSAT-7. The image acquired was processed using the Principal Component Analysis (PCA) method in the ENVI 4.3 software. False colour composite was generated by combining bands using the same software. The image was imported into ILWIS 3.7 where it was georeferenced using latlon WGS84 with tiepoints. Lineaments length density and lineament intersection density was calculated for the area. Basic statistical analysis was also carried out on the data generated from lineaments of the study area. Results shows that the length of lineament in the area ranges from 0.6821km to 17.6668km with a total area of 298.1344km^2 covered by the lineaments. Lineament azimuth ranges from between 4.107 and 180 in the study area. The study further shows that the largest amount of lineaments (60) are found on the alluvium and accounts for 26.55% of the total number of lineaments in the area. The lineaments distribution decreases on rock units in the following order: alluvium>Migmatite>shale and siltstone>porphyritic granite>sandstone, shale and clay>undifferentiated Basement Complex>shales, limestone and sandstone. Structural analysis from rose diagram show that the lineament orientation trends ENE-SWS which confirms that the lineaments with frequency between 51-60^o has the highest distribution in the study area. Results shows that the lineament density of the area is 29.01km. Statistical analysis of lineament data reveals that the mean azimuth of lineaments is 84.61^o with median and mode being 77.42^o and 90^o respectively. Histogram plot of the azimuth data from the area shows that the lineaments of the area has five modal classes of 40-60^o, 60-80^o, 80-100^o, 120-140^o and 160-180^o which accounts for 23.90%, 26.11%, 19.03%, 10.18% and 4.87% of the total number of lineaments in the area respectively.

KEYWORDS: Lineaments, Structural analysis, Statistical analysis, LANDSAT-7.

INTRODUCTION

The importance of geologic structures especially lineaments such as joints, fractures and faults cannot be underestimated. This is because they act as reservoir both for oil, water and gas and also for the deposition of important ores. One of the main features of geological interpretation of satellite

imagery has been the recognition of lineaments varying in length from a few kilometers to hundreds of kilometers (Onyedim and Ocan, 2001). According to O'Leary et. al., (1976), a lineament is a mappable, simple or composite feature of a surface, whose parts are aligned in a rectilinear or slightly curvilinear fashion. Factors that control the variation of lineament intensity include lithology, tectonic history and soil development (Vincent et. al., 1980; Edet et. al., 1994).

Remote sensing techniques are usually adopted in studying lineaments because they give an opportunity of synoptically studying the feature without actually coming into contact with them, especially at the regional level. Many remote sensing imageries have been used in the study of lineament such as ASTER, GEOEYE and LANDSAT imageries amongst others. Landsat imagery was first launched with bands up to seven. Recently, Landsat with eight bands have just been launched. Landsat imagery has been used by many workers to map lineaments in several areas (Kogbe, 1981; Odeyemi, 1993; Onyedim, 1996; Odeyemi et. al., 1999; Bala et. al., 2000; Boukadi et. al., 2000; Anifowose, 2004; Anifowose et. al., 2005; Urbain, 2005). Landsat 7 which is an Enhanced Thematic Mapper (ETM+) sensor with seven bands of multi-spectral data at 30 metres resolution, plus a panchromatic band at 15 m, over a swath 183km wide.

There is also a 60 m thermal infrared band. It is for this reason that Landsat Imagery was employed to carry out a lineament mapping of the southwestern part of Adamawa state. The study area is located between latitude 8^{o}00'N-9^{o}20'N and longitude 10^{o}000'E-12^{o}000'E.

GEOLOGY OF THE STUDY AREA

The hard crystalline Craton basements are ancient Precambrian rocks formed from series of orogenic circles within the mobile belt of central Africa. The various dating revealed Liberian - (2500±200 my), Eburnean - (1800±200 my), and Kibarian - (1200±200 my) orogenic events (Ogezi, 1977). The rocks of these events are commonly gneisses, migmatite and quarzites. However many of the structural traces where obliterated by the Late Proterozoic and Pan African thermo-tectonics events that spanned from 750 to 500 my (Rahaman, 1989).

During the Pan African Orogeny, there was structural development. There was faulting towards NW-SE and SW-SS direction. Late tectonic effect related to the intrusion of granites, and migmatites gneiss; contact metamorphism was associated with some of this granite where they intruded the metasediment Pan-African Orogeny was followed by post metamorphic epeirogenic uplift, cooling, fracturing, faulting causing high level of magmatic activity in the study area. The end of Pan- African Orogeny was terminated by the emplacement of diabase (Rahaman, 1989). The lithology of the rock in the study area (Figure 2) is basically granites which intruded as coarse grained granite in the northeast direction followed by medium grained granite which outcropped in the middle of the study area and to the northeast is an outcropped of fine grained granite and also, migmatite gneiss is intruded in the southern part of the study area.

MATERIALS AND METHODS

The Landsat imagery of the study area was acquired from the archives on the 25th of January, 2013 from Global Land Cover Facility. The imagery has seven bands from the visible to the thermal part of the electromagnetic spectrum. The image was then imported into ERDAS 9.2 where image processing where carried out.

The image processing techniques used were Principal Component Analysis and False Colour Composite (FCC). Band 4-3-2 composite was used (Figure 1). The image was imported into ILWIS 3.7 where it was georeferenced using latlon WGS84 with tie points. Lineaments were picked after carrying out histogram equalization operation. The picked lineaments were then digitized and measured using ILWIS 3.7.

