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Lineament Extraction and Analysis on Jarawa Complex, Northcentral Nigeria Using Remote Sensing and GIS Techniques

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ABSTRACT

This study was carried out to extract and analyze the lineaments within the Jarawa Complex of North Central Nigeria using remote sensing and GIS techniques. Nigeria SAT – X image and ASTER GDEM, where used for mapping, extraction and analyses of the lineaments. Linear stretching and edges enhancement filter were applied to enhance the contrast and edge of the linear features using ILWIS 3.4 software. The enhanced image was visually interpreted and lineaments were extracted using on – screen digitizing in ArcGIS 10.0 environment. A total of 108 lineaments were extracted from the study area. The extracted lineaments were analyzed to determine lengths, distribution, density and orientation in order to generate lineament map, lineament density map, typology map, hill shaded relief map, drainage pattern map and rose diagram. From the results obtained, the lineaments ranged from 0.52 – 7.18 km in length and are spatially distributed within the study area. The northwestern and northcentral parts of the study area are characterized by high lineament densities which serve as conduits for mineral deposits. GEOrient software was used to plot the rose diagram from which the directional frequencies where obtained. The dominant lineament trend is NW – SE, however, two secondary trends are obvious in NNW – SSE and N – S direction.

Keywords : Lineament**,** Remote Sensing, Geographic Information System, Extraction, Satellite Imagery.

I. INTRODUCTION

Linear features on the earth surface have been a theme of study for geologists for many years, from the early years of the 20th century (Hobbs, 1904, 1912) up to now. From the beginning, geologists realized that linear features are the result of zones of weakness or structural displacement in the crust of the earth. Lineaments are defined as mappable linear surface features, which differ distinctly from the patterns of adjacent features and presumably reflect subsurface phenomena. They are usually manifested by topography, vegetation alignments, or tonal soil variations.

Lineament mapping is considered as a very important issue in different disciplines to solve certain problems in the area. For example, in site selection for construction of dams, bridges, roads, etc., for seismic and landslide risk assessment (Stefouli et. al., 1996), for mineral exploration (Rowan and Lathram, 1980), for hot spring detection and for hydrogeological research (Sabins, 1996) the nature and the pattern of the lineaments should be known.

1.1 Aim

The aim of this study is to explore the potential of remote sensing and GIS techniques for lineament extraction and analysis within Jarawa Complex of Northcentral Nigeria.

1.2 Objectives

The objectives of this study are;

1. Map out lineaments from satellite imagery.
2. Analyze the typology and the spatial distribution of lineaments.
3. Assess the existing lineaments for further information extraction using density and orientation techniques.

1.3 Study Area

The study area is located in Jos East LGA of Plateau State in the Northcentral part of Nigeria. It falls within the Maijuju sheet 169NW topographical sheet, which bounded by latitude 9° 45′ N and 10° 00′ N and longitude 9° 00′ E and 9° 15′ N (fig. 1.1).

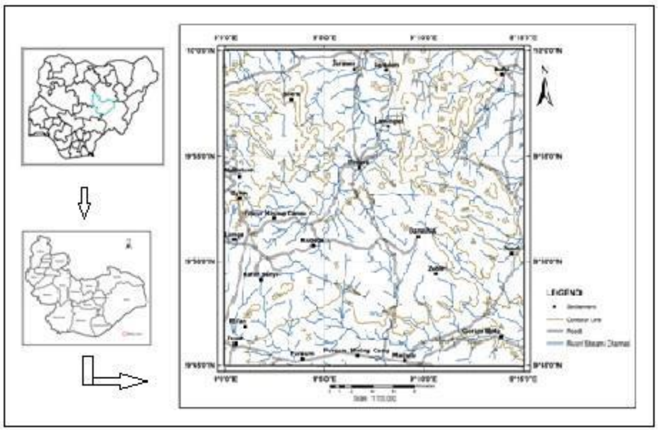

Fig. 1.1: Location map of the study area.

1.4 Geology

Geologically, the area falls within the Crystalline Basement Complex of Northcentral Nigeria and the Younger Granite Province of Nigeria. The area is underlain by Basement Rocks and outcrops of Younger Granites are well exposed within the study area. The Jarawa complex includes only two major intrusions-an early hornblende biotite-granite and a later biotite-granite-but both these phases were succeeded by closely related biotite–mircogranites. The hornblende–biotite–granite defines the eastern and southern perimeter of the Jarawa ring-structure and also forms the two radically arranged masses of the north Jarawa and Fusa Hills.

