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# INVESTIGATION OF GEOLOGICAL STRUCTURES BETWEEN ACIPINAR-HANOBASI-ALTINKAYA (AKSARAY-TÜRKİYE) ABOUT SATELLITE-BASED TECTONIC LINEAMENTS

**Ramazan DEMİRCİOĞLU[1]***

[1]*Aksaray University, Faculty of Health Sciences, Department of Emergency Aid and Disaster Management, 42250, Aksaray, Türkiye*

**Abstract:** The region between Aksaray, Central Anatolia, and Altınkaya (Türkiye) is included in the study area. The area's basement comprises ophiolites, igneous rocks from the Late Cretaceous period, and metamorphic rocks from the Palaeozoic to Mesozoic ages. Late Cretaceous-Quaternary sedimentary units were formed in the area Tuzgolü Basin. The Late Cretaceous-Mio-Pliocene sedimentary rocks in the study area have undergone polyphase deformation under compressive and extensional tectonic regimes. As a result of these deformations the folded, faulted and fractured structures have been developed in the rocks of the area. These structures have formed lineations. In this study, the relationship between the tectonic lineaments identified in the field and those obtained by computer processing of Landsat 8 images was evaluated. The lineament densities obtained by satellite were N40-500E, N50-600E, N30-400W, N40-500W and N80-900W. Similarly, the lineament densities obtained from field studies were determined as N40-500E, N50-600E, N40-500W, N30-400W and N80-900W. The lineaments belonging to the Tuzgölü fault and the structural geological structures determined in the field are in significant agreement.

**Keywords:** Türkiye, Tuzgolu basin, Aksaray, Acıpınar-Altınkaya, Lineament

***Corresponding author:** Aksaray University, Faculty of Health Sciences, Department of Emergency Aid and Disaster Management, 42250, Aksaray, Türkiye
**E mail:** ra.demircioglu@gmail.com (R. DEMIRCIOĞLU)
Ramazan DEMİRCİOĞLU https://orcid.org/ 0000-0003-0616-0331

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## 1. Introduction

The study area is located in the Tuzgölü basin in Central Anatolia, northeast of the Tuzgölü fault zone (Figure 1). It covers the area between Acıpınar and Altınkaya towns in Aksaray province. Important studies have been carried out in different fields of geology in and around the study area.

The study area, it's around have been thoroughly examined by various researchers over the years. Erol (1969), Arıkan (1975), Uygun (1981), Görür et al. (1984), Atabey et al. (1987), Dellaloğlu (1997), and Uçar (2008) also conducted sedimentological studies. Additionally, Çemen et al. (1999) analyzed the geodynamic evolution of the Tuzgölü basin, Dirik and Erol (2003) examined the morphotectonic features of the area and its surroundings, and Koçyiğit (2000) investigated the seismic characteristics of Central Anatolia.

