Using Remote Sensing for Lineament Extraction in the Central Part of Libya

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Abstract:

Remote sensing data is very important for the study of structural geology and extraction of lineament, it gives a glimpse of tectonic events.

The main purpose of this study is to plan a to the extraction method, and lineament mapping from satellite images of Landsat (ETM+) in the study area. The area of this study is one of the important places in Libya, which contains the iron Ore deposits, therefore, the study of geological structures (lineaments) is one of the most important factors, which gives indications about the locations of ore deposits; lineament extraction and *analysis represent one of the routines in mapping large areas using remotely-sensed data, most of which is the satellite images.*

Lineament analysis of a selected area is carried out with the aid of a Landsat ETM+ satellite image and by the application of various image processing techniques. Lineaments were visually interpreted from the enhanced images where lineaments were well over 2 km long and manually traced. The width of the lineaments in the interpreted images were various but not considered for lineament analysis. In the study, a total area of 1105 lineaments were recognized and analyzed.

KEYWORDS: *Remote sensing, lineament extraction, Landsat (ETM+), Libya*

1.Introduction:

A lineament is a linear surface on a planet, like a fault line or fracture line. The term "lineament" is one of the most common terms used in geology. Arlegui and Soriano (1998) used different band combinations of Landsat 5 TM were used to extract lineaments in central Ebro basin (NE Spain)[1]. The best visual quality was obtained with a false colour image utilizing bands 2, 4 and 7 (in blue, green and red respectively). Anwar et al (2009) used Landsat TM imagery and the SPOT with 30m and 10m resolution were used for lineament mapping in Hulu Lepar Area, Pahang, Malaysia, and found that the a 30m resolution images are more efficient for some geologic structural feature extractions compared with 10m image's resolution. Band 4 of Landsat TM-5 and band 3 of SPOT-5 were regarded as the best bands for the automatic extraction of features; especially in the tropical areas, which could also be the best for manual lineament extraction[2]. Lineaments are straight linear elements visible to the surface of the earth, which are the representations of geological or geomorphological phenomena[3] (Clark & Wilson 1994).

Satellite images and aerial photographs are widely used to extract features for different purposes. Since the satellite images are obtained from different wavelength intervals of the electromagnetic spectrum, they are considered a better tool for discrimination, Trains and produce better information than conventional aerial photography[4] (Casas et al. 2000).

The researcher summarizes the definition of the lineament in the different geological features, such as (1) shear zones faults, (2) rift valleys, (3) shortening the digestion (4), both axial traces, (5) joint and fracture traces, (6) topography, vegetation, soil tonal alignment changes, etc. Lineaments generally interpreted as an expression of the surface rock fractures[5] Gupta et al (1991). Hobbs (1904) first used the term to define a lineament "important line of the landscape, which reveals the hidden architecture of rock basement[6]. Remotely sensed faults, folds and other lineaments usually used as an indicator of the major fractures in near surface.

2. Geological Setting:

The study area lies to the south of the Gargaf arch, an E-W trending anticline, built up of a Precambrian core and Cambrian to Devonian clastic sediments with Lower Carboniferous Rocks at its southern limb, striking about 85° with 1-3° dip towards the south. Paleozoic formations containing iron-bearing oolitic layers are reported to occur in several areas beside the Wadi ash Shati. The iron bearing horizons are mostly confined to the Middle and Upper Devonian Awaynat-Wanin formation. In the Shati valley, the Upper Devonian formation consists of 140 meters of gray, tan and brown, fine to medium grained, well-rounded and well-sorted cross bedded sandstone. It is interbedded with thin beds of quartzitic sandstone,varicoloured claystone and siltstone and contains several intra-formational conglomerates.

3. Study Area Location:

The study area is located in Middle West of Libya, in the Province of Fezzan between Latitude 27 ° to 28 ° North and longitude 12° to 16° East covering an area of nearly 60,000 sq km. The study area, where flat lying iron-bearing sedimentary beds are exposed with remarkable regularity.