The rock types that form the bed to other rock types in the study area are the migmatites and granite gneisses, they are old rocks (over 2Ga). These rocks are highly deformed, resulting from the various deformation episodes. The degree of deformation and metamorphism is well marked by foliations. They occupy the lowland areas covered by soil due to the intense weathering and erosion that has affected them, and a few exposures along steam channels and scattered bundlers are seen with no sharp boundaries.

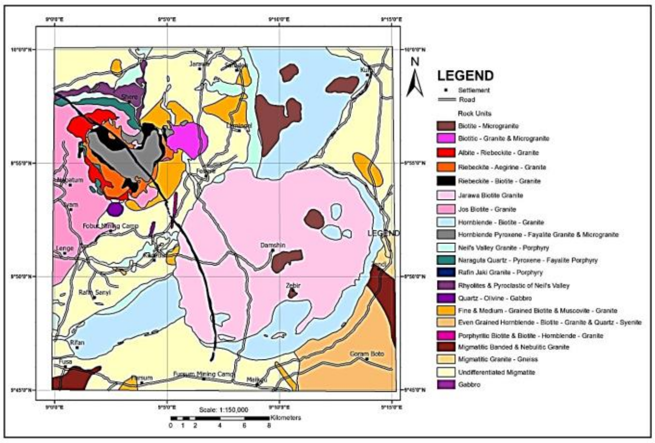

Fig. 1.2: Geological Map of Jarawa Complex

II. METHODS AND MATERIAL

2.1 Data

Three data sets were used for this study:

1. NigeriaSat – X. (Source: NCRS Jos).
2. ASTER GDEM image ASTGTM_N09E009 of L2 processing level, acquired on 6/10/2003 from GLCF.
3. Geological map of Jarawa Complex (Source: Nigeria Geological Survey Agency).

4. Topographical map of Maijuju. Sheet 169 NW, 1:50,000 series produced and published by Federal Surveys Nigeria. (Source: NCRS Jos).

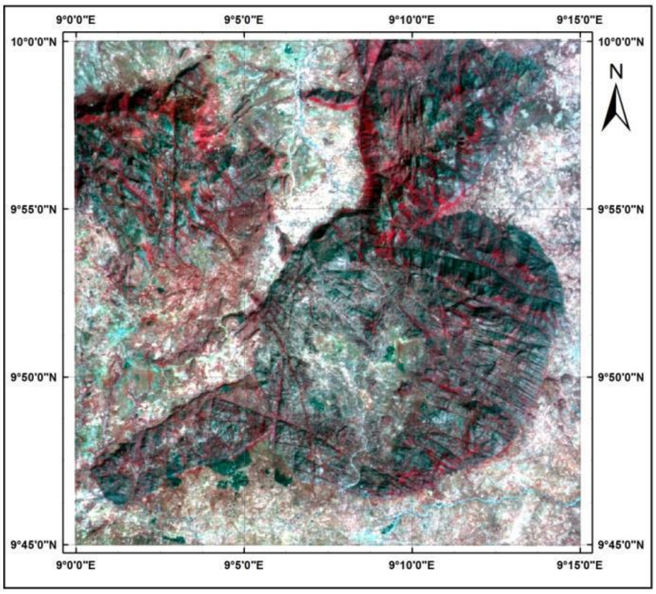

Fig. 2.1: NigeriaSat – X image of the study area.

