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Lineaments Analysis and Mapping From Satellite Images For Southern Iraq

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Abstract

Synergistic display of data recorded by different remote sensing has proved extremely valuable for the extraction of geological features such as lineaments . Accordingly , two satellite images were used for lineaments analyses which are considered as indicators for rock fractures . Image resolution merge and directional filtering methods were applied for lineaments extraction using GIS techniques .Rose diagram and lineaments density analysis were used for the traced lineaments . The output of these techniques are used to trace new lineaments as a regional lineaments map . a synergistic display of these regional lineaments with geophysical images allows the major lithological and structural boundaries to be mapped . Evaluation of lineaments map and its rose diagram analyses shows that the dominant lineament trend is mainly NW-SE and NE-SW. It is concluded that these lineaments indicate the fault zones within the area. Besides, a considerable conformity has been noticed between the location and dimension of such lineaments with subsurface anomalies appeared in geophysical images.

Keywords: GIS , Image resolution merge , Directional filtering , lineaments .

تحليل وتحديد الخطيات من الصور الفضائية لجنوب العراق

الخلاصة

أظهر العرض المشترك للبيانات المسجلة ، باستخدام أنظمة التحسس النائي المختلفة ، أهميته في استخراج الظواهر الجيولوجية ومنها الخطيات .وعلى هذا الأساس استخدمت صورتان فضائيتان لتحليل الخطيات لكونها تعتبر مؤشر لتكسر الصخور. طبقت تقنيتان ، الأولى تقنية دمج الصور لتحسين قدرة التمييز وتقنية المرشحات الاتجاهية لاستخراج وتتبع هذه الخطيات باستخدام تقنية نظم المعلومات الجغرافية . أستخدمت طريقتان للتحليل بواسطة التمثيل الوردي وتحليل كثافة الخطيات . أستخدمت نتائج هذه التحليلات لاستخراج الخطيات الاقليمية وعمل خارطة لها . سمح العرض المشترك للخطيات الاقليمية مع الصور الجيوفيزيائية بتعيين الحدود الليثولوجية والتركيبية . أظهر تقييم خارطة الخطيات والتمثيل ان الاتجاه السائد لهذه الخطيات NE-SW , NW-SE وتشير هذه الخطيات الى أنطقة الصدوع ضمن المنطقة . كما لوحظ توافق واضح بين مواقع واتجاه هذه الخطيات مع الشواذ تحت السطحية الظاهرة في الصور الجيوفيزيائية .

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Introduction

Lineaments mapping and analysis is one of the routines in mapping large areas using remotely – sensed data . Geologic lineaments mapping is very important in solving engineering problems , especially for site selection in construction , seismic and landslide risk assessment , mineral exploration, hot spring detection , hydrology etc [1,2] .

Lineaments are significant lines that reveal the hidden architecture of the landscape that reveal the hidden architecture of the rock basement [2,3] . However O'Leary et. al. (1976) define lineament as a mappable, simple or composite linear feature of a surface whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differ from the pattern of adjacent features and presumably reflects some sub-surface phenomenon [4]. Remotely sensed lineaments are often used as indicators of major features in near-surface . Earlier , lineament interpretations were made from aerial photographs . Recently , geologists have been interested in tracing lineaments from satellite images which have broad coverage under the uniform conditions .

This paper is aimed to integrate the information of lineaments obtained from satellite image with the anomalies of appeared in geophysical images as these lineaments (especially regional lineaments) indicate fault zones within the studied area .

Methodology (Analysis, Results and Discussion)

Remotely sensed lineaments are often used as indicators of major fractures in near-surface. Lineament analysis and interpretations were made from satellite images which have broad coverage under the uniform conditions [4]. The method is composed of four successive steps: The block diagram of the procedure used is given in figure (1).

1- The selection of input data and processing for the next step.
2- Lineament extraction by using manual lineament extraction techniques.
3- Analyses of lineament map including density and rose diagram analyses.
4- Testing final map with the geophysical map of the area.