LINEAMENT LENGTH DENSITY

Lineament length density map was constructed for the area. The lineament density is defined as the total length of all recorded lineaments divided by the area (Edet et. al., 1994) using the equation (i):

$$L_D = \frac{\Sigma L}{A} \quad \text{..... (i)}$$

Where;

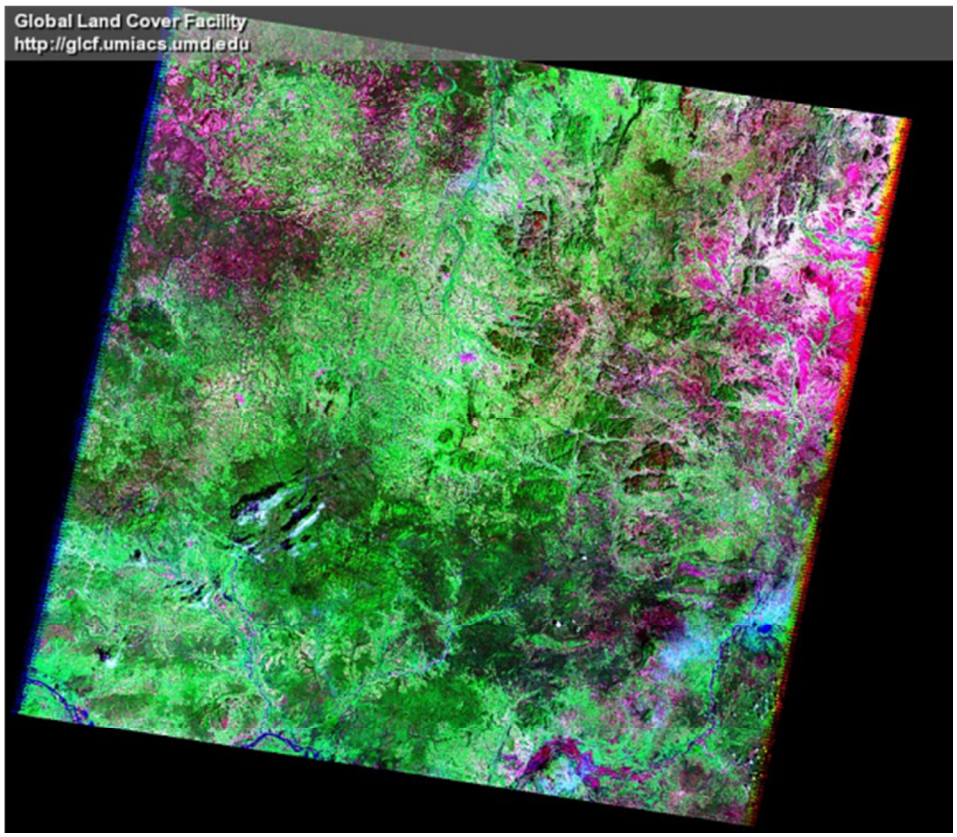

Figure 1. LANDSAT imagery of the study area.

L_D = Lineament length density, km^{-1}
ΣL = Total length of all lineaments, km
A= Area, km^2

LINEAMENT INTERSECTION DENSITY

Lineament intersection density is defined as the total number of lineament intersections divided by the area (Edet et. al., 1994) using the equation (ii):

$$L_1 = \frac{\Sigma N}{A} \quad \text{..... (ii)}$$

Where;
L_1 = lineament intersection density
ΣN = total number of lineament intersection
A = Area

STATISTICAL ANALYSIS

Statistical analysis was performed on the generated data from the digitized lineament map. This was achieved using basic statistical analyses such as mean, median, standard deviation were used in analysis the data from the lineament map.

DISCUSSION OF RESULTS

LENGTH OF LINEAMENT IN THE STUDY AREA

Table 1 reveals that the length of the lineament ranges from 0.6821 km to 17.6668 km (Figure 3). Figure 4 shows the distribution of lineament in the study area. The total area of the lineament on the imagery is 298.1344km, while the total area of the lineaments on the ground is 894.1168km (Table 1). Lineaments azimuth ranges between 4.107° and 180°. Lineaments with azimuth between 51° and 60° has a frequency of 46 which accounts for 20.35% of number of lineaments in the area and has a total length of 171.9591km^2 and accounts for 19.23% of the total actual length of lineaments in the area. However lineaments with azimuth between 81°