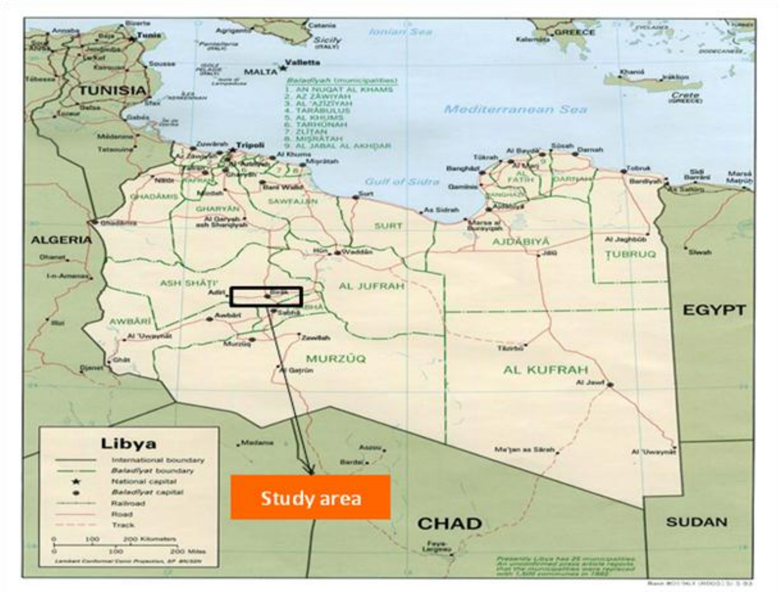

Figure 1: Location map of the study area

4. Methodology and Materials:

A number of digital processing techniques were taken to enhance and correct the acquired images as well as to choose the best band data for later analysis. From visual evaluation, band 7 of Landsat ETM+ image was selected for lineament analysis, since it shows a better contrast and displays better visualization of geological features compared to the other band for each satellite. For lineament analyses spatial enhancement were performed using directional filters. Directional filters are quite useful for producing artificial effects, which may reveal tectonically controlled linear features [7] (Drury 1987). High-pass filtering, which can be considered as an edge enhancement method, emphasizes the high-frequency components that show local details of an image by removing the low-frequency components [8,9] (Jensen 1986; Lilles & Kiefer 2000). Utilizing the high pass filters allows the removing of the lower peak in a histogram and pushing the histogram to higher values.

Filtering technique was used to enhance the structural geological information (lineaments) for each selected band. Lineaments for each direction are filtered separately, and then the tracings were overlapped to produce final lineaments map for each satellite. Sobel directional filter 3 by 3 pixel kernels, were applied to extract the lineaments in the area.

Lineaments for each direction are filtered separately, and then the tracings are overlapped to produce final lineaments map. Four images have been produced from these processes related to the directions' N-S,E-W, NE-SW and NW-SE are shown in figures (2-5), which are used to visual tracing for the negative lineaments. All lineaments appear in two tracing have been traced again in the final lineaments map. There are several rules for the lineament tracings, only lineaments with 2km length or more are taken into account, and overlapped lineaments will be considered as only one lineament in the final tracing.

