Lineaments Extraction of the Gaara Area Using Directional Filters

Cristina Dallos Mosquera[1]*, Ahmed Abbas Hasan[2], Jawad Ali Zwain[3], Mariam Issam Hasan[4]

[1]Geology Department, Faculty of Exact and Natural Sciences, University of Caldas, Manizales, Colombia

[2]Remote Sensing Department, College of Remote Sensing and Geophysics, AlKarkh University of Science, Baghdad, Iraq.

[3]Geology Department, College of Science, Baghdad University, Baghdad, Iraq
4Ministry of Higher Education and Scientific Research, Scientific Research Commission, Baghdad, Iraq

Abstract

This research employs remote sensing techniques to conduct a structural analysis of the Ga'ara region in Iraq's Western Desert. The investigated area spans approximately 10,534 km², bound by the coordinates 33°15'–33°50' N and 39°15'–41°00' E.

The objectives of this study are to demarcate and interpret fracture lineaments. Landsat ETM+ images and DEM data are used in this study. Lineament interpretation, mapping, and quantitative analysis (including length and frequency calculations) were performed through digital processing of Landsat data using a suite of specialized software.

Directional Gradient-Sobel and Gradient-Prewitt filters were applied to interpret linesaments. The study reveals that there were two principal orthogonal fracture systems each of which comprises two sets. Assuming Linear features were enhanced and interpreted using directional Sobel and Prewitt filters. The analysis identified two principal, nearly orthogonal fracture systems: a dominant NW-SE trend and secondary trends oriented NE-SW, N-S, and E-W.

Keywords: Select five keywords that accurately represent the content of the paper.

1. Introduction

The Ga'ara area is located in the Western Desert of Iraq, within the Rutba Subzone. This subzone represents the topographically elevated portion of the Rutba-Jezira zone, which forms part of the stable continental shelf of Iraq (Jassim & Goff, 2006) . It's covering an area of 10534.546833 square kilometers (Figure 1).
The region forms part of the Western Desert, characterized by a subdued topography that gradually ascends eastward, reaching a maximum elevation of 703 meters above mean sea level. Prominent depressions are common, with the most significant being the Ga'ara Depression. The Ga'ara depression is a structural–denudational feature located in the middle of the northern flank of the Ga'ara anticline. On the southern rim of this depression, the lower Permian Ga'ara formation is uncomfortably overlain by upper Triassic carbonate rocks forming numerous cliffs (Jassim & Goff, 2006).
The study area has an arid climate with chilly winters and dry summers. There are significant daily temperature fluctuations, reaching up to 36°C. Due to excessive radiation, the desolate land surface cools at night and becomes extremely hot during the day. This process causes the surface to break into chunks and pieces. Since the mean annual evaporation varies from 3000 to 3500 mm and the mean annual rainfall is very low (75 to 150 mm), rising westward, the limited amount of water that remains is used for chemical weathering processes such as leaching, solution, and hydration. See the general information for specific climatic factors.
The study region is a plain that slopes gently to the E and NE at a gradient of 5 m/km. The strata's dip, which ranges from one to two degrees, is nearly horizontal. The beds drop gradually northeastward in the eastern and central sections, although they dip in all

* Email address of the Corresponding Author

directions in the middle, surrounding the Ga'ara Depression. The research area's structural location inside the Stable Shelf is reflected in the mild plain (Buday and Jassim, 1984).

Figure 1: shows the studied area.

The main previous studies dealing with the area were restricted to detailed investigation and studies made in study area and western desert of Iraq. One of this study made from Bellen et al. (1959) summarized and published knowledge on geology and stratigraphy of the western desert. AL-Amiri 1978 who used land sat image in draw map for lineament of western desert of Iraq. It's Succeeded with study for same searcher using same data in 1979 determined importance this lineament and draw map for lineament.
In 1980, Buday and Hak mapped an area within the western part of the western desert. Buday and Jassim (1982) modified Buday's Hypothesis in 1973, and they divided the Stable Shelf into tectonic divisions.
The results of the provincial geological survey of Iraq were examined by Jassim et al. (1984). Later research used satellite photography to clarify the regional geology of the

middle Western Desert (Al-Mubarak, 1996) and to interpret tectonics west of the Euphrates River (Al-Azzawi, 1988). Additionally, Abdul-Qadir (2002) used satellite imagery to identify possible groundwater activity zones in hydrogeology.