I- Selection of Input Data.

Two different images were used to reduce the missed lineaments in the area. As the area is characterized by its inhomogeneity and its dramatic land cover changes . The used images were :

1- NASA's Landsat GeoCover program mosaic (3 bands in visible spectrum portion) with 14.25 m resolution and acquired in 2000 .
2- Landsat 5 TM imagery with 7 bands (only three of these bands were used in this work) and 30m resolution acquired in 1990.

The integration of Landsat 5 TM imagery with high-resolution panchromatic data provides complementary information with respect to the discrimination of major geologic features and allows lineament extraction in detail [5].The higher spatial resolution and spectral differentiation provided by data fusion techniques increase the interpretability of imagery for geology [6]. It is very useful for the geologic mapping of structures and lithology [7] . Only three of the seven bands have been used (4, 5 and 7) as the resulting image will be applied for visual interpretation only, using

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computer display devices in by which only three bands can be displayed each time.

II - Visual Lineament Tracing

In visual method, the lineaments are extracted from satellite image by manual interpretation. The lineaments usually appear as straight lines or " edges " on the satellite images which are , in all cases, contributed by the tonal differences within the surface material[4]. Image enhancement techniques can contribute to visual lineament extraction. There is an ability to design a directional filter for any interested direction. In this study , commonly known techniques of directional filtering operation are used in the preparation of the final lineament map . Directional Gradient-Sobel and Gradient-Prewitt filters are applied to both mosaic and merged Landsat 5 TM imagery in four directions N-S, E-W, NE-SW and NW-SE. Both Sobel and Perwitt filters gave approximately the same results , but with less noisy background for Sobel filter in comparison with Perwitt filter . So directional Sobel filter kernals used in this work are presented in table (1) with their results illustrated in figure (2) for four directions . Each process will generate a GIS layer that can be linked to other layers easily . A single lineament map has been generated from multiple lineament maps to overcome any confusion or complexity as shown in figure (3).

Most of the lineaments were traced from the first four images obtained from mosaic image . Generally , the lineaments appeared are gathered in two main groups as illustrated in figure (4), and their locations are :

1. Al-Hammar marsh: Many parallel lineaments were appeared during the periods of acquiring the original images (merge image) when Al-Hammar appeared as natural marsh in 1990 and mosaic image in 2000 when the marsh dried .
2. Rumaila: These lineaments appeared due to the big mass of smoke incoming from oil fields .

Finally, an integration was made between topographic maps and lineament map using GIS capabilities to erase lineaments that match exactly roads, oil pipelines and manmade water channels and rivers.

III- Analyses of Surface Lineaments

After lineaments being traced in the processed satellite image , various analyses methods have been employed to analyze these lineaments in order to extract deeper information from surface data . Two approaches were applied for surface lineaments analysis namely rose diagram and lineament density analysis .

Rose Diagram

This technique was used to analyze surface lineaments indicating their lengths and directions. Rose diagram analysis (Fig.5) showed that surface lineaments are distributed in all directions with predominant directions toward N40º–60ºE and minor directions in N20º–50ºW . Most lineaments are traces of irrigation network and river drainages with normal direction to the main rivers .

Lineaments Density Analysis

This analysis has been carried out using Matlab language with grid intervals 2 km and cell dimension 5km * 5km . Output for the number of lineaments per unit area is given in figure (6). The output of this analysis were converted to raster images representing the number of lineaments per unit area (n / km^2)

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(Fig.7). Besides, the number of lineaments intersection per unit area (n/km^2) and the total length of lineaments per unit area (n/ km^2) have been constructed in the same manner (Figs. 8 to 11) .The general trends of these lineaments are directed in NW-SE and NE-SW. To avoid the effect of non- tectonic lineaments, another image representing the average lineament length per km^2 has been constructed (Fig. 12) reflecting new lineaments which could be of tectonic origin (faults).