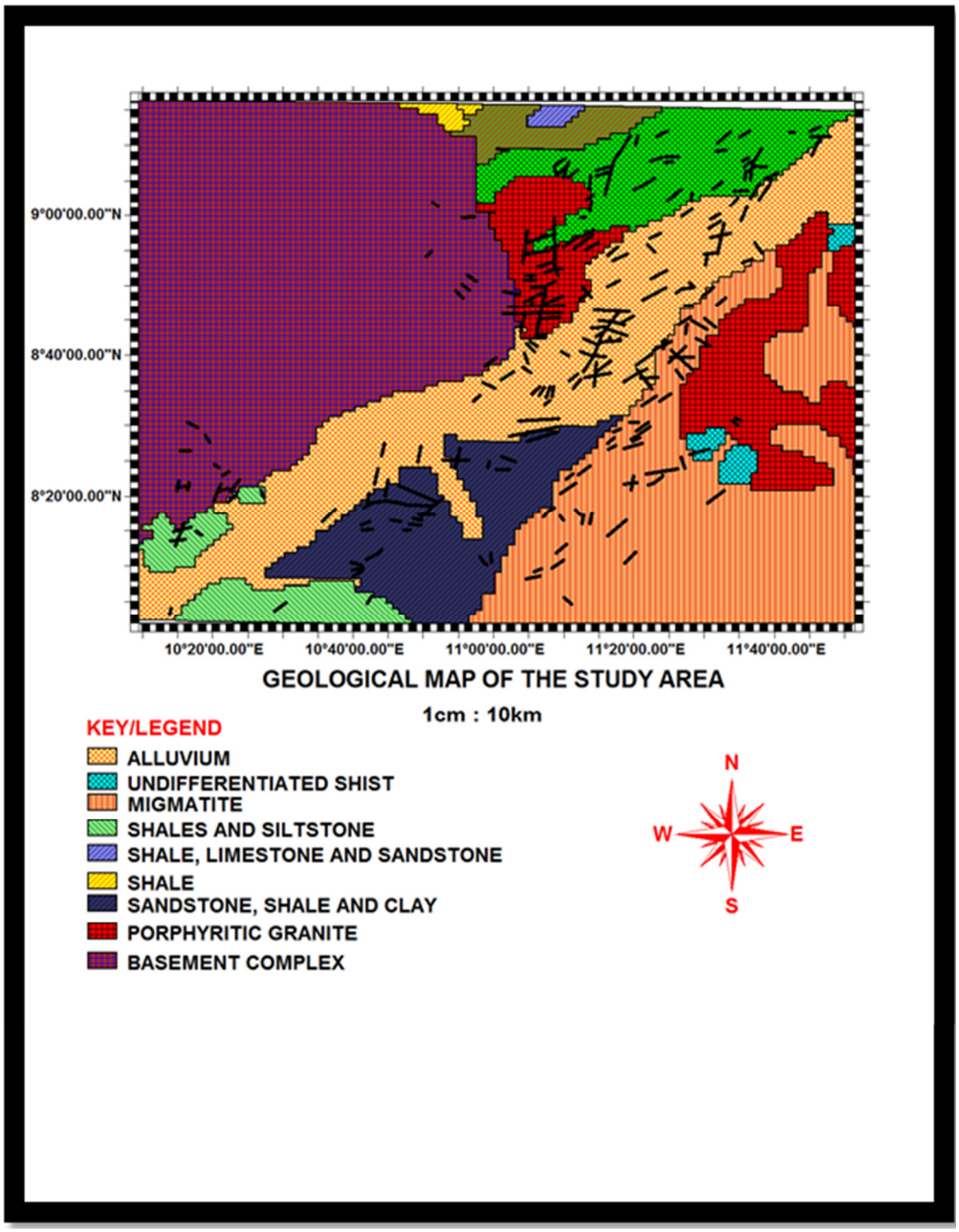

Figure 2. The geological map of the study area.

and 90° has a frequency of 31 and accounts for 13.72% of the lineaments in the study with a total length of 156.62km^2 which accounts for 17.52% of the total actual length of lineaments in the area. The frequency of lineaments based on their azimuth decreases in the following order: The alluvium has the highest number of lineament which amounts to 66 which and accounts for 29.2% of the total lineaments in the study area (Table 2).

DISTRIBUTION OF LINEAMENTS OVER THE ROCK UNITS IN THE STUDY AREA

The lineaments in the study area are distributed over the rock units of the area. The study reveals that the largest amount of lineaments (60) are found on the alluvium and accounts for 26.55% of the total number of lineament in the study area (Figure 2). Migmatite has a total amount of 49 lineaments and