2. Experimental

A natural, planar, or curviplanar fracture caused by tensile force is called a joint. Shear displacement is not a part of joint formation. Joints can be either nonsystematic or systematic. A collection of joints with parallel or sub-parallel orientations and a constant mean spacing is known as systematic joints. (Pluijm and Marshak, 1997).

The term "lineament" refers to quasi-linear surface patterns that can be recognized in aerial or satellite photography by alignments in topography, drainage, vegetation, soil, or tonal contrasts in bedrock. These characteristics frequently indicate the surface representation of underlying fractures.

Satellite images were visually interpreted in order to derive lineaments. These characteristics, which are caused by tonal differences in surface materials, usually appear as linear or edge-like patterns. Interpreter proficiency is crucial for the efficient identification and integrating of discontinuous segments into coherent lineaments (Jensen, 2000).

Several image-enhancing methods can be used to support manual extraction. In particular, spatial filtering methods were used in this work to produce the final lineament map.

To highlight linear characteristics (such as cracks and drainage), directional or edge-detection filters are used. To emphasize patterns in particular azimuths, these filters can be adjusted. The Gradient-Sobel, Gradient-Roberts, and Gradient-Prewitt filters are commonly used operators for this purpose (Levin, 1999).

Landsat ETM+ bands 5 and 7 were subjected to directional Sobel and Prewitt filters in order to enhance feature contrast. To preferentially increase lineaments aligned with these trends, filter kernels were directed along all four cardinal and intercardinal directions (N-S, E-W, NE-SW, and NW-SE), as shown in Table 1.

Table 1 lists the four primary Sobel and Prewitt filters used in this investigation.

	N-S			NE-SW			E-W			NW-SE		
SOBEL	-1	0	1	-2	-1	0	-1	-1	-1	0	1	2
	-2	0	2	-1	0	1	0	0	0	-1	0	1
	-1	0	1	0	1	2	1	2	1	-2	-1	0
PREWITT	-1	0	1	-1	0	0	-1	-1	-1	0	1	1
	-1	0	1	-1	0	1	0	0	0	-1	0	1
	-1	0	1	-1	0	1	1	1	1	-1	-1	0

Figures 2 and 3 illustrate the Sobel and Prewitt filter results for four primary directions. These pictures are used to create two maps: one for Sobel and another for Prewitt. Figures 4 and 5 display the Sobel filters' result lineament map and frequency histogram, respectively. The histogram and map. Conversely, Figures 6 and 7 depict Prewitt filters, respectively.

There are significantly different numbers of lineaments found in these two filters. Sobel's number is 210, while Prewitt's is 277.