Regional Lineaments (Expected Subsurface Lineaments)

Three layer image has been combined (Fig. 13) from the above three single band images of lineament density analyses . Other lineaments are appeared in the new image . Also a new rose diagram is given (Fig. 14) indicating that the predominant direction of lineaments is N40º– 60º W, with maximum length in the direction N40º- 50º W and with minor direction is observed in the direction N30º –60º E .

Satellite Image Interpretation Against Geophysical Images

An integration has been made between lineaments obtained from satellite images and anomalies appeared in geophysical images by displaying the GIS layer of lineaments over the geophysical images. A new map / image is obtained which is shown in figure (15) . It can be shown that there is a coincidence between the surface structures and their associated gravity and aeromagnetic anomalies with the main axes trending NW-SE or N-S .

Conclusions

From the resulted maps and rose diagrams, one may point out the following points

1- Directionally filtered imagery is excellent for the delineation of major lineaments while synergistic display allows the major boundaries to be mapped even where there is total vegetation cover.
2- Generally, there is a great conformity between the direction of lineaments with the main subsurface structures and their associated geophysical anomalies with predominant trending axes in NW-SE indicating that these surface features are reflections for subsurface ones.
3- Most of the lineaments in the region are associated with positive gravity anomalies against less lineaments associated with negative gravity anomalies .
4- Some of lineaments zones separate the main geologic structures appeared in the region. These structures are associated with couple of lineament signatures. That is well observed in N. Rumaila, between N. and S. Rumaila, between Ratawi and N. Rumaila, between Nahr-Umr anomalies, and between Nahr-Umr and Zubair. These zones may be resulted from tectonic activities.

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Table (1). Sobel filters applied in four main directions [3,4].

<table>
<tr><th></th><th colspan="3">N-S</th><th colspan="3">NE-SW</th><th colspan="3">E-W</th><th colspan="3">NW-SE</th></tr>
<tr><td rowspan="3">SOBEL</td><td>-1</td><td>0</td><td>1</td><td>-2</td><td>-1</td><td>0</td><td>-1</td><td>-2</td><td>-1</td><td>0</td><td>1</td><td>2</td></tr>
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<tr><td>-1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>2</td><td>1</td><td>2</td><td>1</td><td>-2</td><td>-1</td><td>0</td></tr>
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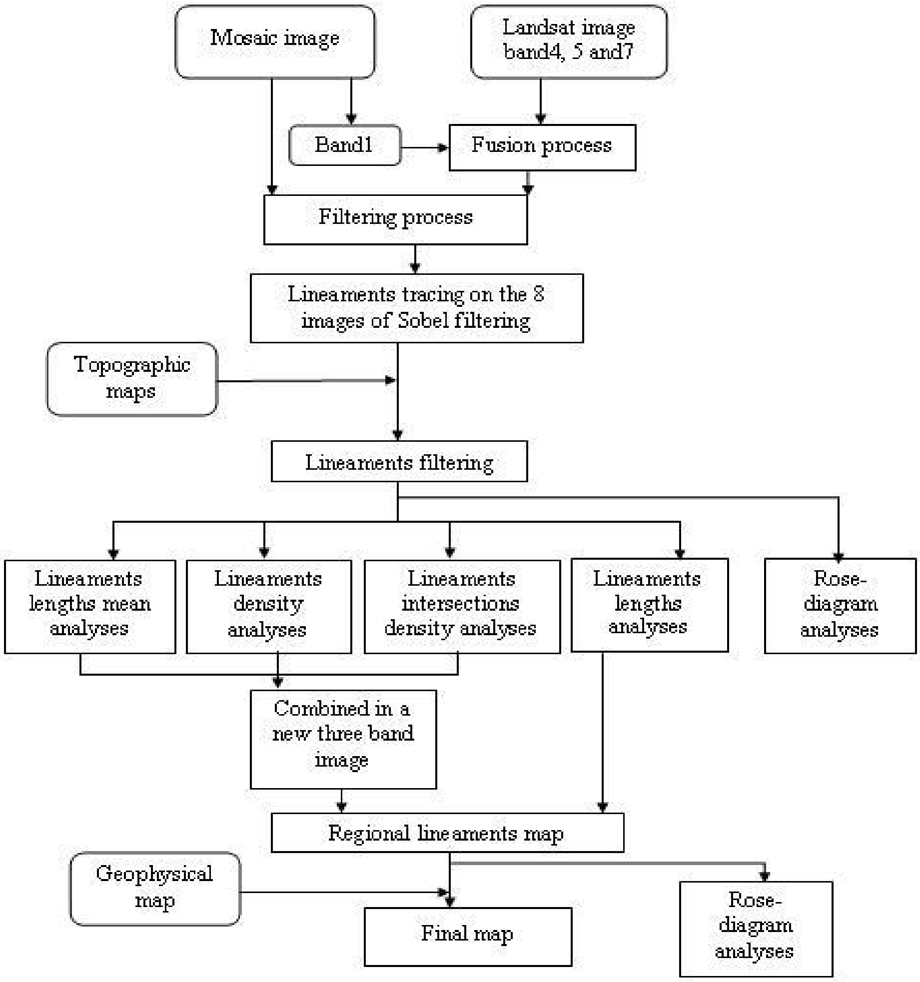
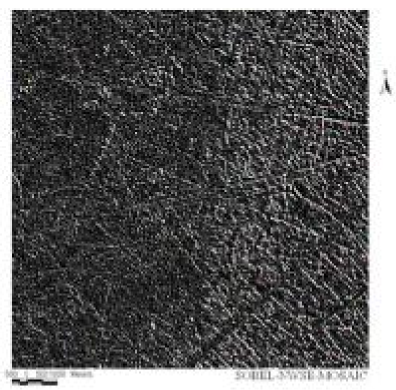