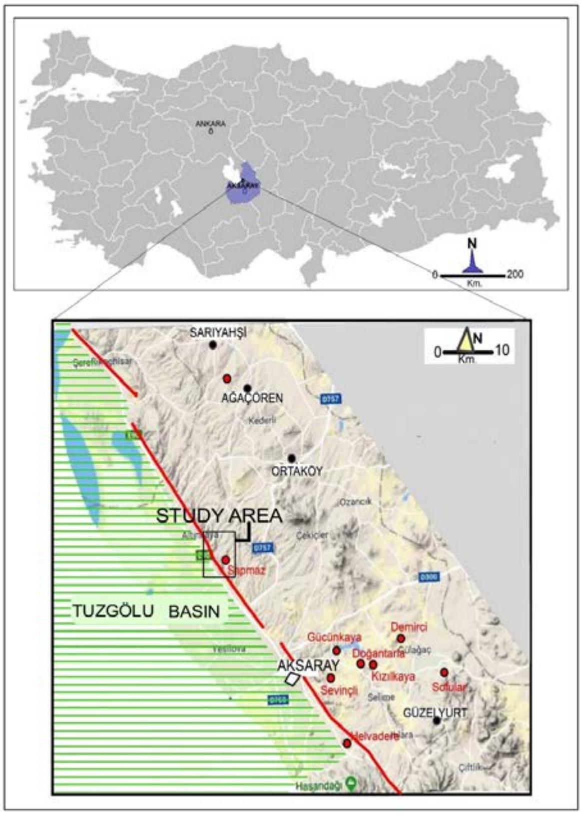


**Figure 1.** Map of the study area's location.

Some researchers, such as Şaroğlu et al. (1992) and Emre (1991), conducted active fault mapping studies in Some researchers, such as Şaroğlu et al. (1992) and Emre (1991), conducted active fault mapping studies in Türkiye to assess the earthquake-generating potential of the Tuzgölü fault zone, which passes through the study area. Kürçer (2012), Kürçer and Gökten (2011), and Kürçer and Gökten (2014) also realised palaeoseismological studies on segments of the Tuzgölü fault zone.

Recently, remote sensing studies with satellite and aerial photographs have increased. One of these studies is the determination of tectonic lineaments obtained by remote sensing studies. Lineament studies are very important in geological studies. In particular, there are many studies on the relationship between mining areas and tectonic lineaments. Some of these studies are Shirazi et al. (2022), Cherai et al. (2022), Sassioui et al. (2023), Dutra et al. (2023), Nouri and Arian (2023). For geothermal areas, linearity studies are important. Some of the related studies are Arrofi et al. (2022), Mahwa et al. (2023), and Heriawan et al. (2019). There are also studies on the relationship between geological structures and tectonic linearity. Some of them are Benaafi et al. (2017), Akram et al. (2019), Redouane et al. (2022), Skakni et al. (2022), Ahmadi et al. (2023), and Baruah et al. (2023).

The purpose of this study is to compare satellite-based tectonic lineaments with the lineament structures in a specific area. This comparison has not been performed in any other study. This study looks at lineaments belonging to faults, folded structures, and shear fractures observed in the Late Cretaceous-Miocene aged units between Acıpınar and Altınkaya. These lineaments were compared with those obtained by processing satellite images. This study found that the lineaments collected from satellite-based methods and field studies are generally compatible.

## 2. Materials and Methods

To begin with, the study area underwent comprehensive field evaluations that took into account prior research. Through a combination of on-site and remote sensing methods that utilized satellite imagery, the tectonic lineaments of the region were determined. The Landsat-8 OLI satellite image was initially processed in the ENVI program within a computer environment. From there, the resultant image was transferred to the ArcGis program after taking into account the threshold values in the Geomatica program, revealing the lineaments. Linearities obtained from both field and satellite studies were used to create rose diagrams, which were generated using the Rockwork program. A visual representation of these processes can be found in Figure 2.