ISSN: X417-3105

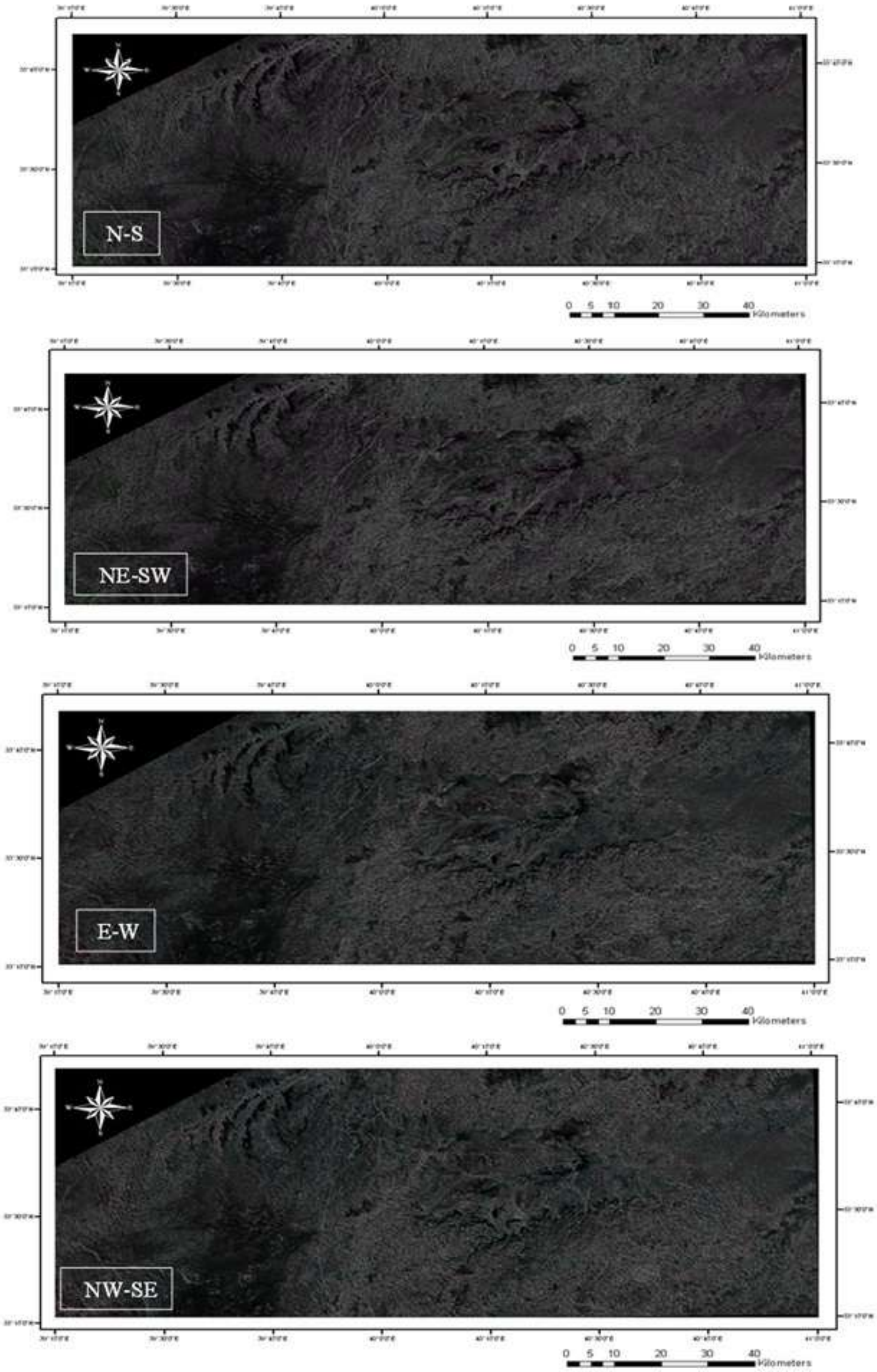


Figure 2: Sobel filtered image in N-S, NE-SW, E-W, NW-SE directions.

