Tectonic Study of Lineaments for Part of Zagros Belt, Northeast Iraq

Abdulkadhim J. Alabidi

Department of Geology, Faculty of Science, and Remote Sensing Center, University of Kufa, Najaf, Iraq

Abdulkhadhimj.alabidy@uokufa.edu.iq

Abstract

The study area situated in the western part of Zagros fold-thrust belt**,** north east (NE) Iraq. Google earth image for study area was used to build up lineaments map. Studying and processing of these lineaments revealed that there are two dominant directions of lineaments northeast-southwest (NE-SW) and northwest- southeast (NW-SE), compatible with the main regional stress direction and Zagros belt direction respectively. It was found that there is no significant change of lineaments density in different tectonic zones and there is no obvious effect of lithology on lineament density in the study area. Length rose diagrams showed an obvious increase in the value of NW-SE lineaments direction, starting from low folded zone toward NE, despite frequency rose diagrams of different tectonic zones showed no significant change of the main prevailing direction. It is found that some lineaments shifted or bended some folds or ridges in the study area. Field observations demonstrated that some lineaments of study area had field criteria of faults while they did not described in tectonic map.

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Keywords: Lineaments, Zagros belt, Arabian plate, field criteria

دراسة تكتونية للتراكيب الخطية لجزءمن حزام زاكروس, شمال شرق العراق

عبدالكاظم جيثوم العابدي

قسم علوم الارض ، كلية العلوم ومركز التحسس النائي ، جامعة الكوفة ، النجف الاشرف ، العراق

Abdulkhadhimj.alabidy@uokufa.edu.iq

الخلاصة

تقع منطقة الدراسة في الجزء الغربي لحزام طيات- اندفاعات زاكروس في شمال العراق. وقد استخدمت مرئيات كوكل ارض لبناء خارطة التراكيب الخطية لمنطقة الدراسة. بينت دراسة هذه التراكيب وجود اتجاهين سائدين للتراكيب الخطية وهما اتجاه شمال شرق- جنوب غرب واتجاه شمال غرب- جنوب شرق واللذين يتوافقان مع اتجاه الجهود الاقليمية الرئيسة واتجاه حزام زاكروس على التوالي. لقد ظهرعدم وجود تغير في كثافة التراكيب الخطية في الانطقة التكتونية المختلفة وكذلك عدم وجود تأثر واضح لهذه الكثافة بنوع الصخور المنكشفة في منطقة الدراسة. أظهرت المخططات الاتجاهية لأطوال التراكيب الخطية زيادة واضحة في قيمة التراكيب الخطية باتجاه شمال غرب- جنوب شرق ابتداء من نطاق الطيات الواطئة نحو الشمال الشرقي, رغم ان المخططات الاتجاهية العددية للانطقة التكتونية المختلفة لم تظهر تغير واضح في الاتجاه السائد الرئيس. اثبتت الملاحظات الحقلية ان بعض التراكيب الخطية لمنطقة الدراسة تمتلك شواهد صدوع حقلية في حين لم يتم تثبيتها في الخارطة البنيوية لمنطقة الدراسة.

كلمات مفتاحية: التراكيب الخطية، حزام زاكروس، الصفيحة العربية، الشواهد الحقلية

Introduction

The study area (**figure 1**) situated in NE Iraq between longitude 44 00E and 45 25 E and latitude 35 45 N and 36 33 N, in Zagros fold-thrust belt according to literature [1].

Lineaments are very important in different geological studies, including the tectonic study, construction and site selection [2], hydrogeological prospecting [3,4], landslides [5], and for mineral exploration [6,7].

Lineament may reflect a subsurface phenomenon [8], and perhaps related to planar structures such as fractures and foliations that intersect the surface of the Earth [9]. They may be the surface expression of a deep-seated lineament [10].

This paper aimed to study the lineaments and their tectonic interpretation in the study area.

Materials and methods

The following materials and methods were adopted to achieve the aim of this study:

1- Geological and topographic maps

2- Google earth images

3- Field observation notes

4- Published articles and reports

5-ArcMap10.3,RockWorks16 software

Google Earth satellite images were used to extract lineaments in the study area. A geological reconnaissance (trip) was done in part of the study area between HaibatSultan Mountain and DokanLake (21 to30July 2017); observe some geological features which were noticed in satellite images.

Geology of study area

The geology of the studied area is described briefly hereinafter as stratigraphy and tectonic setting:

Stratigraphy

The exposed outcropped formations in the study area (**figure 2**) are briefly mentioned herein after (table 1).

Tectonic setting

Study area situated in the western part of Zagros fold-thrust belt [13, 14] within Iraqi territory. It extends throw a low folded zone, high folded zone, and imbricated zone according to tectonic map (**Figure3**).

Lineaments in study area

Lineaments may be extracted by visual image interpretation or automated extraction techniques [15]. In this study visual lineament extraction (manual lineament extraction) was employed because it has more reliability and gives better results [16]. Accordingly, extracted lineaments map represented in **figure 4**.

The study of this map reveled that there are two main dominant directions of lineaments. They are NE-SW and NW-SE directions.

A directional analysis was carried out for Lineaments in study area. So frequency and length (density) rose diagrams for lineaments were drawn for each tectonic zone, and for the total area. **Figure5** showed that the main dominant direction (in the frequency rose diagram and length rose diagram) for the total area is N 65 E, and it is found that there are two another secondary directions (N 55 W) and (N 05 E).The main dominant direction in the total area is corresponding with the main regional force causing Zagros belt.