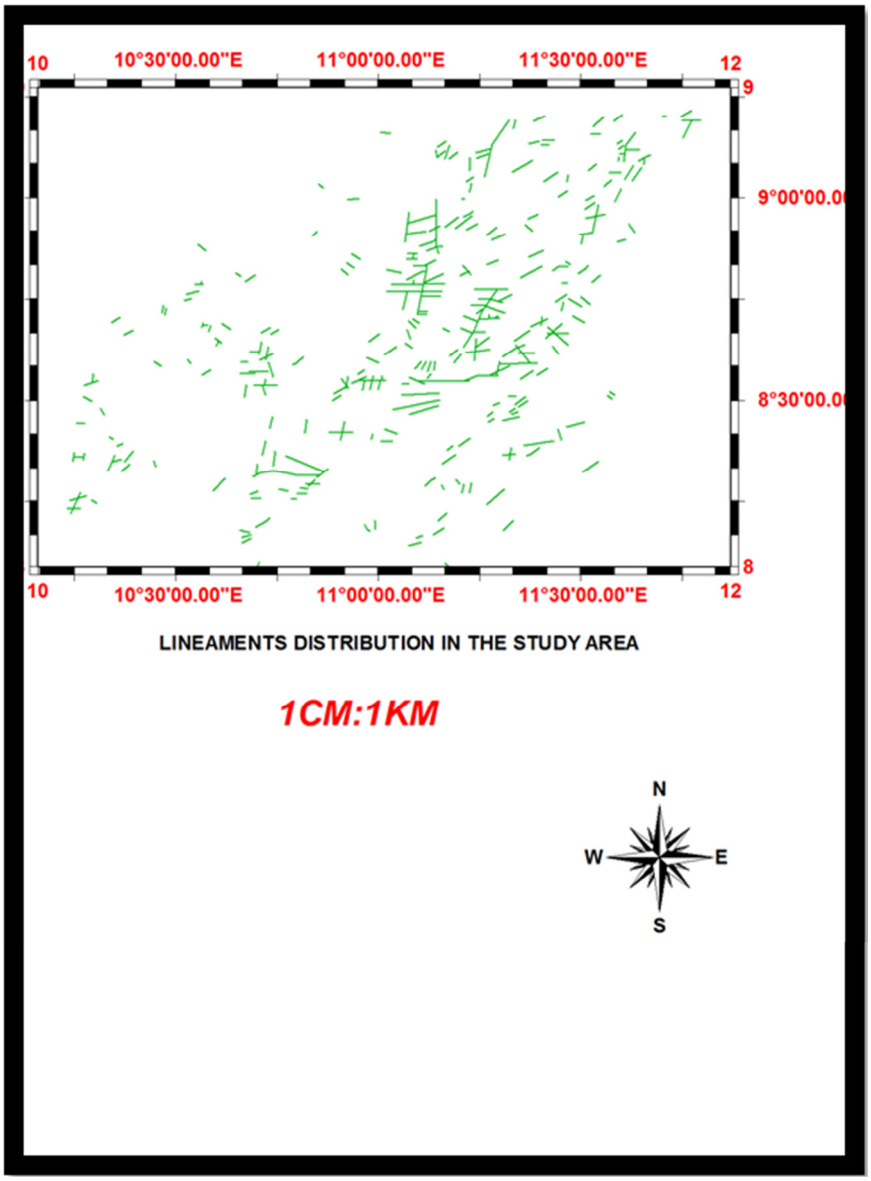

Figure 3. Lineament map of the study area.

accounts for 21.68% of the total amount of lineament in the area (Table 2). Shales and siltstone has a total number of 34 lineaments and account for 15.04% of the total number of lineament in the study area.

Porphyritic granite has a total number of 30 lineaments and account for and accounts for 13.27% of the total number of lineament in the area. Sandstone, shale and clay have a total number of 25 lineaments and accounts for 11.06% of the total number of lineaments in the study area. The undifferentiated Basement Complex in the area accounts for 9.29% of the total number of lineaments in the study and has 21 lineaments over it. Shales, limestone and sandstone have only one lineament on it and accounts for 0.44% of the total lineaments in the study area.

STRUCTURAL ANALYSIS OF LINEAMENTS

For the area percentage frequencies of lineaments in ten degree (10º) were used to plot rose diagrams (Figure 7). The rose diagram shows that the