ISSN: X417-3105

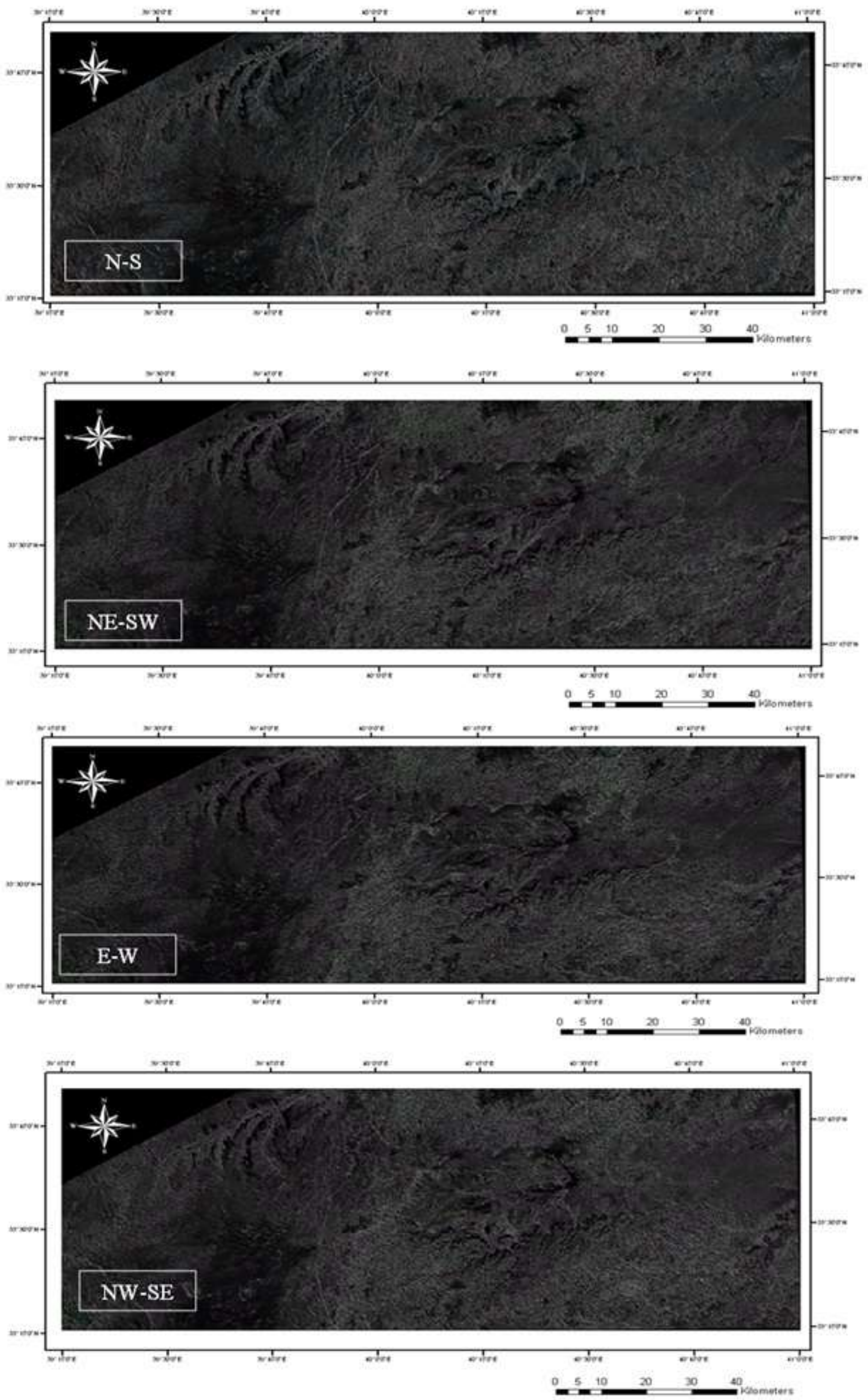


Figure 3: Prewitt filtered image in N-S, NE-SW, E-W, NW-SE directions.