Frequency rose diagram for low-folded zone (**figure 6-A**) showed that the main dominant direction of lineament is N55 E. It is noticed that there are three

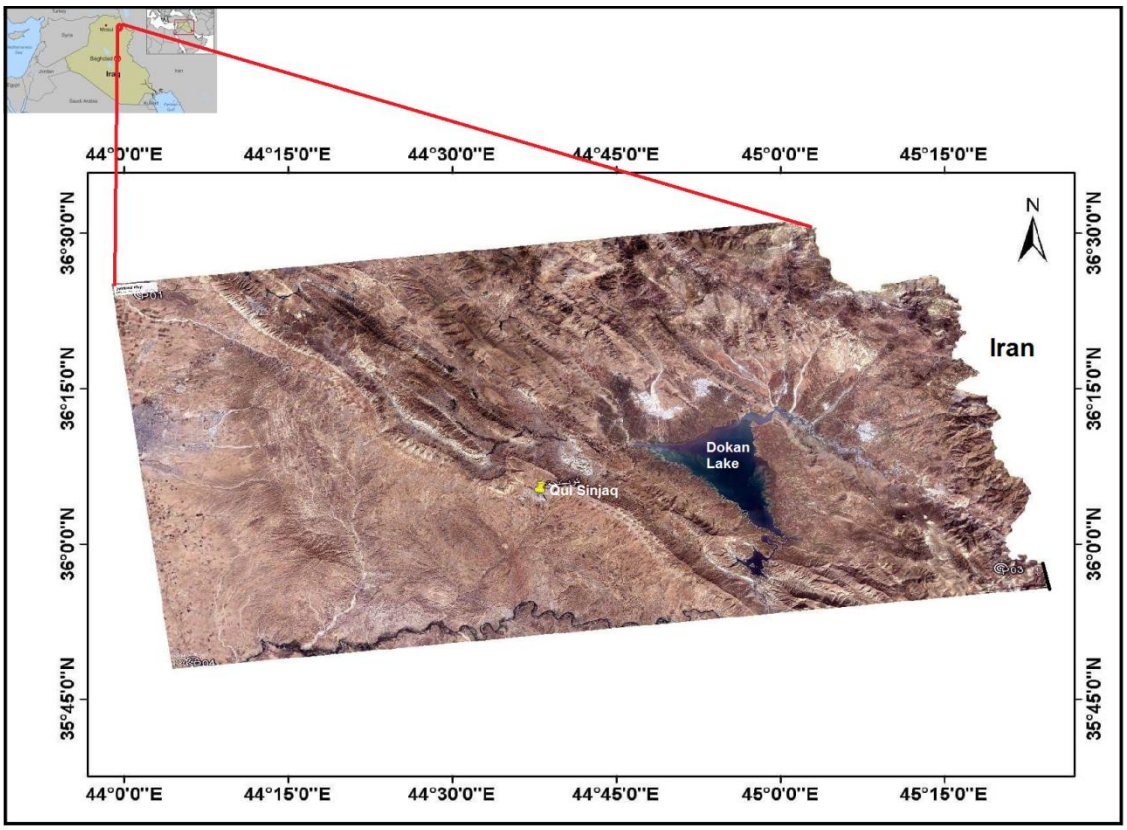

Figure 1: location map for study area.

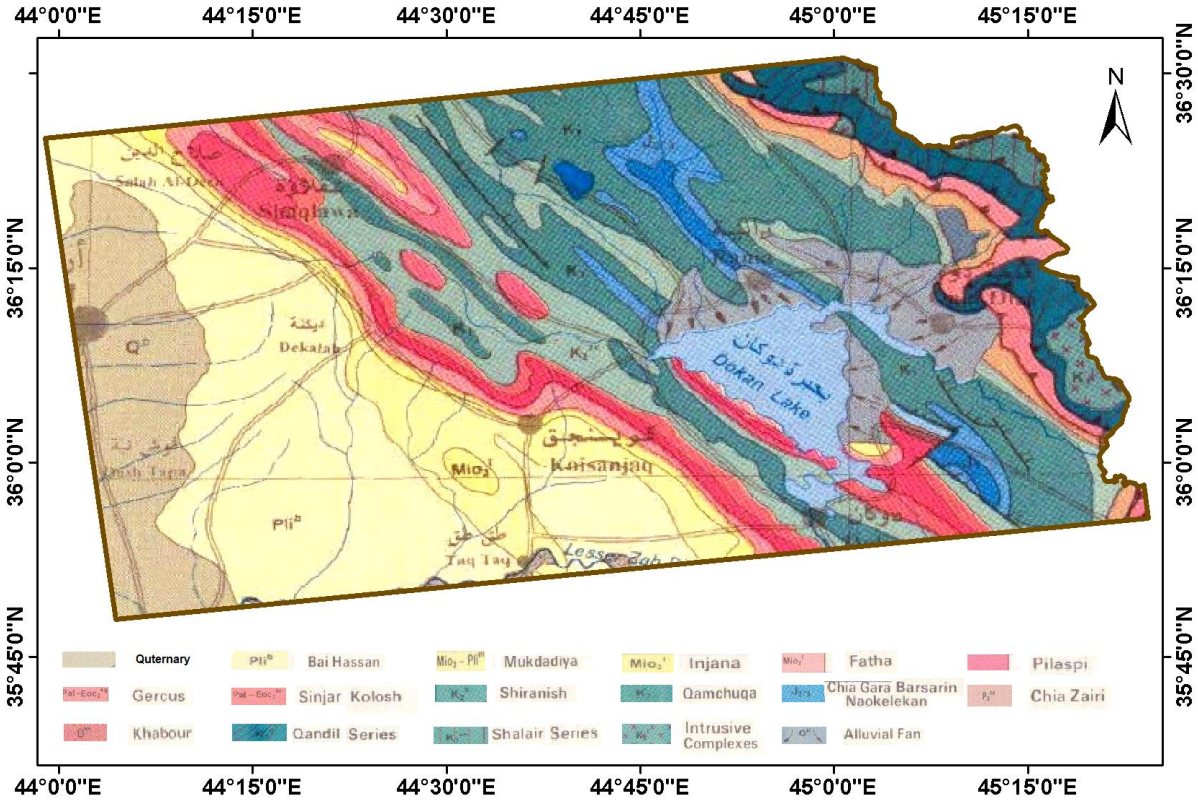

Figure 2: Geological map of the study area (modified after [11]).