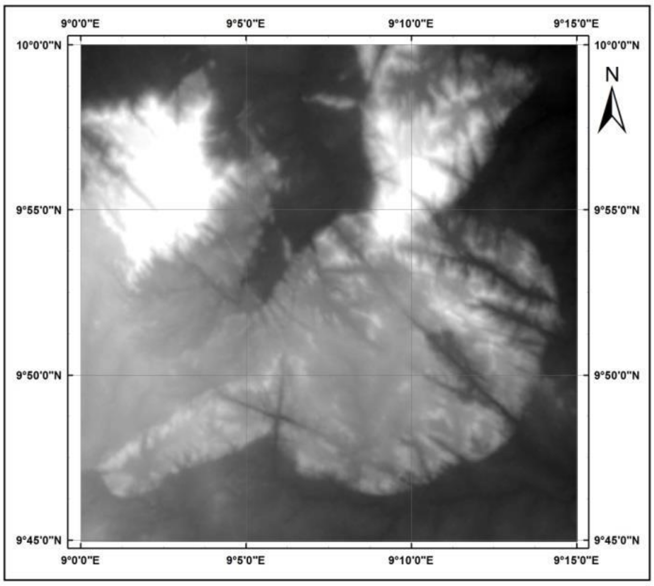

Fig. 2.2: ASTER image of the study area.

2.2. Software

For this study, two software were used;
1. ILWIS 3.4
2. ArcGIS 10.0

2.3 Methodology

The method of this study consists of four main steps.

1. The first step of the study is selection of the input data. Satellite images, topographical map and ancillary data.

2. In the second step of the study, image enhancement operation which include; filtering and stretching were applied to the images to remove noise and enhance the image. Geometric correction was carried out on the images in order to re-project the coordinate systems of the images. The topographic map was scanned and then imported into the different software from which roads and settlement layers where created.

3 The third step of the study is the extraction of lineaments from the satellite images. The lineaments were extracted from the satellite images using interactive visual interpretation and digitizing. GEOrient software was used to plot the rose diagram of lineaments extracted.

4 The final step of the study includes the analysis of the lineaments extracted, cartographic visualization and presentation of results in the form of maps, charts and rose diagram.

III. RESULTS AND DISCUSSION

Lineaments were delineated by visual interpretation of NigeriaSat – X and ASTER images of the study area. The extracted lineaments were assessed using the lineament density and lineament frequency parameters. The results were presented as lineament map, typology map, charts, lineament density map, and rose diagram.

A total of 108 lineaments were extracted from NigeriaSat – X and ASTER GDEM images (Fig. 3.1). The lineaments where digitized using ArcGIS 10.0 software. This was carried out with the aim of discarding non geologic lineaments.

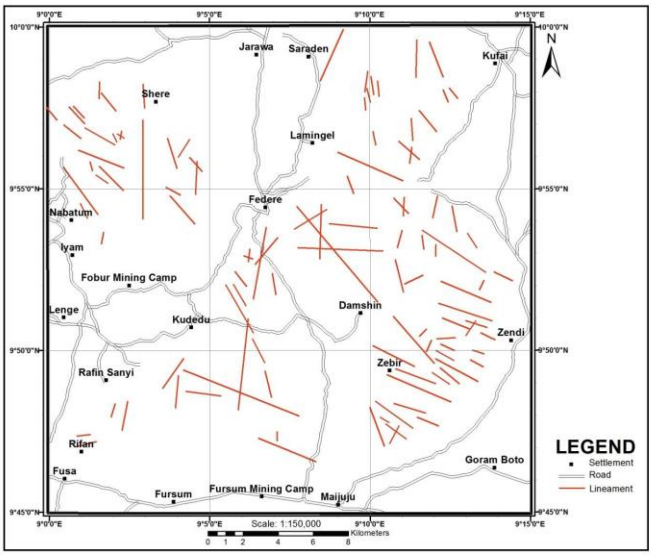

Fig. 3.1 : Lineament map of the study area

Length analysis

The total length of the lineaments within the study area measured 195069.45m (i.e. approximately 19.51km). The minimum length is 520 meters and maximum length 7180 meters respectively. The typology of lineaments is based on length analysis using grouping method. The lineaments are grouped into four classes as follows; Very short, short, long and very long.