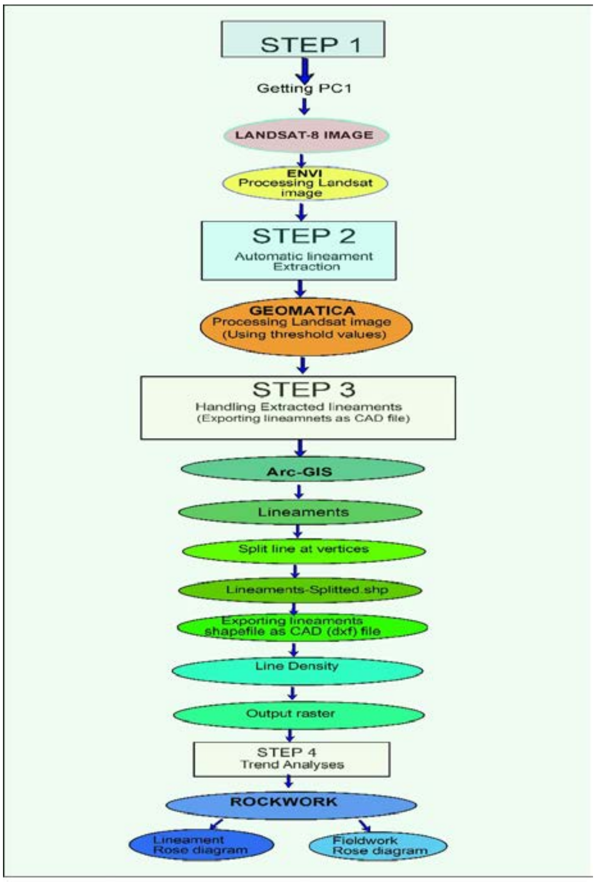


**Figure 2.** Flowchart of the lineament map generation.

Through the acquisition of data, an assessment was conducted on the tectonic lineaments in the area spanning from Acıpınar to Altınkaya. This was accomplished by analyzing both field and satellite-based lineaments. The lineaments extracted from the Landsat-8 satellite image were cross-referenced with those found in field research, which are related to various faults and fractures.

### 2.1. Geological Setting

#### 2.1.1. Stratigraphy

The study area and its surroundings cover the region between Acıpınar and Altınkaya in Aksaray province. Late Cretaceous-Mio-Pliocene aged rocks outcrop in this area (Figure 3).

Although not visible in the study area, the Kirsehir massif's Paleozoic-Mesozoic aged metamorphites, Late Cretaceous aged ophiolites, and plutonic rocks form the surrounding and study area's basement. The Kızıltepe Formation, consisting of late Cretaceous-aged sedimentary rocks, is the oldest unit in the study area, with burgundy-red-colored conglomerates, sandstones, and siltstones indicating a terrestrial environment (Figure 3). The Asmabogazi Formation overlays this unit unconformably, starting with conglomerates and continuing with sandstones containing *Orbitoides* fossils and limestones containing Rudist and *Hippurites* towards the top, indicating a terrestrial-marine environment (Uçar, 2008). These unit's sandstone, mudstone, and marl succession sometimes have thin coaly levels. Dellaloglu

(1997) set the unit's age as Miocene based on the palaeontological studies on the coal levels. The Miocene aged Cihanbeyli formation covers this unit angularly, with sandstone, siltstone, and mudstone levels present towards the top, including tuffaceous levels. Dellaloğlu (1997) and Toprak and Rojay (1997) set the late Miocene-Pliocene age for this unit based on palaeontological and radiometric ageing studies on the units and tuffaceous levels, respectively. The Sapmaz formation, of the Miocene-Pliocene aged, is laterally vertically transitional with this unit (Uçar, 2008). Finally, all these units are unconformably overlaid by Quaternary aged alluvium (Figure 3).