Figure (1) Flow chart for the procedure applied in the experimental work.



1.SOBEL-NWSE-on mosaic image

2.SOBEL-NWSE-on merge image

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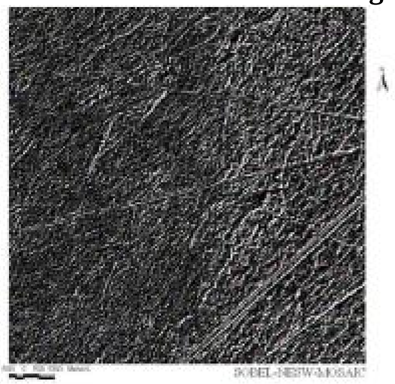
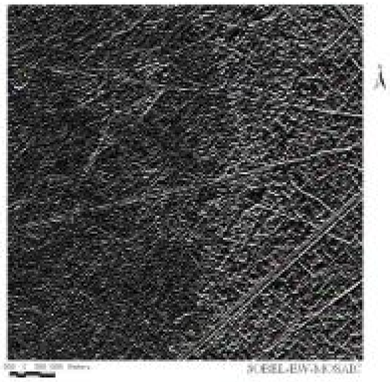
3. SOBEL-NS-on mosaic image

4.SOBEL-NS-on merge image

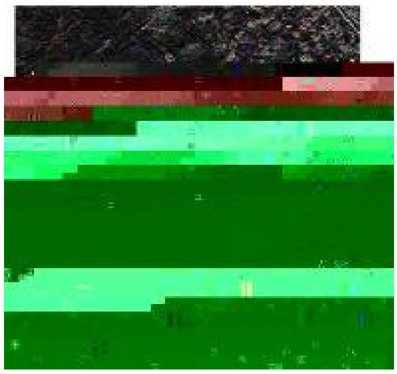


5. SOBEL-NESW-on mosaic image

6. SOBEL-NESW-on merge image



7. SOBEL-EW-on mosaic image



8. SOBEL-EW-on merge image

Figure (2) Sobel filtered images in E-W, NE-SW, NW-SE, NS directions.