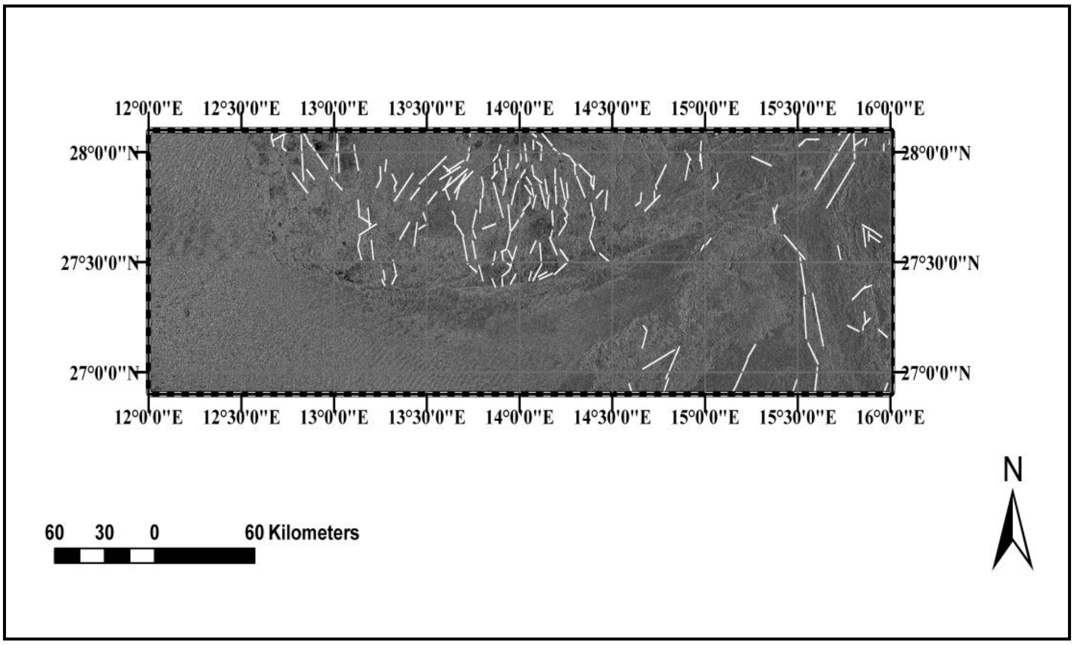

Figure2: Filtered image of Landsat ETM+ band 7 in N-S direction.

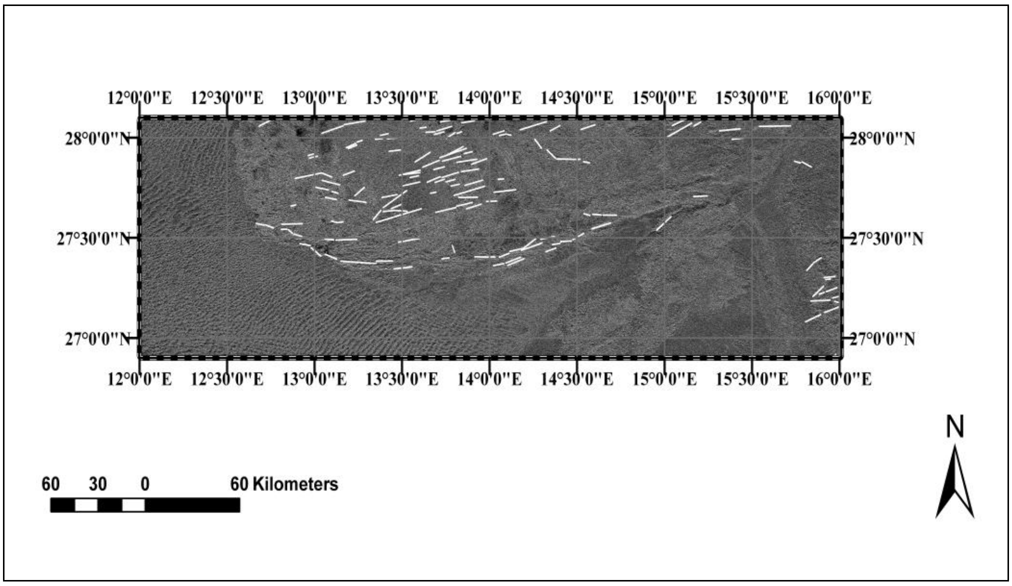

Figure 3: Filtered image of Landsat ETM+ band 7 in E-W direction.