Table 1: Geologic formations in the study area according to [12]

Formation	Age	Brief description
Quaternary deposits	Quaternary	Polygenic synclinal fill, slope sediments, pediment deposits, alluvial fans, sheet run-off sediments, flood plain and valley fill deposits.
Bai Hassan	Pliocene	Conglomerate
Mukdadiya	Pliocene	Fining upwards cycles of gravely sandstone, sandstone, and red mudstone.
Injana	Late Miocene	Thin bedded calcareous sandstone and red and green mudstones with one gypsum bed and a purple siltstone, they are overlain by fining upwards cycles of sandstone, siltstone and red mudstone.
Fatha	Middle Miocene	The lower member comprises thick basal unit of organodetrital limestone and anhydrite with minor amount of green dolomitic marl followed by cyclically interbedded gypsum, green marl and thin limestone. The upper member comprises a cyclic succession of green and red mudstone and gypsum and a few thin oolitic or recrystallized shelly limestone beds.
Pilaspi	Late Eocene	Well bedded, bituminous, chalky, and crystalline limestone, with bands of white, chalky marl and with chert nodules toward the top in the upper part of the formation while a well bedded hard, porous or vitreous, bituminous, white, poorly fossiliferous limestone, with algal or shell section in the lower part.
Gercus	Middle Eocene	Red and purple shales, mudstones, sandy and gritty marl, pebbly sandstone and conglomerate. Gypsum lenses and halite occure near the top of the formation. Rare lignite and sandstones are present near the base.
Sinjar	Late Palaeocene-Early Eocene	Limestone of algal reef, lagoonalmiliolid, and nummulitic shoal facies. The limestone are often dolomitized.
Kolosh	Late Palaeocene-Early Eocene	Limestones and shales, red shales and sandstone, blue shales and green sand. Koloshand Sinjar formations are interfingering.
Shiranish	Campanian-Maastrichtian	Thin bedded argillaceous limestone (locally dolomitic) overlain by blue pelagic marls.
Qamchuqa	Albian	Organodetrital and detrital and locally argillaceous limestones with variable degrees of dolomitisation. In some areas fresh- or brakish- water limestone beds were ound.
Chia Gara,Naokelekan	Callovian-Oxfordian	Laminated argillaceous bituminous limestone alternating with bituminous shale and fine-grained limestone found in the lower unit. Thin bedded fossiliferous dolomitic limestone represents a middle unit. Thin bedded, highly bituminous dolomite and limestone with bed of black shale in the lower part represent the upper unit(mostly obscured in the type section)
Chia Zairi	Late Permian - Mid Triassic	The lower member consists of alternating thin bedded organic detrital limestone, dark blue limestone and massive, cliff-forming silicified limestone with black shale beds. The middle member comprises dolomite, recrystallized braccia and recrystallized marls. The upper member composed of thin bedded organic detrital limestone with some silicified limestone. Ooliticlimestones with clastic beds occur in the uppermost part.
Khabour	Mid- late Ordovician	Beds of thin bedded, fine grained quartzite. Siltstoe and micaceous shale.
Qandil series	Pre-Tertiary	Composed of three group. The oldest group consists mainly of pillow basalt, the overlying Gimo Group comprises marbles, calcschists and metaolcanics, and the youngest unit is Sirginil Group which consists of metapelites, calcschists, marble and rare metavolcanics.
Shalair series	Triassic- early Cretaceous to Aptian-Cenomanian	Quartiz-sericiteschists, sericiteschists, and silty-clayey schists with slightly metamorphosed limestone, tuffaceous and relatively rare recrystallized limestone.