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Figure (3) Example of combining the lineament maps steps.

1.On merge images

2.On mosaic images

Figure (4) Location of lineaments that are traced from merge filtered images.

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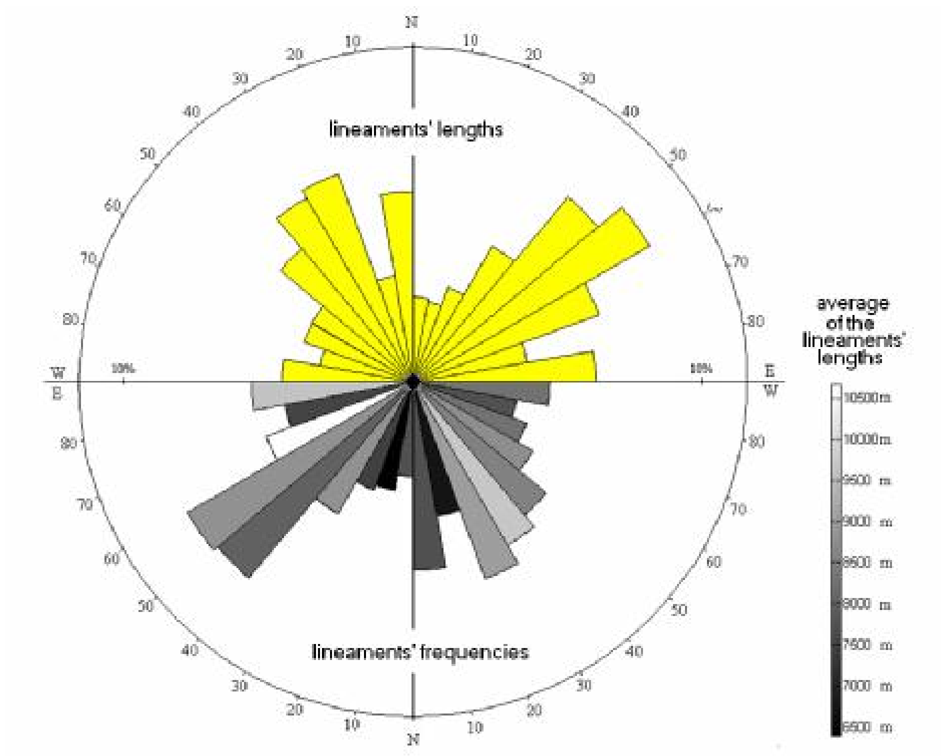

Figure (5) Rose diagram for surface lineaments.

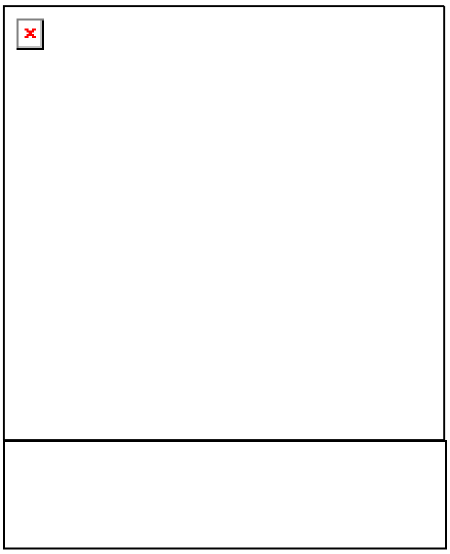

Figure (6) Density map of lineaments using MATLAB .