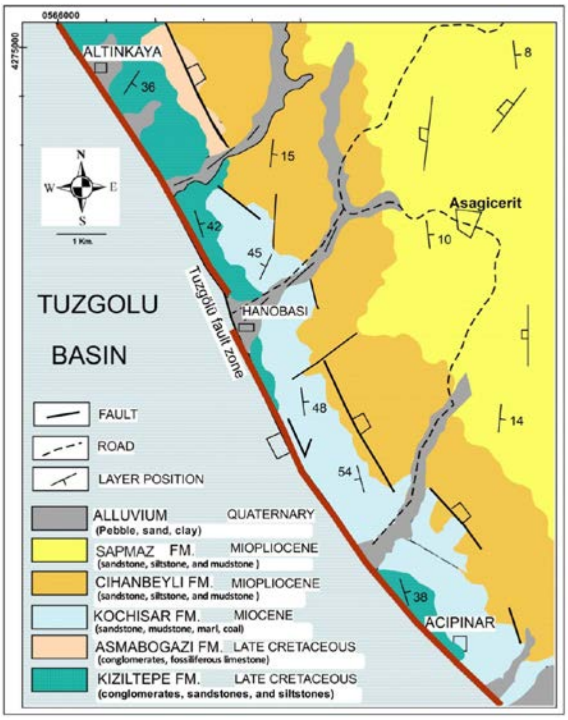


**Figure 3.** Geological map of the research region and its environs.

**2.1.2. Structural geology**

The Tuzgölü basin boasts numerous geological studies, with a particular focus on the Koçhisar-Aksaray segment of the Tuzgölü fault zone. Here, the fault segment's strikes tend to vary between N30 and 45$^0$W. The study area features northwest-southeast horst and graben structures, including the Hanobasi horst and Asagıcerit graben (Figure 3). The Late Cretaceous-Mio-Pliocene aged rocks in these areas have undergone significant deformation, attributable to the closure of the Inner Tauride Ocean and the ensuing compressive tectonic regime. The formation of folded structures, faults, and shear fractures were realised in this period. In more recent times, during the late Miocene and early Pliocene, the area has experienced the effects of the extensional tectonic regime, leading to the formation of the Tuzgölü fault zone and normal faults that possess a directional thrust fault character and a vertical thrust component (Kürçer and Gökten, 2014).

## 3. Results

**3.1. Geological Structures Presenting Linearity**

The Tuzgolu Fault Zone is the most significant linear tectonic structure in the study area. The direction of the Tuzgolu fault zone varies, and it includes the Koçhisar-Aksaray segment within the study area. Field studies show that structures like faults, fractures, and fold axes exhibit tectonic linearity, as shown in Figure 4. In Altınkaya village, the Koçhisar-Aksaray fault line is visible (Figure 4a). Similarly, the Koçhisar-Aksaray fault line is clearly visible around Acıpınar village (Figure 4b). Furthermore the fold axes of the units which exhibit folding form lineations in the study area. The shear and tension fractures also formed due to the polyphase deformation in the study area (Figure 4d, e, f).

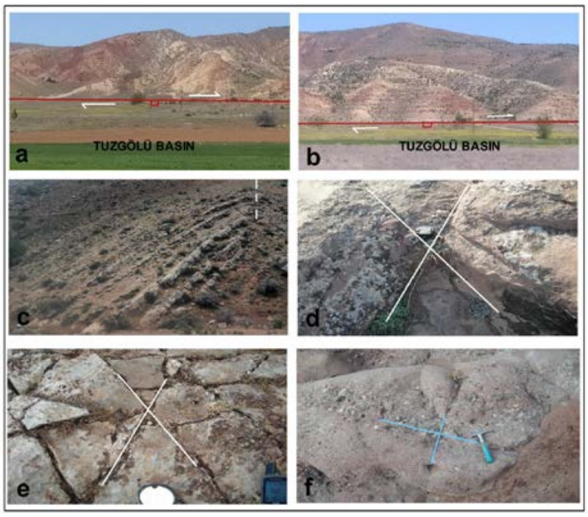


**Figure 4.** a-The Koçhisar-Aksaray fault line from Altınkaya village. b-The Koçhisar-Aksaray fault line from Acıpınar village c- Fold and fold axis appearance in the Asmabogazi Formation. d- Shear fractures in sandstones of the Kochisar Formation. e- Shear fractures in Asmabogazi limestones f- Tension fractures in conglomerate of the Sapmaz Formation.

In the study area, there are two types of lineations: morphological lineations caused by erosion and tectonic lineations. Additionally, there are important normal faults including the Koçhisar-Aksaray fault that forms the Hanobası horst are present. The normal faults, which have developed in parallel or semi-parallel directions to this fault, also form lineations.

**3.2. Lineament maps**

One of the satellite images between Acıpınar and Altınkaya is the Google Earth image where the Koçhisar-Aksaray fault is seen (Figure 5). In this image, the Koçhisar-Aksaray fault is visible. Landsat-8 OLI satellite imagery obtained from earthexplorer.usgs.gov/ web address was used to create the lineament maps (Figure 6). This image was processed in the Envi programme. Then, in Geomatica, the image was prepared for the ArcGis program by using threshold values to obtain sufficient detail. A lineament map was obtained in the

ArcGis programme (Figure 7). By superimposing the density map and lineament map of the lineaments between Acıpınar and Altınkaya, a density-lineament map of the study area was created (Figure 8).