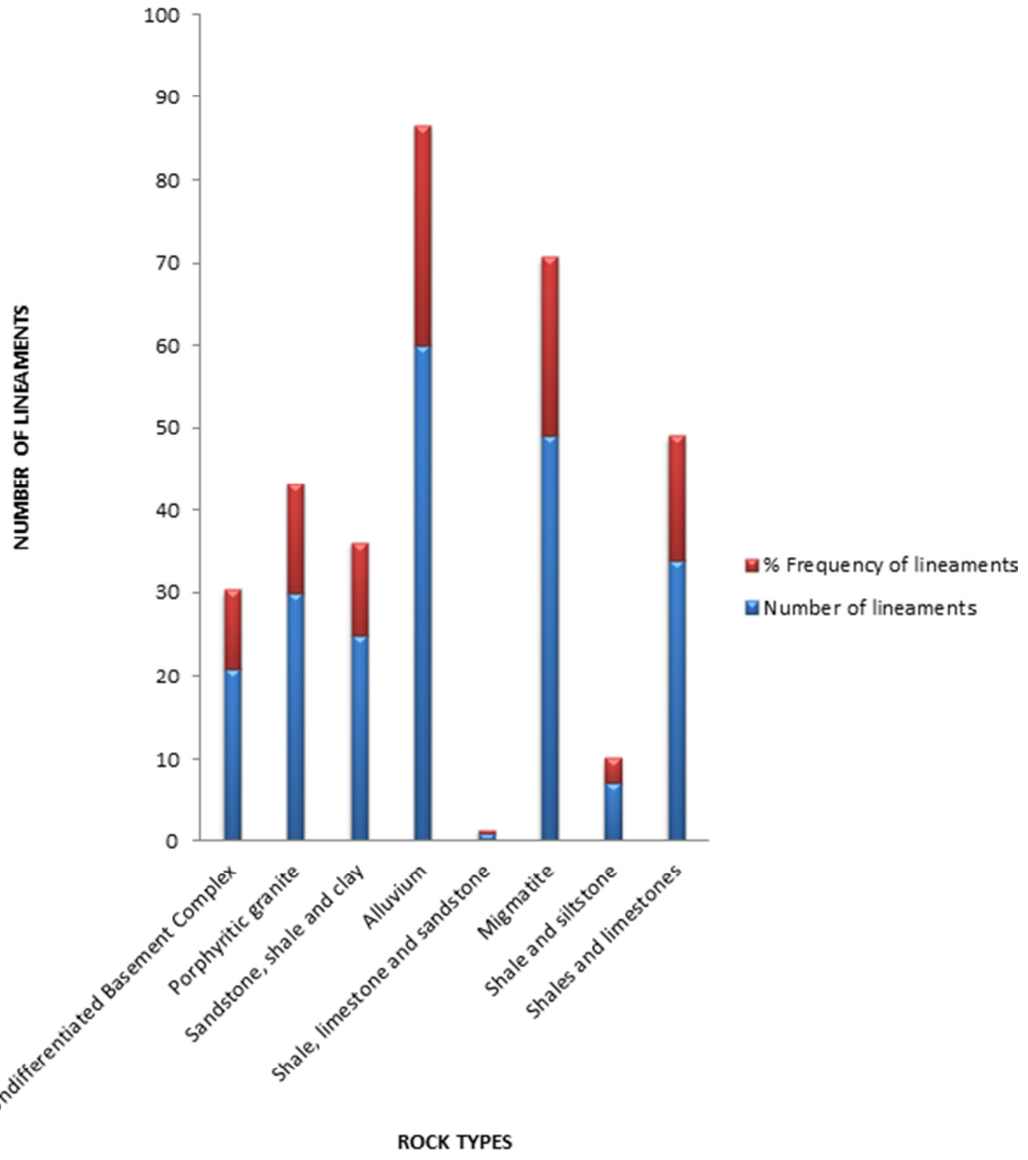

Figure 4. Distribution of lineaments over the rocks in the study area.

lineaments in the study area have an orientation of ENE-SWS. It also confirms that lineaments with frequency between 51-60^{o} has the highest distribution in the study area.

LINEAMENT LENGTH DENSITY

The lineament density map as calculated from equation 1 shows that the lineament density of the area is 29.01km. The lineament density map (Figure 6) of the study area shows that areas marked as “1” in the northeastern and western part of the study area has the largest lineament length density up to 15km. This is followed the area marked “2” which is on the southwestern part of the study area. This is closely followed by the area marked “3” located on both the northeastern and northwestern part of the study area. The area marked “4” has the least lineament density on the western part of the study area.

STATISTICAL ANALYSIS OF DATA FROM LINEAMENT STUDY

The minimum azimuth in the area is 4.73^{o} and maximum of 180^{o} (Table 3). The data from the study

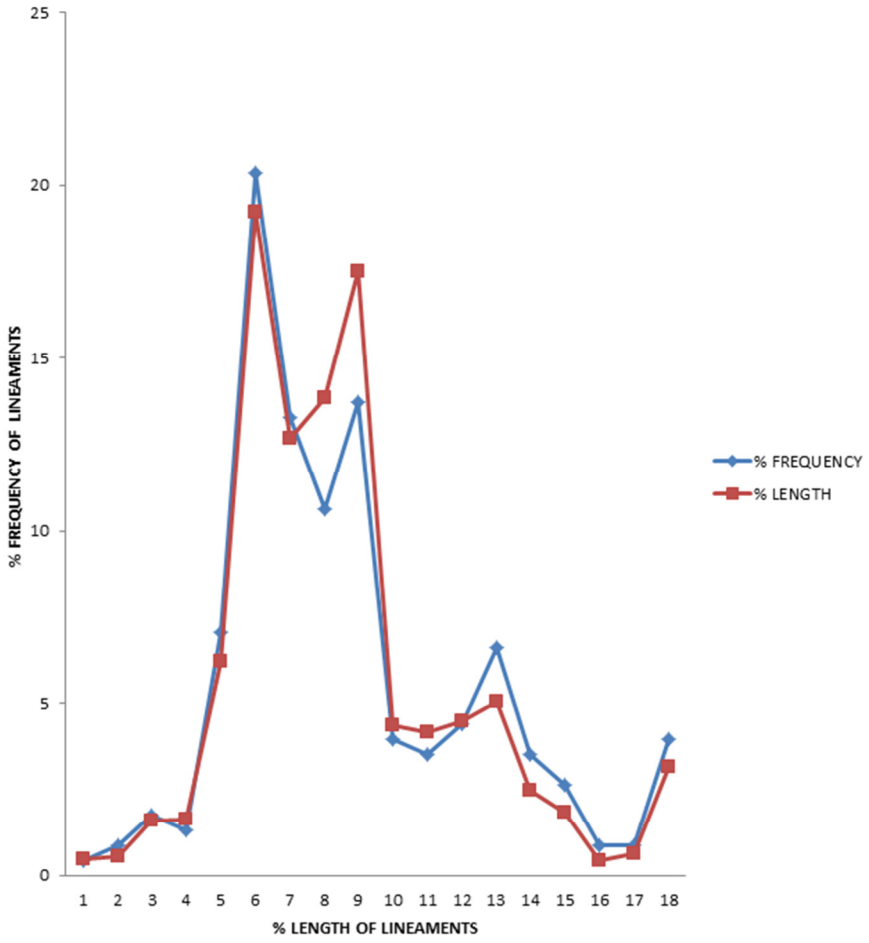

Figure 5. Relationship between percentage frequency of lineaments and percentage length of lineament.

reveals that the mean azimuth of lineaments in the area is 84.61° while the median and mode is 77.42° and 90.00° respectively. The standard deviation is 36.28 and the variance is 1316.31°. The skweness is 0.814 and shows those lineaments are geologically related. The kurtosis is 0.259. The range of the data is 175.27. The sum total of azimuth of lineaments in the area is 19,210.99. The mean length in the study area is 3.96km and the median is 3.44, while the mode is 4.91 and the standard deviation is 2.37. Variance analysis shows a value of 5.64 and the skweness of 8.32. The range of the length is 16.98 and the sum of the length of lineament in the area is 896.17km.