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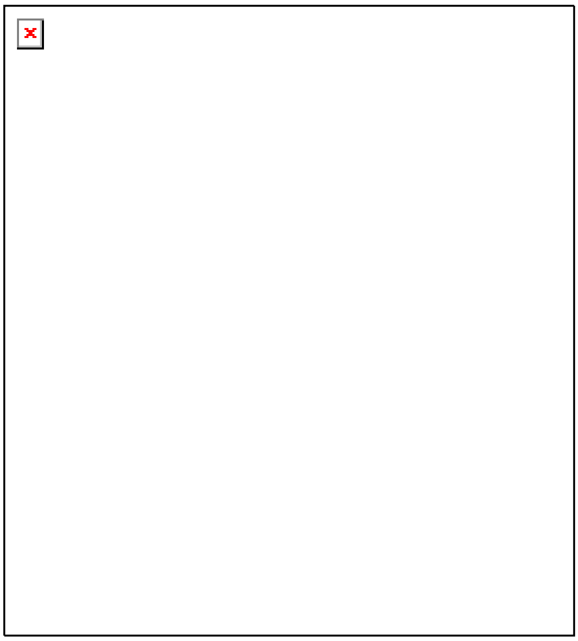

Figure (7) . Density map of lineaments.

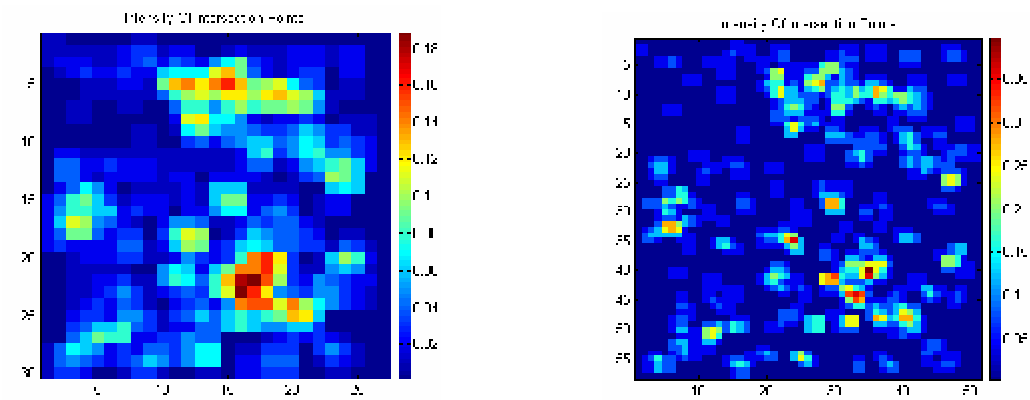

Figure (8) Density map of lineaments intersection using MATLAB .

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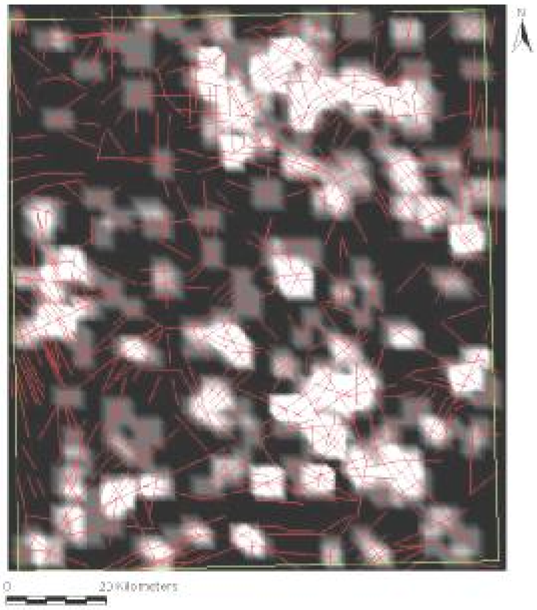

Figure (9) Density map of lineaments intersection.