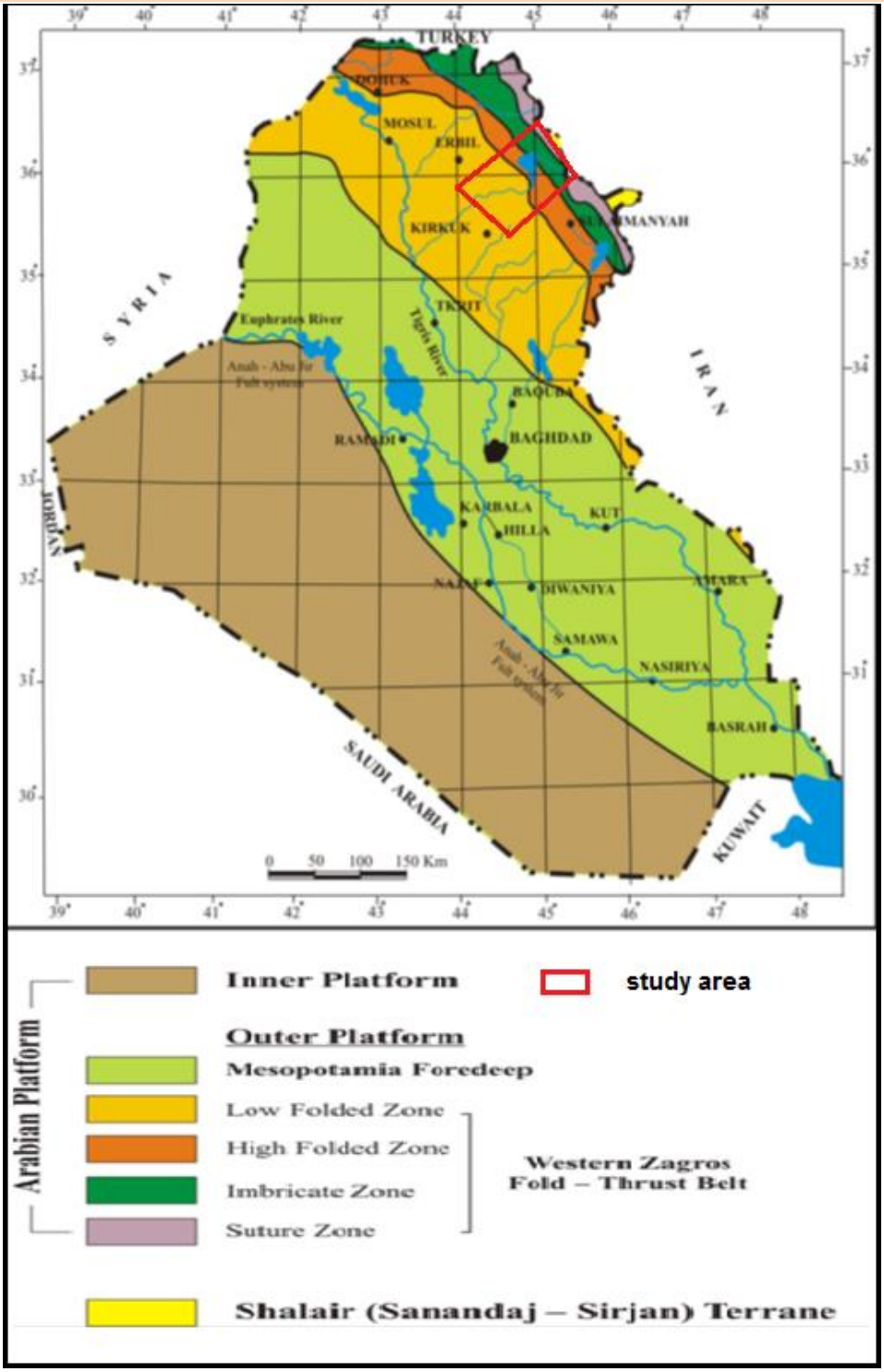

Figure 3. Tectonic map of Iraq (after[13]).

secondary directions in this zone, they are N 5 E, N 35 W, and N 55 W. The same dominant directions were found in the length rose diagram for this zone (**figure 6-B**).

The study of this map reveled that there are two main dominant directions of lineaments. They are NE-SW and NW-SE directions.

A directional analysis was carried out for Lineaments in study area. So frequency and length (density) rose diagrams for lineaments were drawn for each tectonic zone, and for the total area. **Figure5** showed that the main dominant direction

(in the frequency rose diagram and length rose diagram) for the total area is N 65 E, and it is found that there are two another secondary directions (N 55 W) and (N 05 E).The main dominant direction in the total area is corresponding with the main regional force causing Zagros belt.

Frequency rose diagram for low-folded zone (**figure 6-A**) showed that the main dominant direction of lineaments is N 55 E. It is noticed that there are three secondary directions in this zone, they are N 5 E, N 35 W, and N 55 W. The same dominant directions were found in the length rose diagram for this zone (**figure 6-B**).

In high-folded zone, frequency rose diagram (**figure 7-A**) revealed that the main dominant direction is N 55 E and the second dominant direction is N 45 W. The same dominant directions were found in length rose diagram for the same zone but it was noticed that the value of the secondary dominant direction was nearly equal to the main dominant direction (**figure 7-B**).

Frequency rose diagram for Imbricated zone (**figure 8-A**) showed that the main predominant direction of lineaments in this zone is N 55 E and there are three secondary directions of lineaments, they are N 25 E, N 45 W, and N 05 W. Length rose diagram for this zone (**figure 8-B**) revealed that there are two main dominant lineament direction, they are N 55 E and N 45 W. Additional secondary direction is found in this figure, it is N 05 W lineaments direction.

In suture zone, frequency rose diagram (**figure 9-A**) revealed two dominant lineaments directions. The main dominant direction is N 55 E and the less dominant direction is N 35 E. Two additional secondary directions, N 05 E and N 30 W are found. Length rose diagram (**Figure 9-B**)revealed the same dominant directions but it showed three secondary directions; they are N30 W, N 55 W, N 75 W.

Discussion and interpretation

The study of lineaments map and rose diagrams for the study area showed that:

The two dominant directions of lineaments (NE-SW and NW-SE) are compatible with the main regional stress direction resulting from movement of Arabian plate, and Zagros belt direction respectively.

As seen in figure 10 bellow, there is no significant change of lineaments density in different tectonic zones in the study area (low folded, high folded, imbricated, and Zagros suture zones).

There is no obvious effect of lithology on lineament density despite that the most exposed formations in low folded zone are detrital formations, while the main bulk of exposed formations in high folded, and imbricated zones are composed of limestone (figure 2 and table 1).

The prevailing direction of lineaments is NE-SW (normal to general direction of Zagros belt), which compatible with the main stress direction resulting due to movement of Arabian plate. This result corresponding with [17, 18].