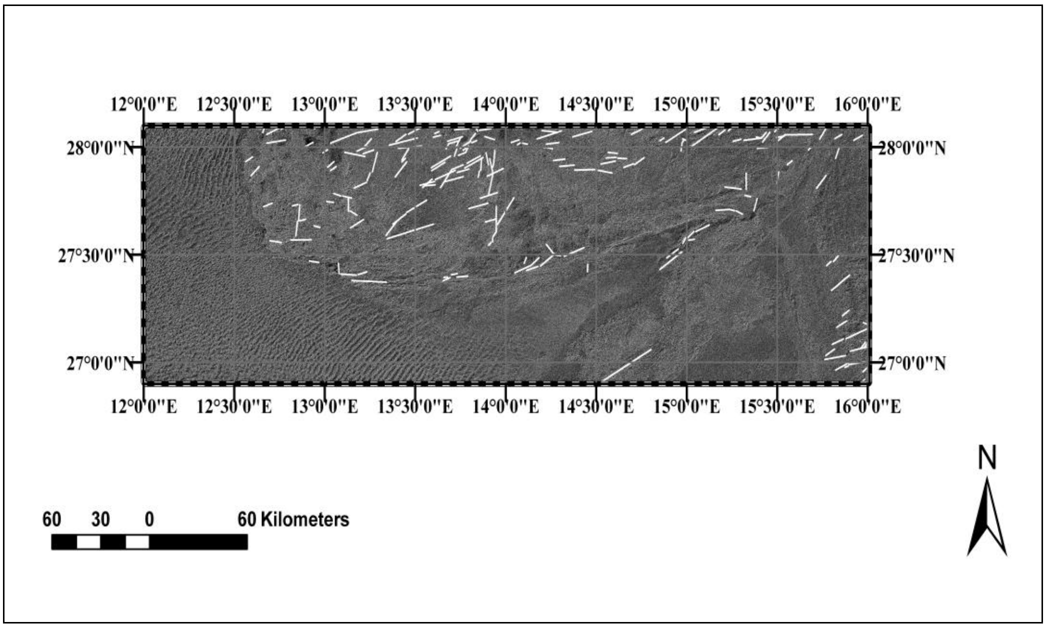

Figure 4: Filtered image of Landsat ETM+ band 7 in NE-SW direction.

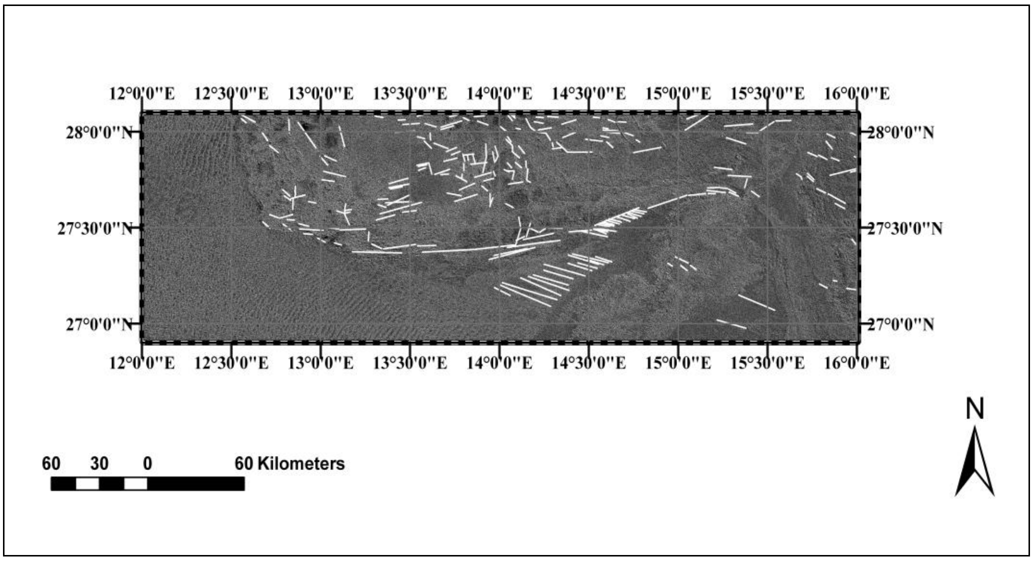

Figure 5 : Filtered image of Landsat ETM+ band 7 in NW-SE direction.

5. Results and Discussion:

5.1 Lineament extraction:

The area of this study is one of the important places in Libya, which contains the iron ore deposits, therefore, the study of geological structures (lineaments) is one of the most important factors, which gives indications about the locations of iron deposits; Lineament extraction and analysis are one of the routines in mapping large areas using remotely-sensed data, most of which is the satellite images.