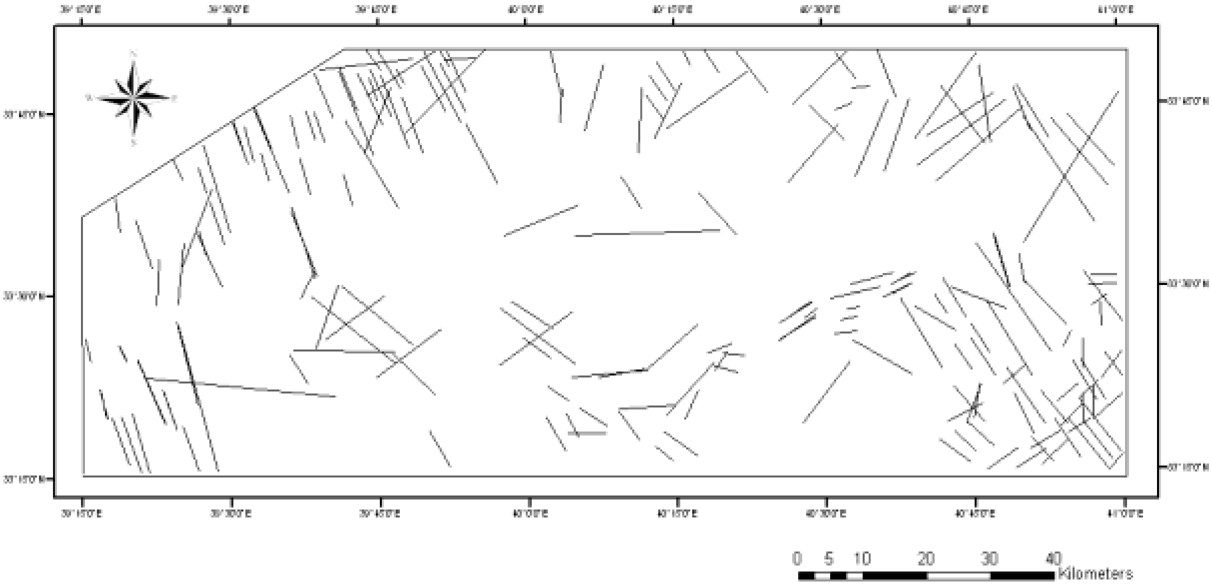
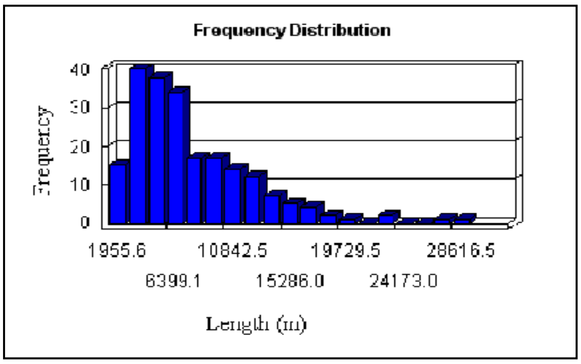


Figure 4: Lineament map prepared after Gradient-Sobel filtering operation.



Count	210
Minimum Length (m)	1955.568
Maximum Length (m)	29746.751
Sum (m)	1717710.472
Mean(m)	8179.57
Stander Deviation	4612.94

Figure 5: Length frequency distribution of Gradient-Sobel filtering operation.

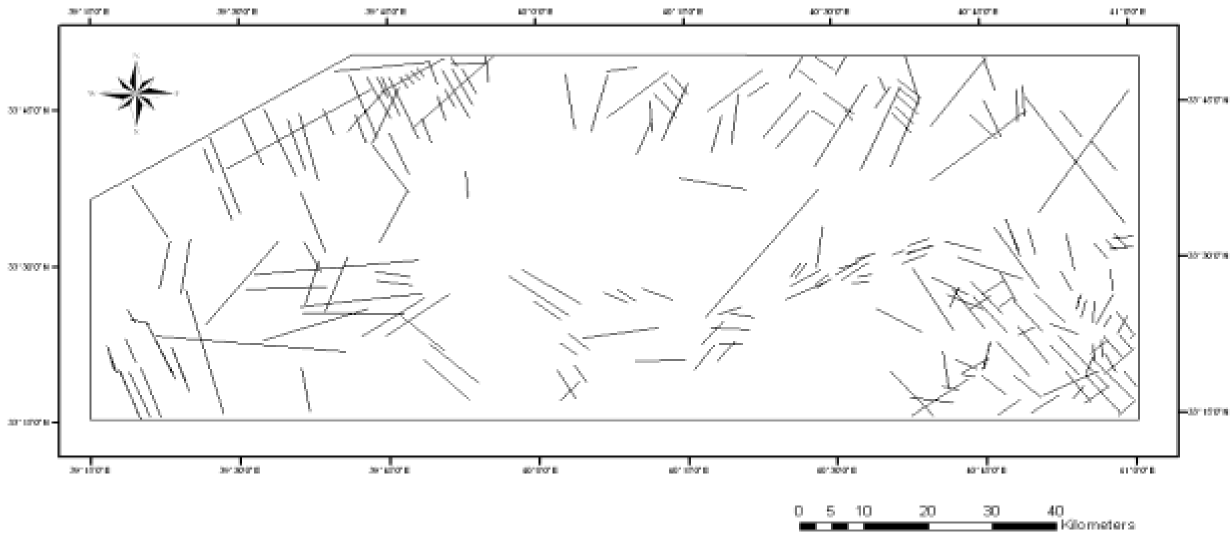
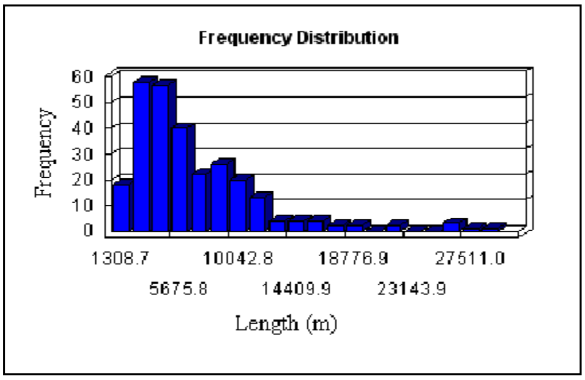