Correlation analysis of the data shows that the correlation of percentage frequency of lineament with the percentage length of the lineament is positive (Figures 5 and Figure 6) and thus further shows that it is geological in origin. The histogram (Figure 8) shows that the lineament has five modal classes which is represented by different peaks and thus confirms the rose diagram plots for the azimuth in Figure 7. The class 40-60° has a total number of 54 lineaments and accounts for 23.90% of the total number of lineaments in the area. The class 60-80° has a total number of 59 lineaments which account for 26.11% of the total number of lineaments in the area. Other peaks are 80-100° which has 43 lineaments, 120-140° which has 23 lineaments and 160-180° which has 11 lineaments and accounts for 19.03%, 10.18% and 4.87% of the total number of lineaments in the area.

CONCLUSION

The study reveals that lineaments are abundant in the study area. A total of 226 lineaments with

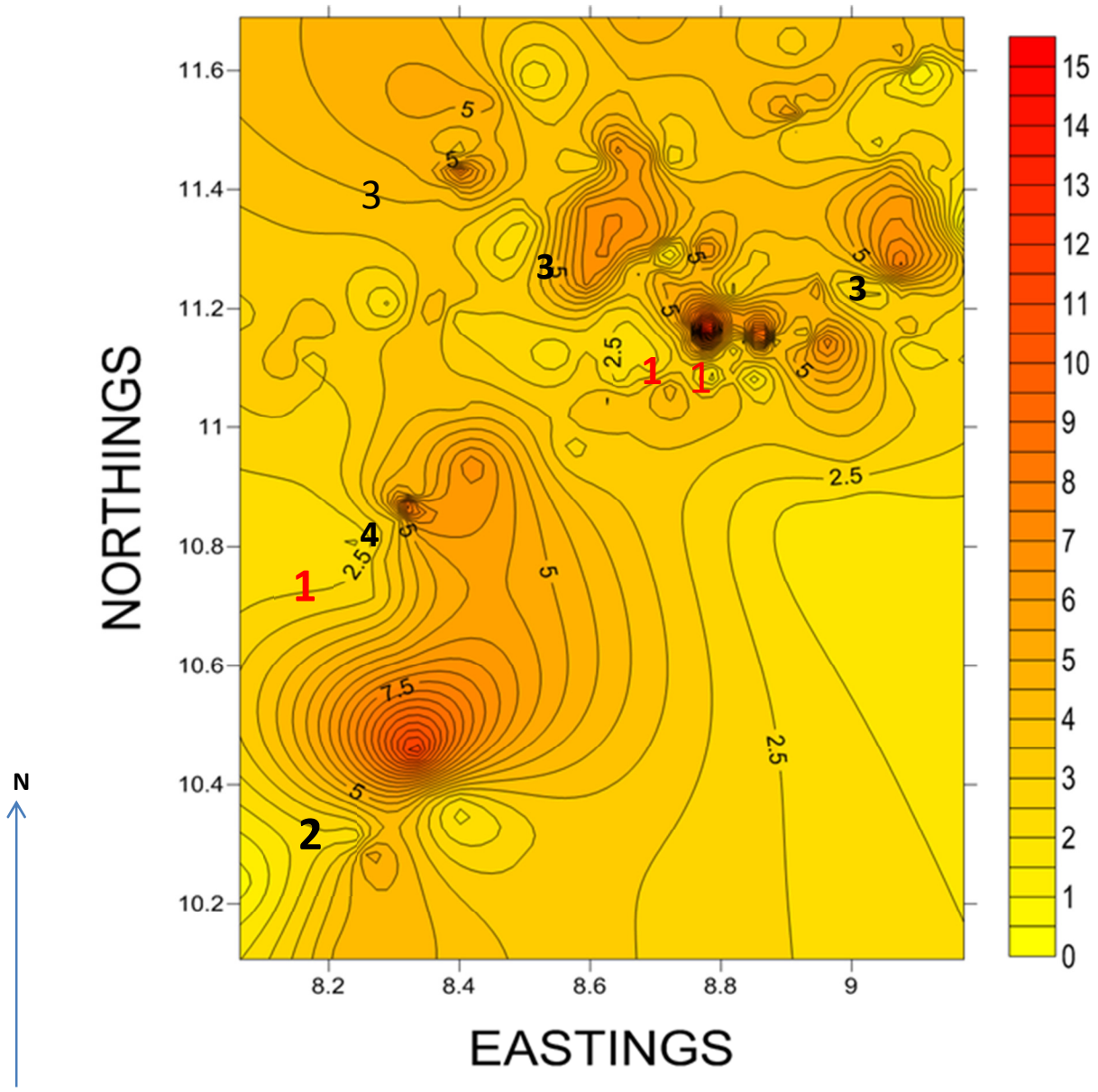

Figure 6. Lineament density map of the study area.

azimuth ranging from 4.107° and 180° and length that ranges from 0.6281km and 17.6668km. Lineaments in the study area cover an area of 291.1344km on the imagery and 894.1168km. Lineament with azimuth 51°-60° has the highest frequency and accounts for 20.35% of the total lineaments in the area.

The lineament density map of the study area shows that areas marked in the northeastern and western part of the study area has the largest lineament length density up to 15km. The study shows that the lineaments in the study area have an orientation of ENE-SWS. It also confirms that lineaments with frequency between 51-60° has the highest distribution in the study area. The study also reveals that (60) 26.55% of the lineaments in the study area are found on the alluvium.

ACKNOWLEDGEMENT

The author appreciates the Global Land Cover Facility (GLCF) for providing the remote sensing data used for this study.