Lineament analysis of a selected area is carried out with the aid of a Landsat ETM+ satellite image and by the application of various image processing techniques. Lineaments were visually interpreted from the enhanced images where lineaments were well over 2 km long and were manually traced. The width of the lineaments in the interpreted images were various but not considered for lineament analysis. In this study, a total area of 1105 lineaments were recognized and analyzed. The interpreted lineament map of the area is shown in Figure 6.

Classification of the lineaments for direction was made based on the interval of 10º of the lineaments direction for lineament map. Based on the lineaments frequency of the rose diagram for Landsat ETM+ in the dominant lineament was in the direction of Northwest-Southeast between 310º-319º. The second dominant direction is 320º-329º. All this lineaments direction is parallel with the major faults reported by previous researchers. It seems that there is a relationship between the length of the lineaments and the orientation in the area, which means the length of the lineaments, plays the important role of certain orientations. The sun azimuth effect was clearly evidence of the appearing of lineaments in the EW& ENE-WSW directions.

Lineament density and intersection density of lineaments are also useful for characterizing the spatial patterns of lineaments. The purpose of this study is to analyze the spatial distribution of lineaments extracted from satellite images according to their density, and orientation in order to contribute to the understanding of the faults of the study area. The purpose of the lineament density analysis is to calculate frequency of the lineaments per unit area. This is also known as lineament-frequency. This analysis will produce a map showing concentrations of the lineaments over the area. Analysis of lineament density is performed by counting number of lineaments contained in specified unit area.

Visual interpretation of density map (Figure 7) shows only different densities in different parts of the area. The density is very high in the northern part of the area, which indicates that, the rocks in that part of the area highly fractured. The southern and western parts of the study area are low density that means the rocks in those parts are less fractured. The high density area reflect the fractured rocks such as granite and sandstones, where the low density area reflect the less fractured rocks such as metamorphic rocks.

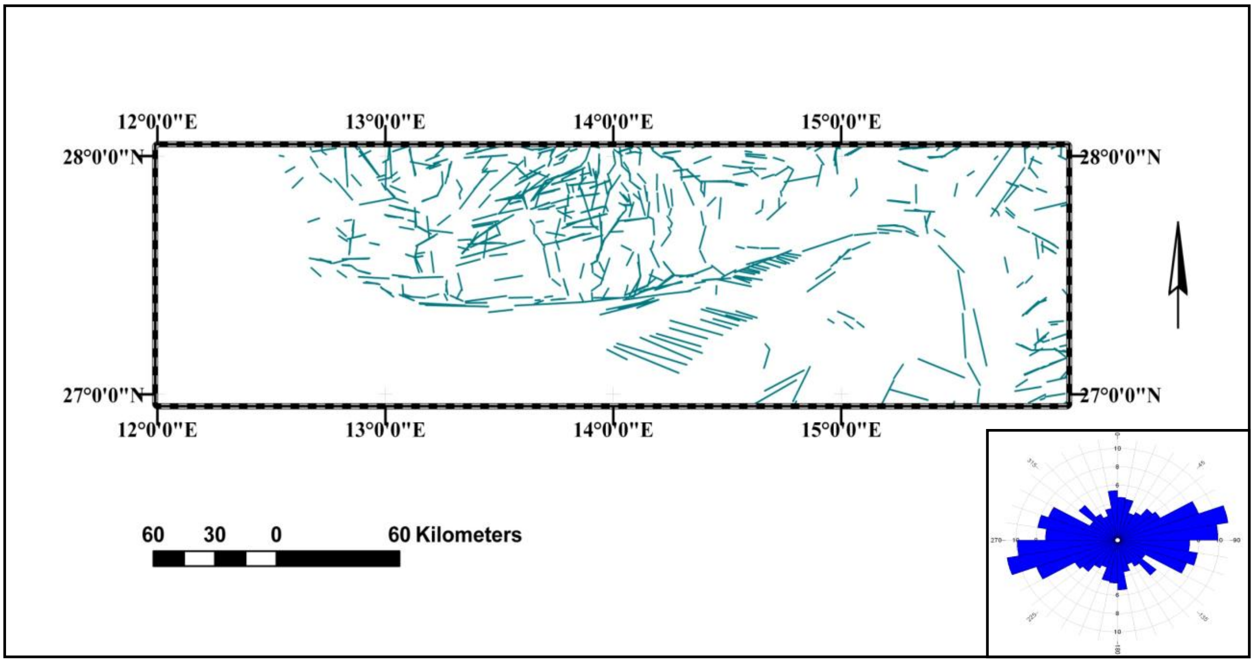

Figure 6 : Lineament map of the study area extracted from ETM+ imag.