Figure 6: Lineament map prepared after Gradient-Prewitt filtering operation.



Count	277
Minimum Length (m)	1308.74
Maximum Length (m)	29960.84
Sum (m)	2009951.04
Mean(m)	7256.14
Stander Deviation	4725.86

Figure 7: Length frequency distribution of Gradient-Prewitt filtering operation.

3. Results and Discussion

A frequency rose diagram of whole study area showed two system of lineaments occur in this diagram. the first system is composing two sets assuming the following directions NW-SE, NE-SW, the secondary system is composing two sets assuming the following directions N-S, E-W. the The identified lineament sets exhibit an approximately orthogonal relationship. A total of 277 lineaments were mapped across the study area.
A frequency rose diagram for the total lineaments showed the primary direction is N35W, there are also three important secondary directions (N 30-60 E, N 5 E, N 85 E) in this diagram (Figure 8). This diagram illustrates that the highest density of lineaments is oriented along the...N 35 W direction.

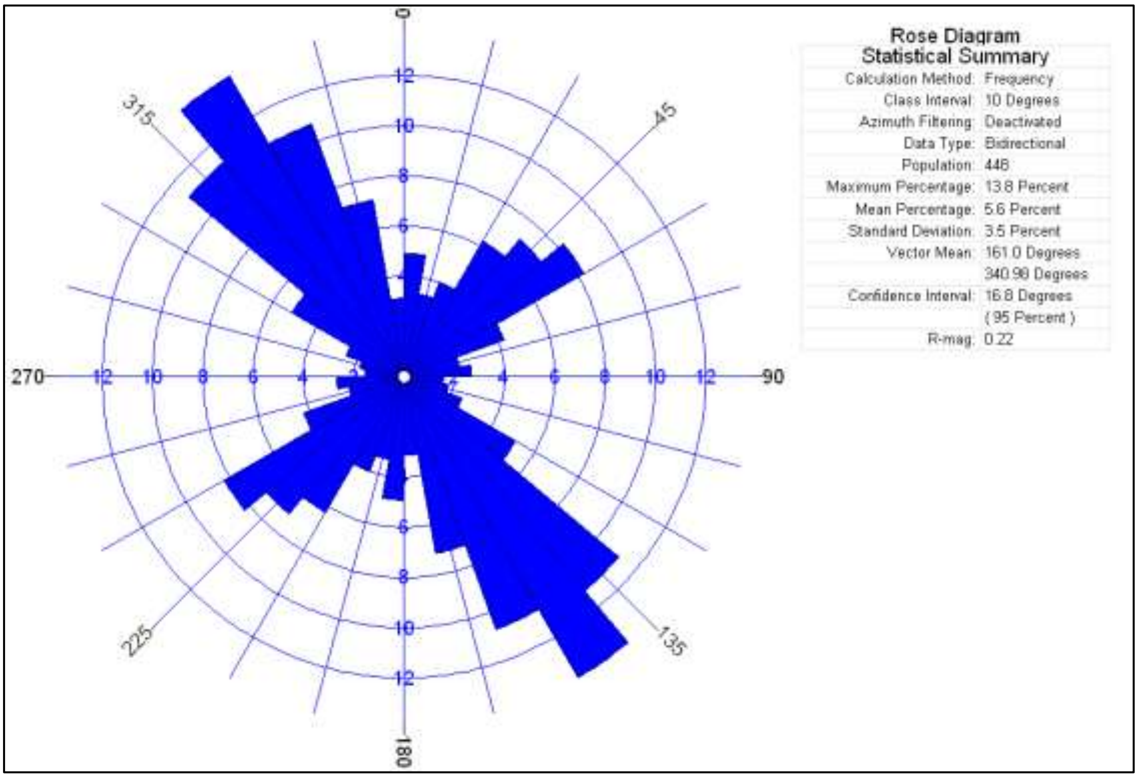


Figure 8: Frequency rose diagram for whole study area

The density rose diagram shows two systems of lineaments occurring in the area, one of these systems composing two perpendicular sets. The first set (N 35 W) represents the dominant direction in the study area. The other sets (N 5 E, N 30- 60 E, N 85 E) are secondary directions (Figure 9).

The density rose diagram shows that the percentage of lengths of (N 35 W) direction represent higher percentage value compared to other directions, that is indicating the lineaments in this direction are well developed and relatively recent. The maximum and the minimum lengths of lineaments in the whole study area are 30.1 Km and 1.4 Km, respectively