Despite that frequency rose diagrams of different tectonic zones and for the total area showed no significant change of the main prevailing direction(figure 5A, 6A ,7A ,8A ,and9A), length rose diagrams showed an obvious increase in the value of NW-SE lineaments direction while moving from low folded zone toward NE (Figures

6B, 7B, 8B, and 9B). The growing up of the NW-SE dominant direction of lineament length value may be interpreted by the increase of thrusting accompanying folding while moving from low folded toward imbricated zones, and due to the change of folding style (narrowing and tightening of folds which reflected on lineaments expression).

It is found that some lineaments in the study area lead to bending in some ridges and folds or shifted them as en-echelon style (figure 11).

It is found in field reconnaissance that some lineaments in the study area have field criteria of faults although they did not described in tectonic map of the area (Figure 11).

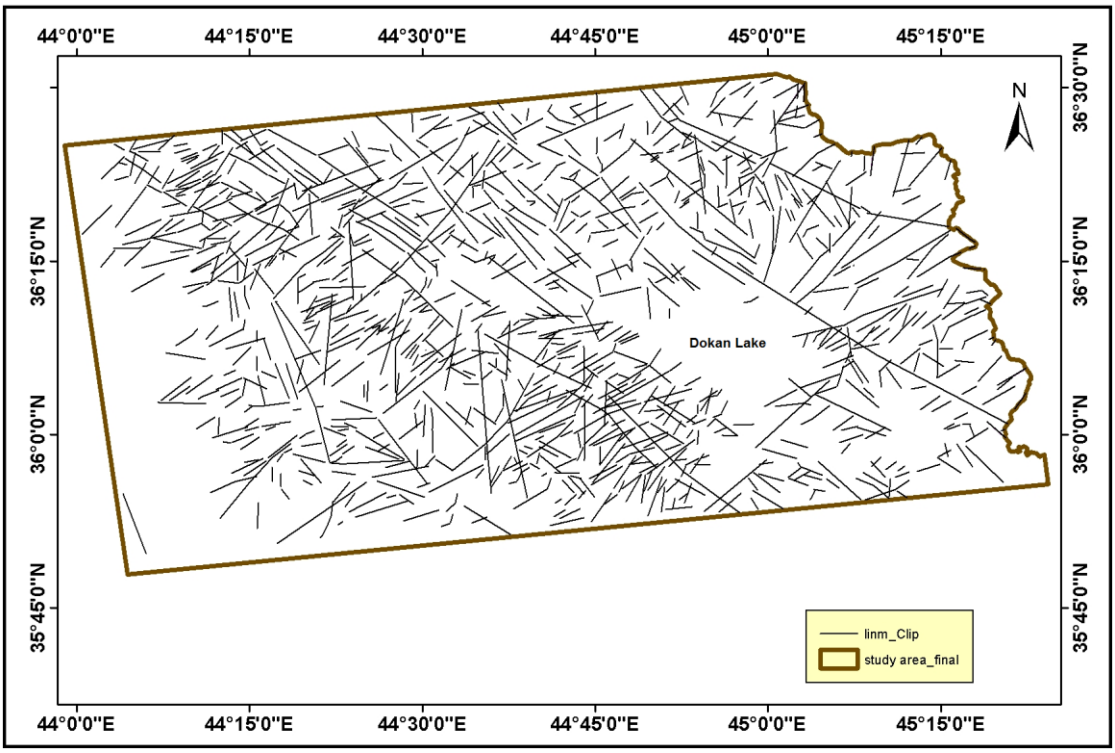

Figure 4.Lineaments map of study area.

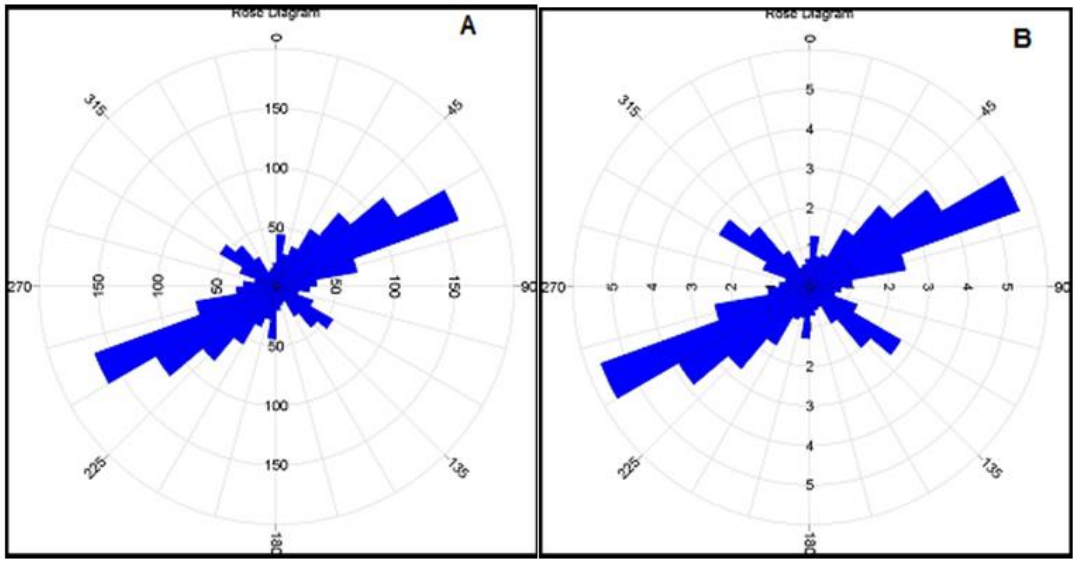

Figure 5. Rose diagram for the total area. (A) Frequency rose diagram. (B) Length rose diagram.