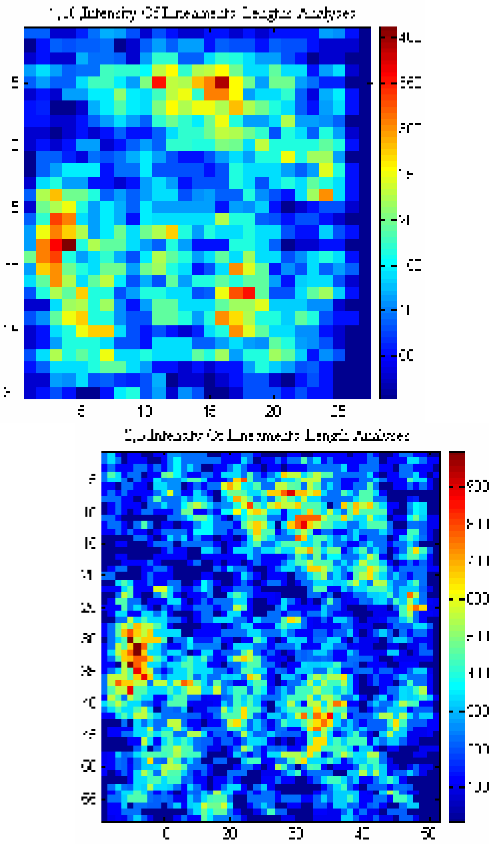

Figure (10) Lineaments-length density map using MATLAB language.

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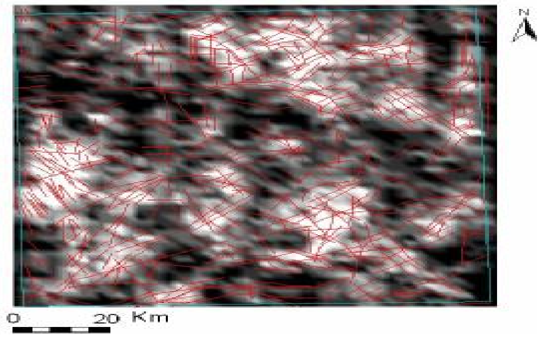

Figure (11) Lineaments-length density map.

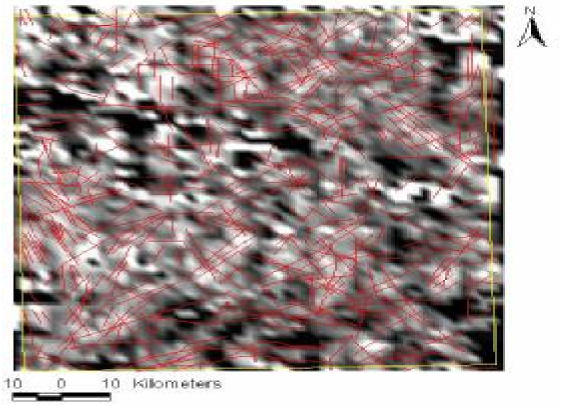

Figure (12) Average of the lineaments length per unit area map.

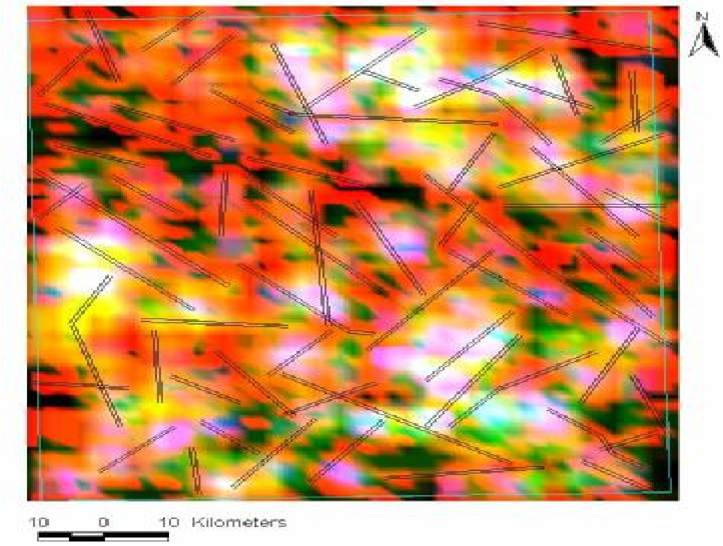

Figure (13) . Combined map of density analyses with the new lineaments .