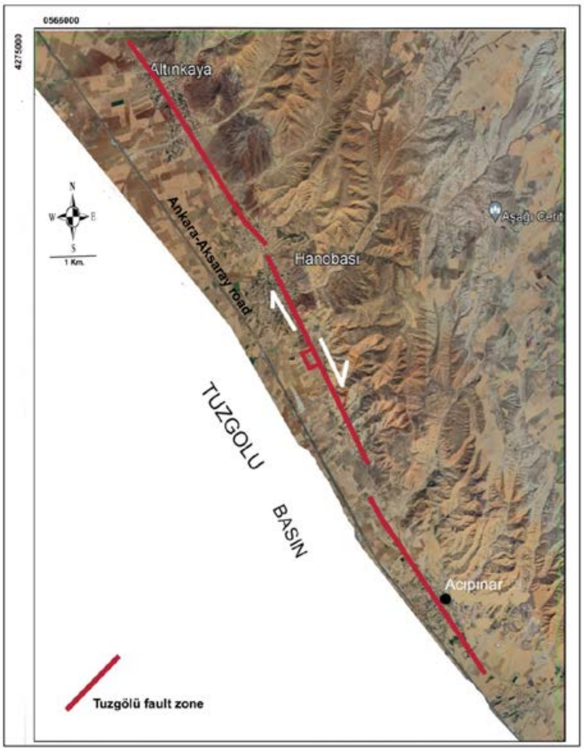


Figure 5. Google Earth image of Acıpınar-Altınkaya.

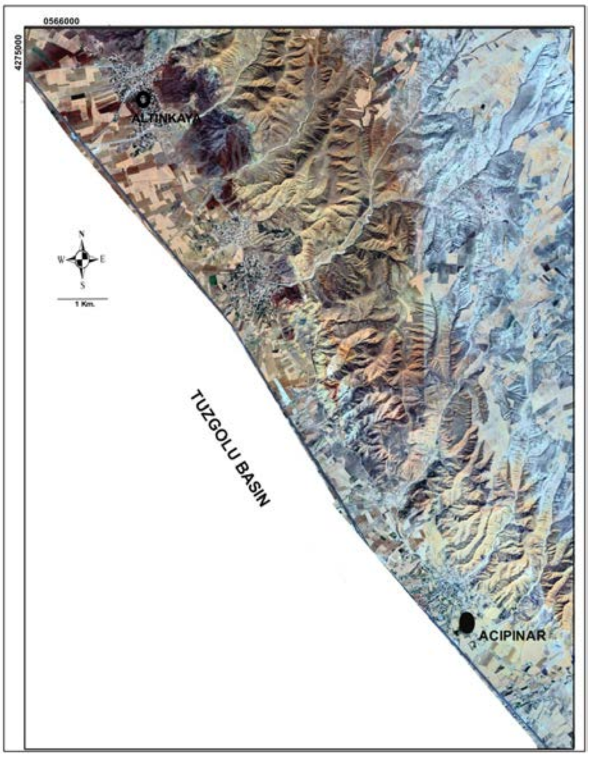


Figure 6. Landsat-8 OLI satellite image.