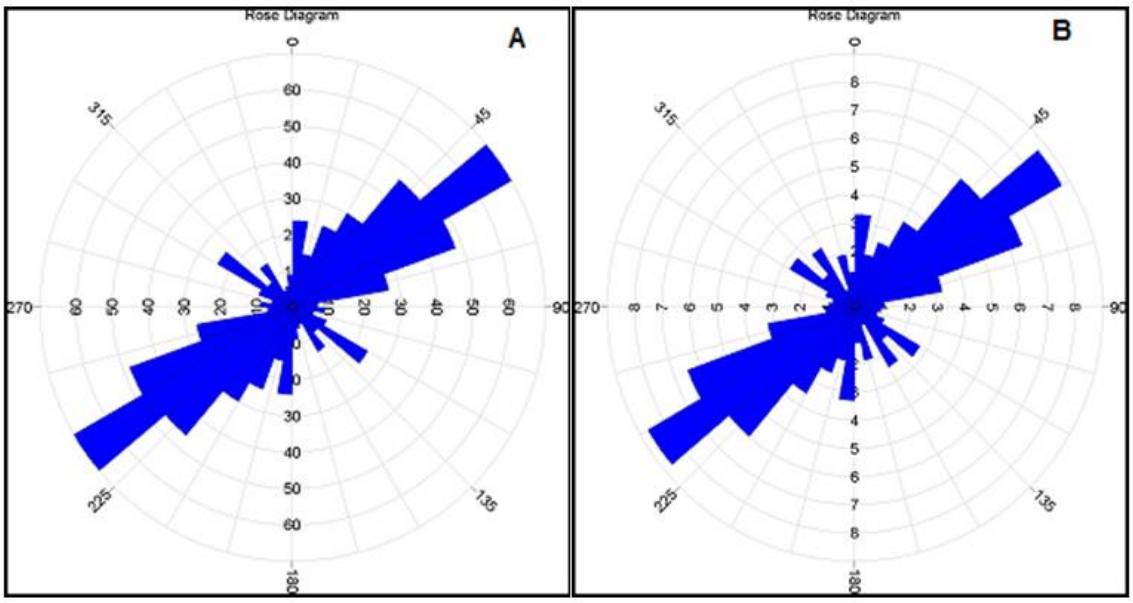

Figure 6. Rose diagram for low folded zone. (A) Frequency rose diagram.

(B) Length rose diagram.

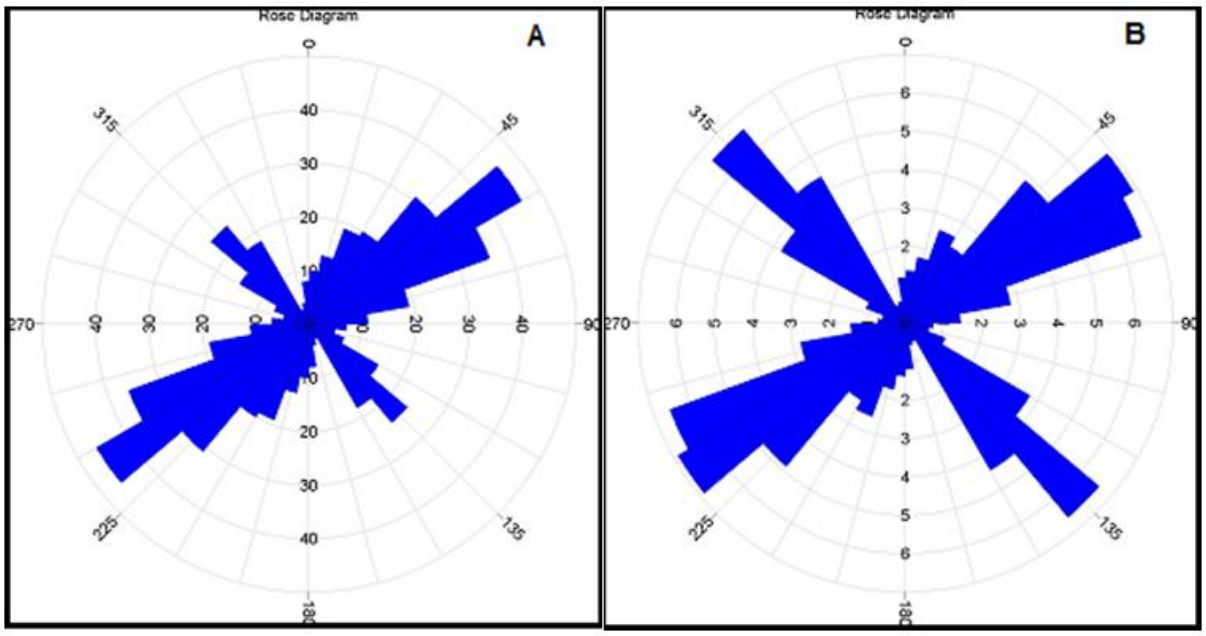

Figure 7. Rose diagram for high-folded zone. (A) Frequency rose diagram.

(B) Length rose diagram.