Rose diagrams in all applications in the literature usually analyze orientation of the lineaments. These diagrams display frequency of lineaments for regular intervals. The interval in this study for all analyses is selected as 10 degrees. The diagram is prepared by counting each fault line as an element regardless of its length. Therefore, the resultant diagram is not length-weighted. The orientation of lineaments was plotted for the dominant direction relative to mostly ENE-WSW (Figure 6), The other lineament directions are not considered, because it not that much important for discussion. Comparisons are made for four sets of rose diagrams with respect to their number and lengths in each 10-degree interval. They are located based on different types of Lithology.

The geologic map of the area was used to identify the various changes in lithologies and fault patterns. All this lineaments direction is parallel with the major faults reported by previous researchers. Lineament density classes are depicted on this map as ranging from areas of lower lineament density, to areas of higher lineament density (Figure 7). This map shows the area of higher lineament density in the northern to the North West portion of the map area, coincident with major subsurface structural development along the igneous and metamorphic rocks, where these rocks show highly fractured in the field. Areas of lower lineament density are found in the western, southeast and southwest portions of the map. Lineament density appears artificially lower in the areas covered by sand dunes and soft rocks, in less fractured rocks.

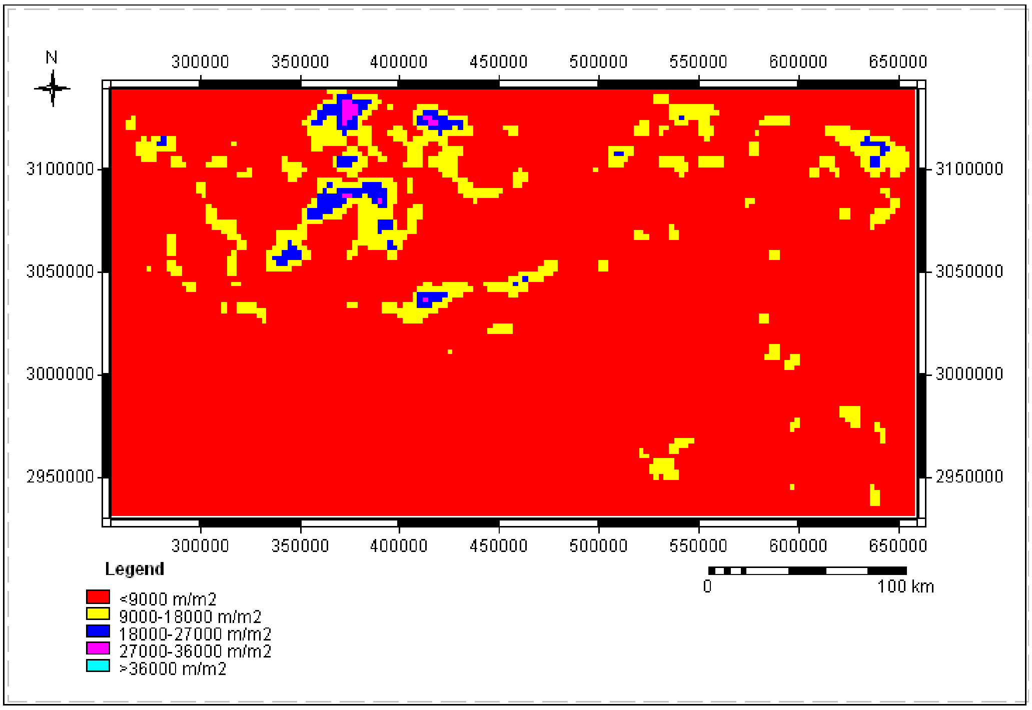

Figure 7: Lineament density map of the area.

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