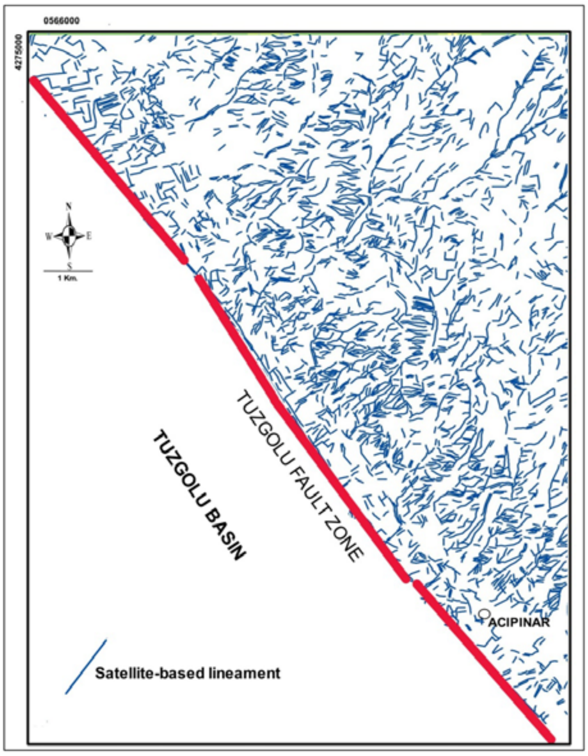


**Figure 7.** Tectonic lineament map between Acıpınar-Altınkaya.

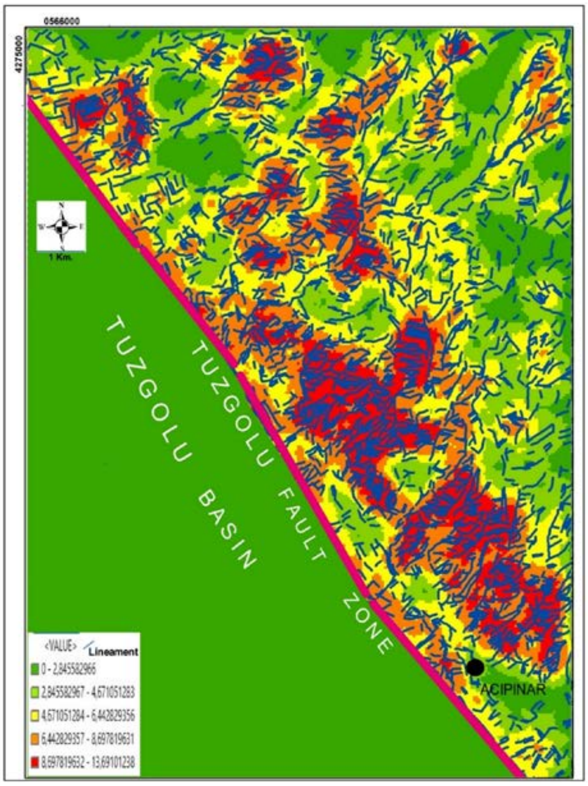


**Figure 8.** Lineament density and lineaments map.

### 3.3. Assessment of fieldwork and satellite lineaments

To ascertain the predominant distribution directions of the lineaments collected between Altınkaya and Acıpınar, rose diagrams were constructed. The length as a proportion of the total lineament length (%L) and the length as a percentage of the total lineament population (%N) were used to produce two different types of rose diagrams.

The diagrams showed that lineaments were present in all directions, but the dominant directions were N40⁰-50⁰E, N50⁰-60⁰E, N30⁰-40⁰W, N40⁰-50⁰W, and N80⁰-90⁰W.

Furthermore, a rose diagram of the faults was created in the Rockwork programme. It was based on 67 measurements taken from faults ranging from centimetres to metres in size, which were determined in the Late Cretaceous-Mio-Pliocene aged rocks. The dominant fault directions were found to be concentrated between N40⁰-50⁰E, N50⁰-60⁰E, N30⁰-40⁰W, N40⁰-50⁰W, and N80⁰-90⁰W

Based on the measurements taken from the shear fractures in Late Cretaceous-Miocene-aged units, a rose diagram was created. The dominant fracture directions were N20⁰-30⁰E, N40⁰-50⁰E, N30⁰-40⁰W, N40⁰-50⁰W, and N80⁰-90⁰W, totaling 157 measurements.