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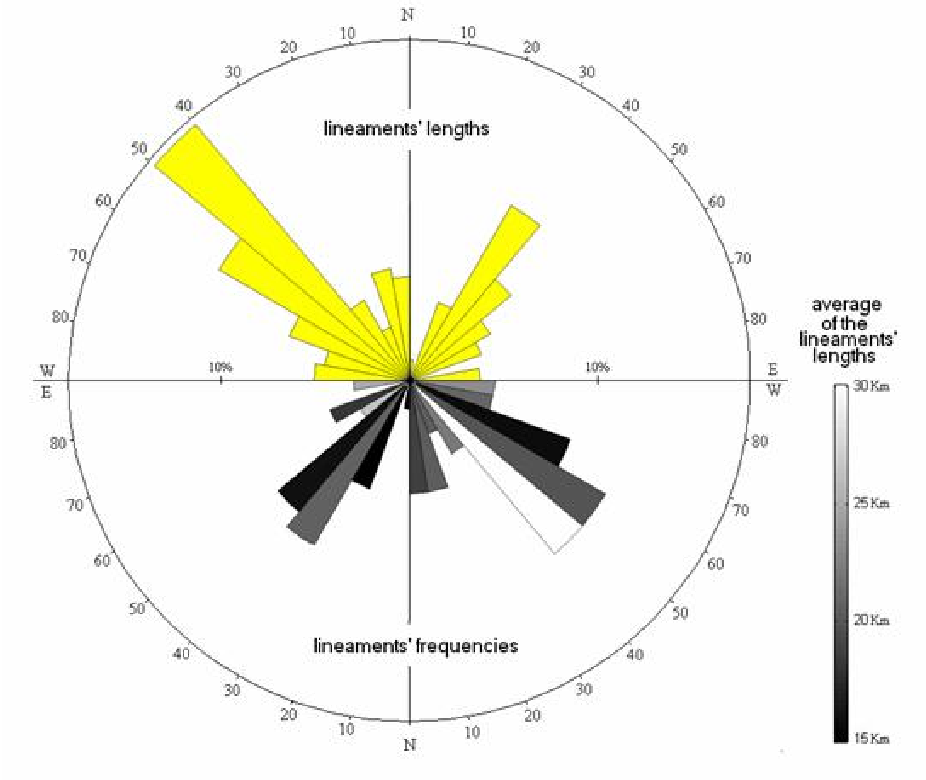

Figure (14).Rose diagram analyses of regional lineaments (subsurface expected lineaments).

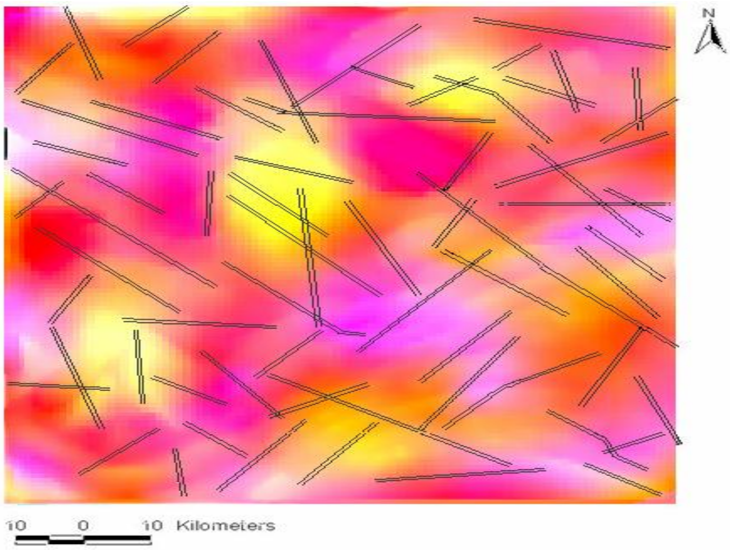

Figure (15) . Final lineaments map applied on the geophysical map.

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