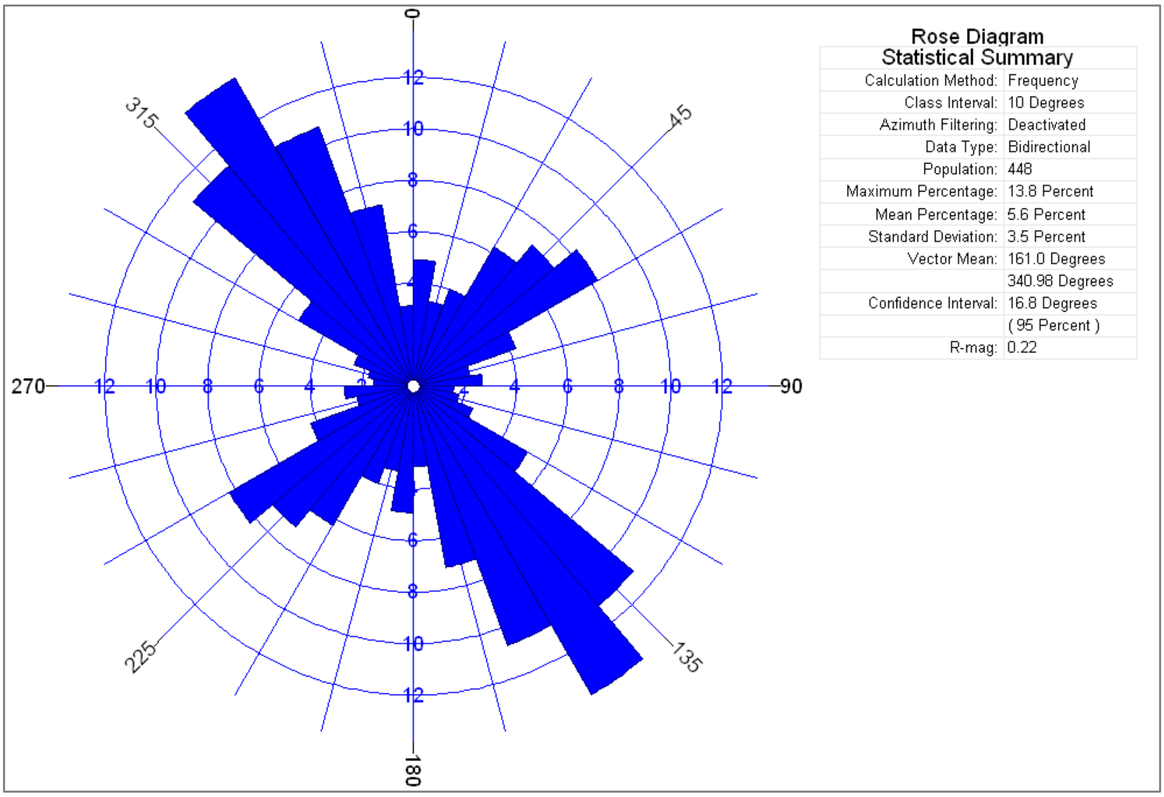


Figure 9: Density rose diagram of the whole study area

4. Conclusions

In arid, well-exposed regions like the Ga'ara area, where fieldwork access is difficult, this study highlights the value of remote sensing for geological mapping. Satellite imagery lineaments are thought to be surface manifestations of possibly deep-seated fractures. When Sobel and Prewitt filters were applied to Landsat ETM+ bands five and seven along various azimuths, directional filtering proved to be quite successful for lineament augmentation. Different detection counts were obtained by the two filters, recognizing 210 and 277 lines, respectively.

Two main orthogonal fracture systems were identified via rose diagram analysis. Sets trending N35W and N45E are included in the first, and trends N5E and N85E are included in the second. The NW-SE (N35W) direction's strong dominance indicates that these structures are the most developed in the area and may be connected to deep-seated fault systems.

Conflicts of interest

There are no conflicts to declare.

Acknowledgements

The authors express their gratitude to Al-Karkh University of Science and the University of Caldas for their logistical and academic assistance. We also thank the Ministry of Higher Education and Scientific Research for making vital information and resources more accessible.

We are deeply grateful to the US Geological Survey for supplying open-access DEM data and Landsat ETM+ imagery, which were essential to this research.

The creators of the software tools used for spatial analysis and image processing are also acknowledged by the authors. Lastly, we would like to express our gratitude to the anonymous reviewers for their insightful feedback that improved the manuscript's quality.

References

Abdul-Qadir, A., M., 2002, Integration of remote sensing and GIS for optimal Utilization of water resources in the western desert of Iraq, unpub., Ph.D. Thesis Univ. of Baghdad, Iraq, p152.