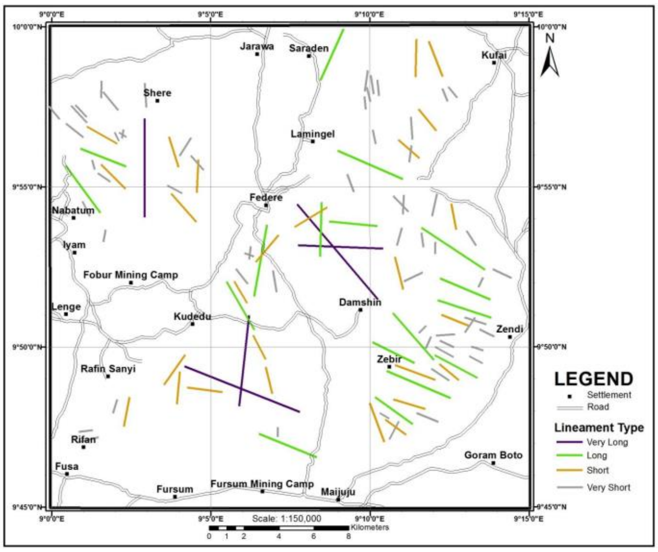

Fig. 3.2: Typology map of the study area

Table 3.1 : Statistical table of extracted lineaments within the study area.

S/No	Type	Length (m)	No. of lineaments
1	Very Short	520 – 1400	60
2	Short	1401 – 2480	25
3	Long	2481 – 4380	18
4	Very Long	4381 – 7180	5
TOTAL			**108**

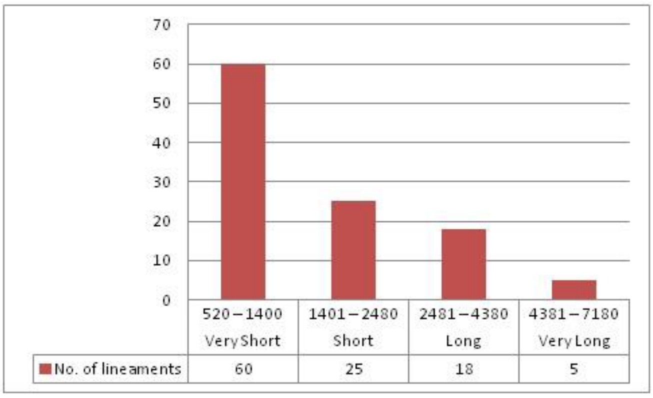

Fig. 3.3: Frequency distribution of lineaments extracted within the study area.

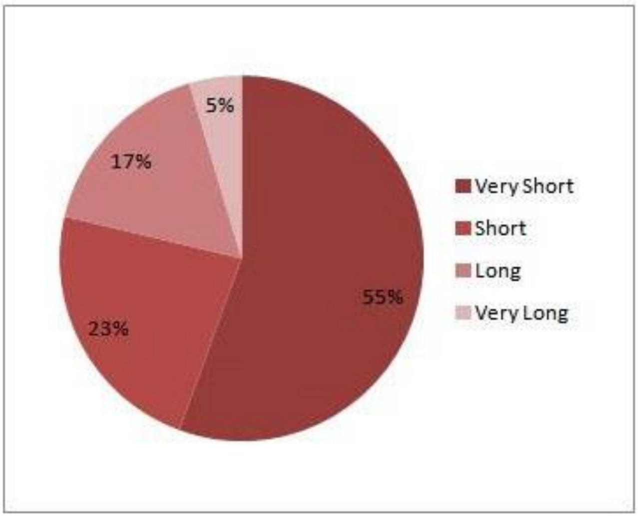

Fig. 3.4: Percentage distribution of lineaments

Lineament density mapping

Lineament density is defined as the number of lineaments per unit grid of cells. The purpose of the lineament density analysis is to calculate frequency of the lineaments per unit area. This is also known as lineament-frequency (Greenbaum, 1985). This analysis produces a map showing concentrations of the lineaments over the area.

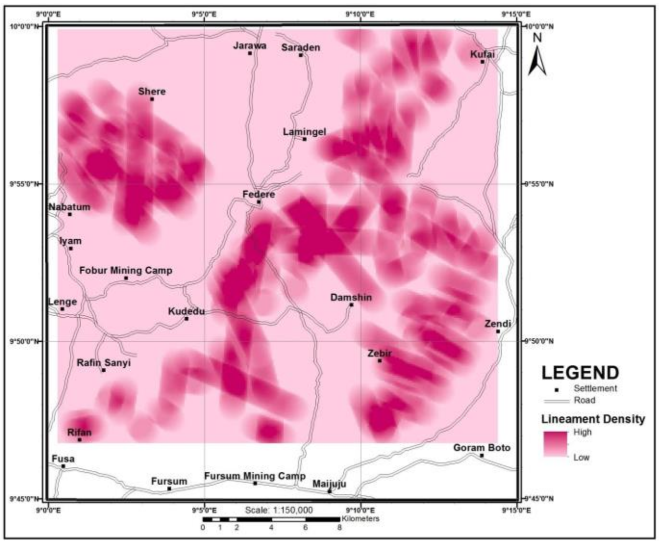

Fig. 3.5 : Lineament density map of the study area.