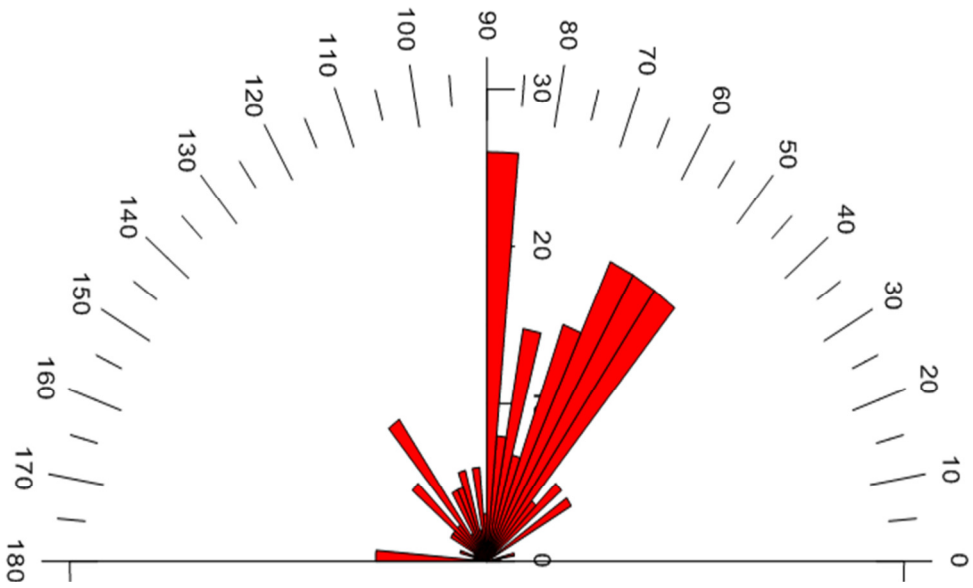

Figure 7. Rose Diagram from Lineaments mapped from Landsat imagery (N = 226).

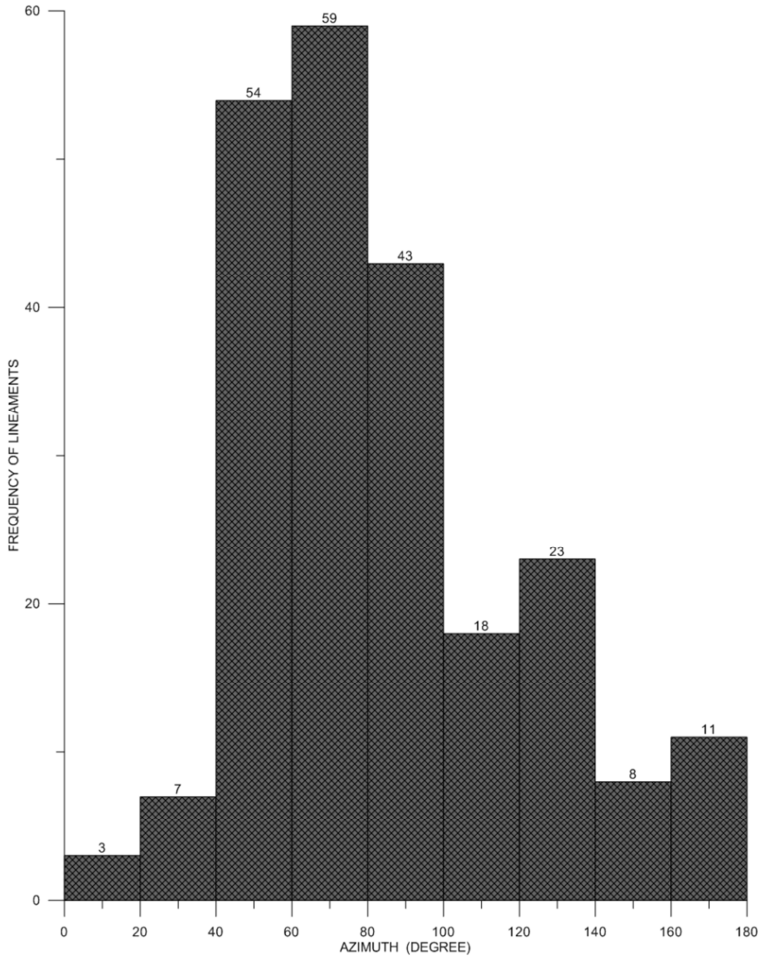

Figure 8. Histogram obtained from azimuth data of the area.