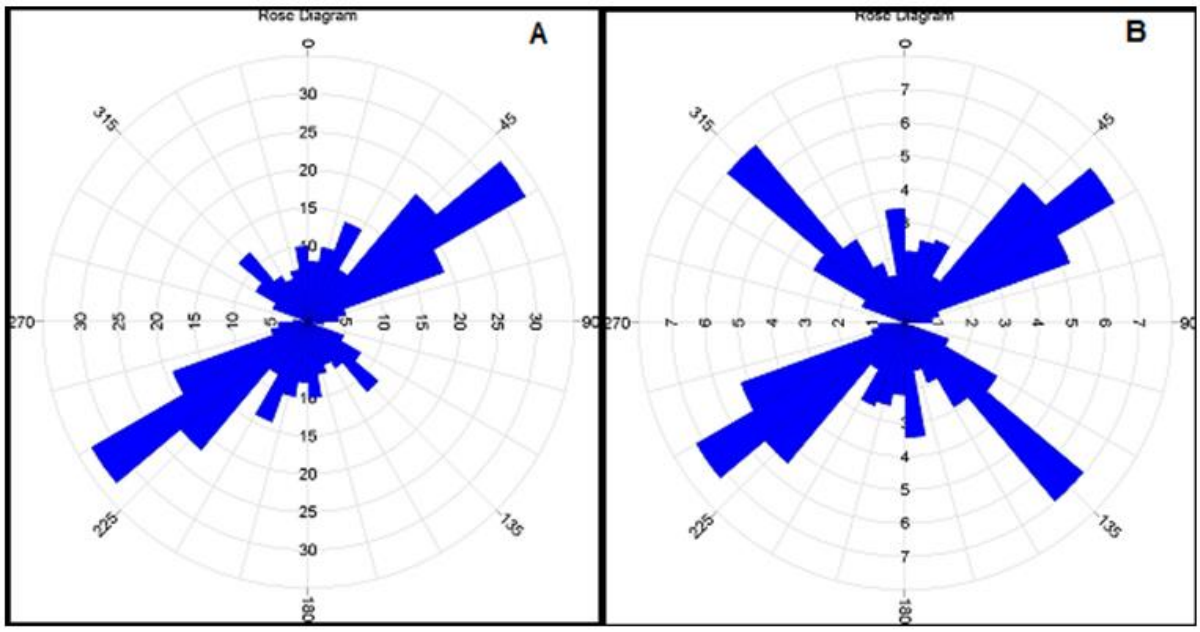

Figure 8.Rose diagram for Imbricated zone. (A) Frequencyrose diagram. (B)Lengthrose diagram.

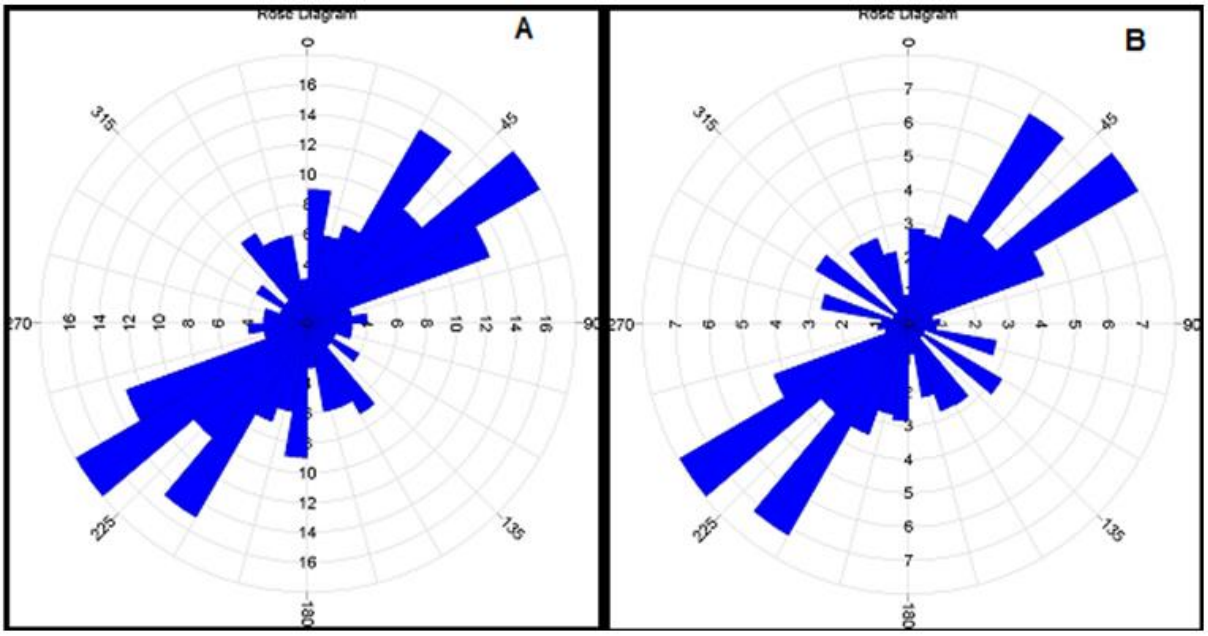

Figure 9. Rose diagram for suture zone. (A) Frequency rose diagram. (B) Length rose diagram.