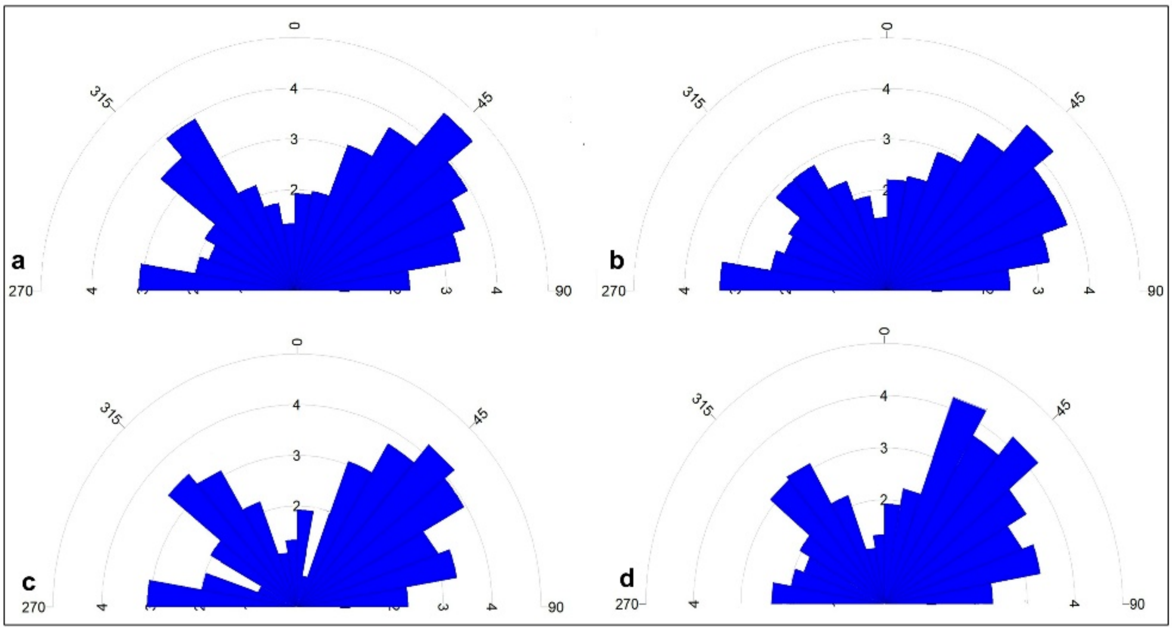


**Figure 9.** a- %L rose diagram b- %N rose diagram. c- Rose diagram of the faults d- Rose diagram of shear fracture in sedimentary rocks.

## 4. Conclusions

Lineaments in the region between Acıpınar and Altınkaya, derived from field and satellite-based surveys, were analyzed. Within the Late Cretaceous-Mio-Pliocene aged rocks in the study area, faults, fractures, and folds resulted from polyphase deformations, forming lineaments. These lineaments were assessed, particularly those located northeast of the Tuzgölü fault zone. Using the Rockwork program, rose diagrams were generated for both field and satellite-based lineaments, which revealed that the lineaments were distributed in all directions due to polyphase deformations, with the most intense directions being N40⁰-50⁰E, N50⁰-60⁰E, N30⁰-40⁰W, N40⁰-50⁰W, and N80⁰-90⁰W, according to %L and %N. A rose diagram was created based on the directional measurements of the faults determined in the field, which showed that the dominant fault directions were N40⁰-50⁰E, N50⁰-60⁰E, N40⁰-50⁰W, N30⁰-40⁰W, and N80⁰-90⁰W, similar to the fault directions of the Koçhisar-Aksaray segment. Similarly, a rose diagram was prepared for the measurements taken from the fractures in the area, revealing dominant fracture directions of N20⁰-30⁰E, N40⁰-50⁰E, N30⁰-40⁰W, N40⁰-50⁰W, and N80⁰-90⁰W, similar to the faults.

From the obtained rose diagrams, fractures have developed in all orientations due to polyphase deformation. By evaluating the fracture and fault planes in the rose diagrams, it is possible to determine the dominant compression and extension directions.

The lineaments obtained from the field surveys and satellite-based studies were found to be highly compatible.

**Author Contributions**

The percentages of the author' contributions are presented below. The author reviewed and approved the final version of the manuscript.

| | R.D. |
|---|---|
| C | 100 |
| D | 100 |
| S | 100 |
| DCP | 100 |
| DAI | 100 |
| L | 100 |
| W | 100 |
| CR | 100 |
| SR | 100 |
| PM | 100 |
| FA | 100 |

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

**Conflict of Interest**

The author declared that there is no conflict of interest.

**Ethical Consideration**

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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