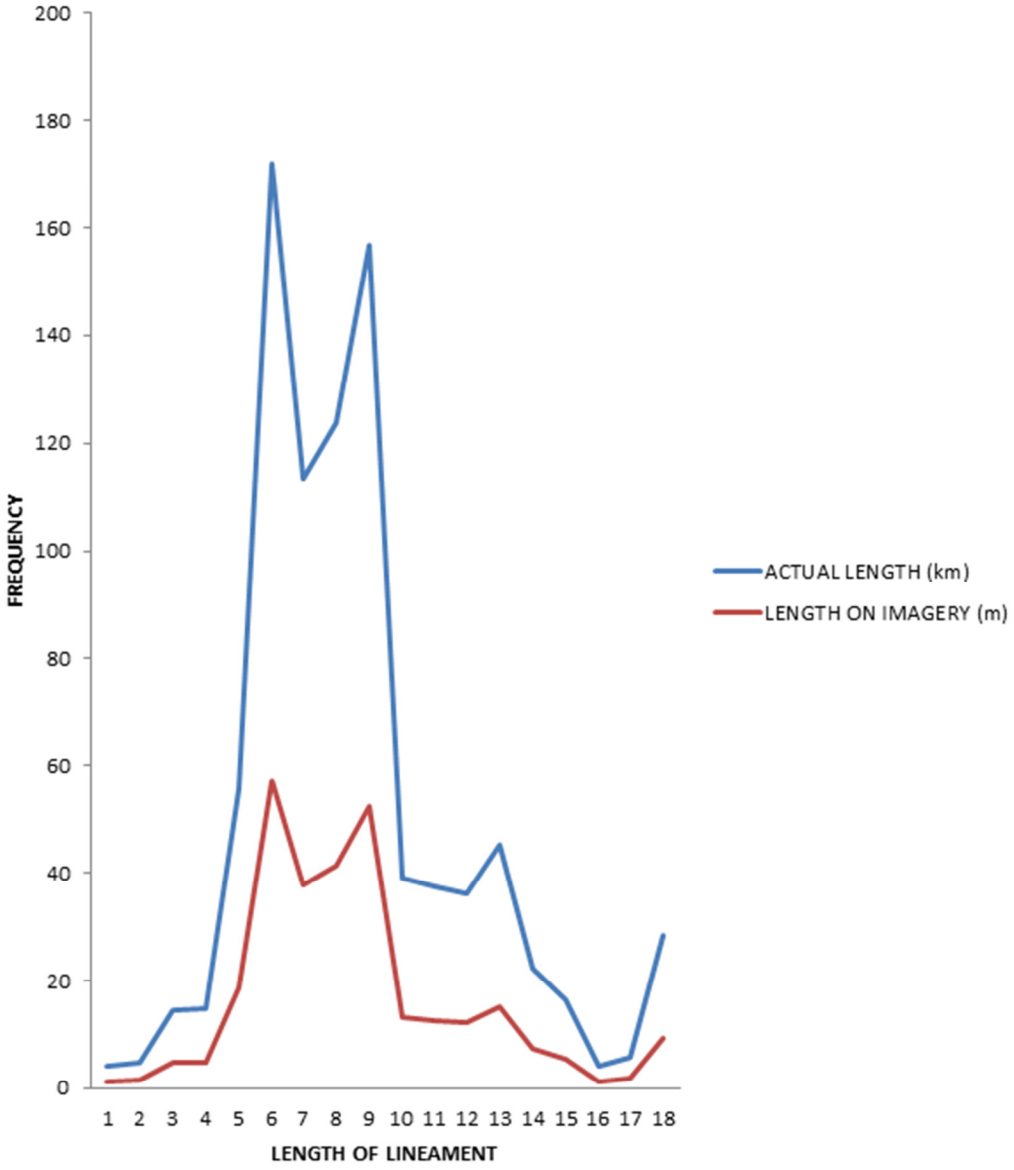

Figure 9. Relationship between the actual length of lineaments and lineaments on imagery.

Table 1. Data generated from the lineament mapped from LANDSAT-7 imagery.

AZIMUTH	ACTUAL LENGTH (km)	FREQUENCY	LENGTH ON IMAGERY (m)	% FREQUENCY	% LENGTH
0-10	4.1066	01	1.3688	0.4428	0.4593
11-20	4.8821	02	1.6274	0.8850	0.5460
21-30	14.4140	04	4.8047	1.7699	1.6121
31-40	14.7291	03	4.9097	1.3274	1.6474
41-50	55.6874	16	18.5625	7.0796	6.2282
51-60	171.9591	46	57.3197	20.3540	19.2323

Table 1. Contd.

61-70	**113.3999**	**30**	**37.80**	**13.2733**	**12.6829**
71-80	123.6915	24	41.2305	10.6195	13.8339
81-90	156.6168	31	52.2056	13.7168	17.5164
91-100	39.0843	09	13.1067	3.9823	04.3713
101-110	37.3202	08	12.4401	3.5398	04.1739
111-120	36.2176	10	12.0725	4.4248	04.5066
121-130	45.1264	15	15.0421	6.6372	05.0470
131-140	22.1474	08	07.3825	3.5398	02.4770
141-150	16.5608	06	05.5203	2.6549	01.8522
151-160	4.1213	02	01.3738	0.8850	0.4474
161-170	5.7158	02	01.9053	0.8850	0.6393
171-180	28.3865	09	09.4622	3.9823	3.1748
	Σ=894.1168	Σ=226	Σ=298.1344	Σ=98.23	Σ=100.45

Table 2. The distribution of lineaments on different rock types.

S/N	Rock Types	Number of lineaments	% Frequency of lineaments
1	Undifferentiated Basement Complex	21	9.29
2	Porphyritic granite	30	13.27
3	Sandstone, shale and clay	25	11.06
4	Alluvium	60	26.55
5	Sandstone, shale, siltstone, coal and ironstone.	-	-
6	Shale, limestone and sandstone	1	0.44
7	Migmatite	49	21.68
8	Shale and siltstone	07	3.10
9	Shales and limestones	34	15.04
		Σ = 226	Σ=100.43

Table 3. Statistical analysis of data generated over the study area.

Parameters	Azimuth (°)	Length (km)
Mean	84.6062	3.9565
Median	77.4150	3.4360
Mode	90.00	4.91
Standard Deviation	36.28094	2.37380
Variance	1316.307	5.635
Skewness	0.814	2.387
Standard error of skweness	0.162	0.162
Kurtosis	0.259	8.324
Standard error of Kurtosis	0.322	0.322
Range	175.27	16.98

Table 3. Contd.

Minimum		
Maximum	180.00	17.67
Sum	19120.99	894.17

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