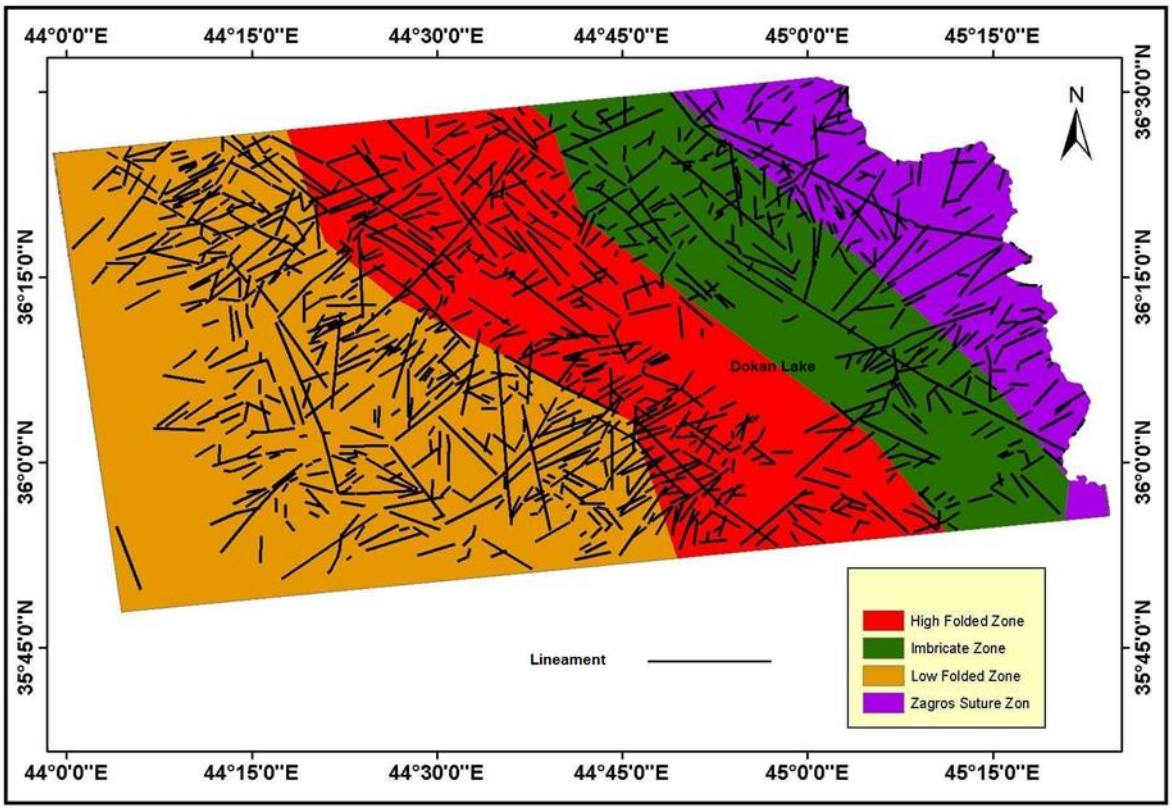

Figure 10. Lineaments density in different tectonic zones in the study area.

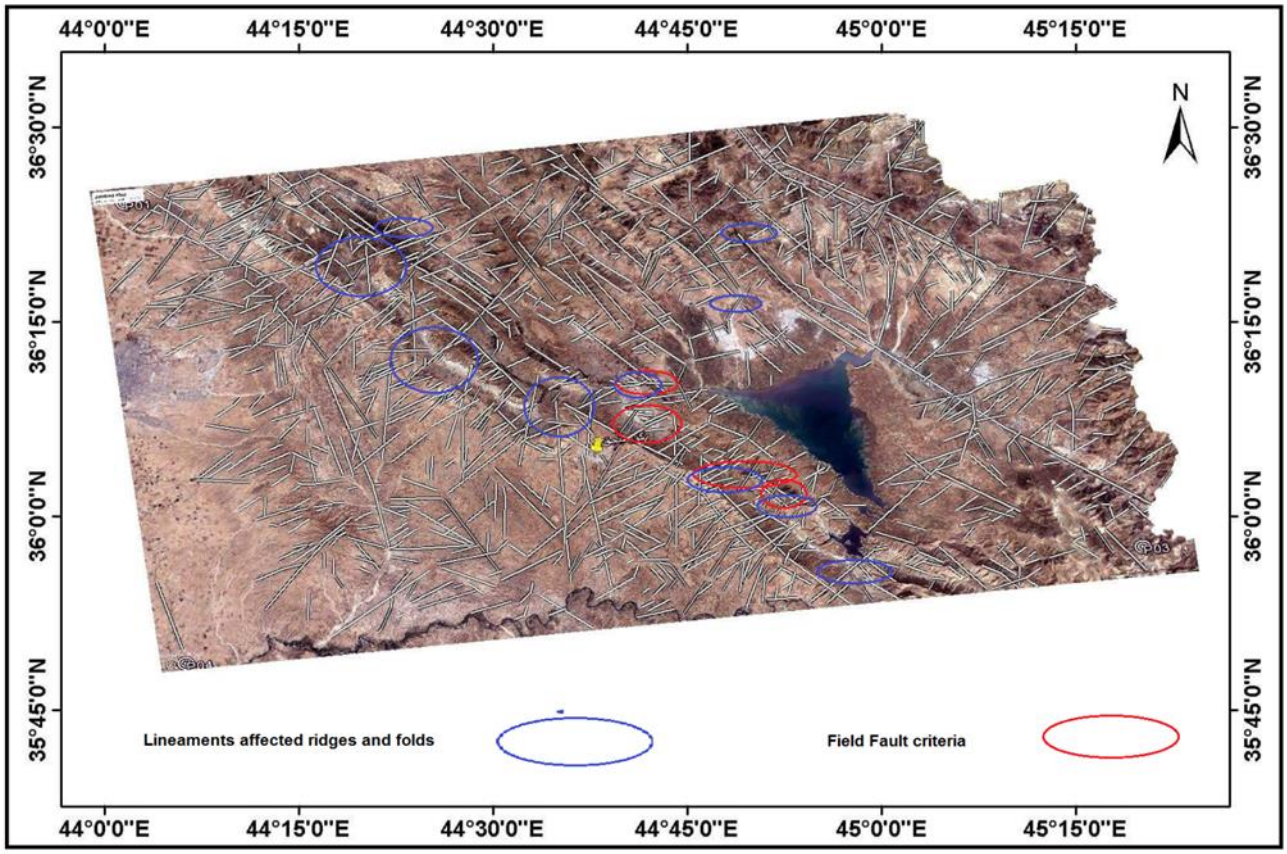

Figure11. Areas showed field fault criteria and the effect of lineaments on folds and ridges.

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