The lineament density map shows lineament density variation between high and low. The denser the lineaments typified the intensity of rock fracturing which is a pre-requisite for the development of hollow passages over an area.

Orientation analysis

Orientation of lineaments is usually analyzed using rose diagrams. This diagram displays frequency of lineaments for regular intervals. The interval in this study for all analyses is selected as 30 degrees.

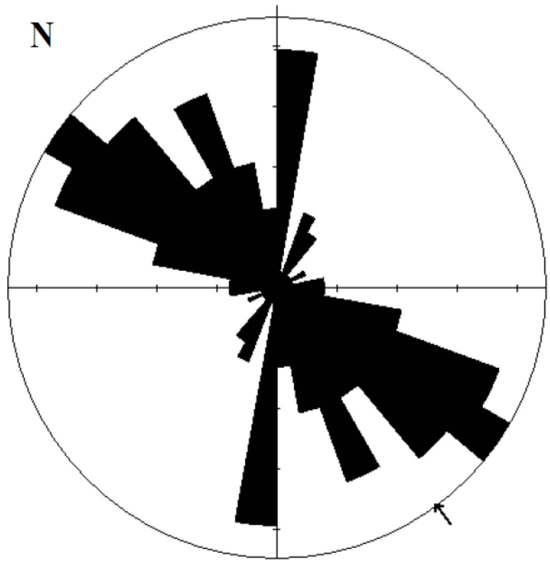

Fig. 3.6 : Rose diagram of the extracted lineaments within the study area, showing the major trends (NW – SE, NNW – SSE and N – S).

IV.Discussion

In terms of length, the lineaments have been categorized into five classes; Very short, short, long and very long (fig. 3.2, 3.3 and 3.4). Based on that classification, very short lineaments constitute 55%, short 23%, long17% and very long 5%.

The areas around the Northcentral, part of Northwest, part of Northeast and southeastern parts of the study area have by high lineament density values and are also characterized by high lineament intersection. According to Edet et. al., 1998, zones of relatively high lineament densities are identified as zones of high degree of rock fracturing which can be conduit for groundwater passage. Lineament density analysis have been the stock in trade in most geological applications of structural controls to mineralization such that points of intersections and trends are usually sort after in explorations. Hence, zones where these lineaments intersect or cross rock boundaries constitute valuable target areas during mineral exploration (Ashano and Olasehinde, 2010). The rose diagram (fig. 3.6) shows the directional frequency of the lineaments within the study area, the dominant trend is NW – SE. Also, NNW – SSE and N – S are observed within the study area. These trends are principal directions of regional structures. The presence of NW-SE, NNW – SSE and N – S trends has been reported in the Pan-African basement by Oluyide (1988) and Edet et. al., (1994).

V. CONCLUSION

This study was carried out to evaluate the lineaments within Jarawa Complex of Northcentral Nigeria using remote sensing and GIS techniques. NigeriaSat – X and ASTER GDEM images together with the topographical map of the area were used in this study.

Remote sensing has proven to be a useful tool in lineament identification and mapping. Results have shown that the application of remote sensing and GIS in lineament mapping and structural analysis are enormous. The synoptic view that remote sensing affords us and the realization that geologic structures are usually very large up to tens of kilometers makes this method a must for structural geologist.

The result of the analyzed lineament indicate that they have numerous long and short fractures whose trends are mainly NW – SE, NNW – SSE and N – S and corresponds to the general regional trends within the Nigerian Basement Complex. The relatively high density areas on the lineament density map are areas around the northwestern, central and southeasrtern parts of the study area and are potential zones for ground water and feasible zones for mineralization. The study area has undergone atleast two stages of regional deformation as is the case with the entire Nigeria Basement Complex.

Finally, from this study it has been proven that the remote sensing and GIS can be used as a powerful tool in mapping and analyzing lineaments in complex terrains such as the Jarawa Complex of Northcentral Nigeria.

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