Al-Amiri, H., M., 1978. Structural interpretation of Landsat satellite imagery for western Desert, Iraq, Unpub. Rep., No.923, GEOSURV, Iraq, p 60.

Al-Azzawi, A., Dawood, R., Buni, Th., Karim, S., Philip, W., Abdul Lateef, I., Ezzildin, L., Odisho, H., Bassim, S.,. Salman, B., and Yousif, W., 1996. Report on the detailed geological survey for bauxite exploration in NW Kilo 160 area. W. Desert. GEOSURV, Unpub. rep. no. 2431.

Bellen, R.C., van, H.V. Dunnington, Wetzel, R., and Morton D., 1959. Lexique Stratigraphique International, Asia, Fasc., 10a, Iraq, Paris.

Buday, T. and Hak, J. 1980. Report on the Geological survey of the western part of the western desert, GEOSURV, Unpub. Rep., library No.1000, Iraq.

Buday, T., and Jassim, S.Z., 1984. Tectonic Map of Iraq. GEOSURV, Baghdad, Iraq.

Buday, T. and Jassim, S.Z., 1987. The Regional Geology of Iraq. Tectonism and Metamorphism, Vol.11, GEOSURV, Baghdad, Iraq.

Buday, T., 1980. The Regional Geology of Iraq, stratigraphy and paleogeography, Volume 1, Dar Al-Kutib Publishing House, University of Mosul, Iraq, p 445.

Jassim, S. Z. and Goff, J. C., 2006, Geology OF IRAQ, Dolin, Prague and Moravian Museum, Brno, 431p.

Jensen, J. R., 2000, Remote Sensing of the Environment: An Earth Resource Perspective. New Jersey, USA, Prentice Hall.

Levin, N. ,1999, Fundamentals of Remote Sensing, IMO - International Maritime Academy, Trieste, Italy, 225 p.

Lillisand, T.M. and kiefer, R.W., 2000, Remote sensing and Image Interpretation, John wiley and sons Inc., 6th Ed., Canada 721p.

Marshak, S. and Pluijm , B. A. , 1997 , Earth Structure , WCB/McGraw-Hill , 471p.

Sarp, G., 2005. Lineament Analysis from Satellite Images, North-West of Ankara. Master of Science Dissertation, School of Natural and Applied Science of Middle East Technical University, Ankara.