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## Determination of fault morphology of Antakya-Kahramanmaraş depression area by using methods of Remote Sensing (RS) and Geographical Information Systems (GIS)

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### Abstract

Antakya-Kahramanmaraş depression has nearly 180 – 200 km length and 5 – 40 km width. Research area is located on the Eastern of the East Mediterranean. There are many studies that have been carried out in this area. These studies are mostly geological and some of them have been made in terms of physical and human geography. This area has a great variety of morphological characteristics. Geographical Information Systems (GIS) and Remote Sensing (RS) methods are very useful in morphological researches. Many morphological studies have been carried out recently by using these technologies. In this study, fault morphology was investigated by using GIS and RS technologies. Digital Elevation Model (DEM) and Landsat TM Satellite images with 7 bands of different dates were used as main data in this study and many analyses were applied to these data. Firstly, faults were determined by DEM and correlated to existent faults on the geological maps. Subsequently, the relationships between faults and drainage were emphasized. Consequently, fault morphology of area was interpreted through analysis.

This study is a preliminary work on geomorphological features of the region. Fault morphology of the region will be obtained through detailed studies. Morphological studies are very important for the planning of this region, especially the densely populated places in this depression. In addition, due to the morphological variety in Antakya-Kahramanmaraş depression and its surroundings, there are many economic activities going on here.

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### 1. Introduction

#### 1.1. Study Subject

Antakya-Kahramanmaraş Graben was formed with East Anatolian Fault Zone (EAFZ), the Dead Sea Fault Zone (DSFZ), and the Cyprus Arc. Although there are a lot of geological studies [1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14] related to the region, geomorphological studies are few in this graben area [15; 16; 17; 18; 19; 20; 21; 22]. River capture in the Quaternary period and precipitates resulted from fault activity following Neogene played an important role in the formation of lake and swamps in the graben area. While Aksu Stream, a tributary of the Ceyhan River, was flowing in the direction of Kahramanmaraş-Antakya graben in the Quaternary (early in the Holocene), it was connected to the Ceyhan river through a capture action [23]. After the capture action, the old valley dried up and a large row of lakes, small lakes and swamps were formed.

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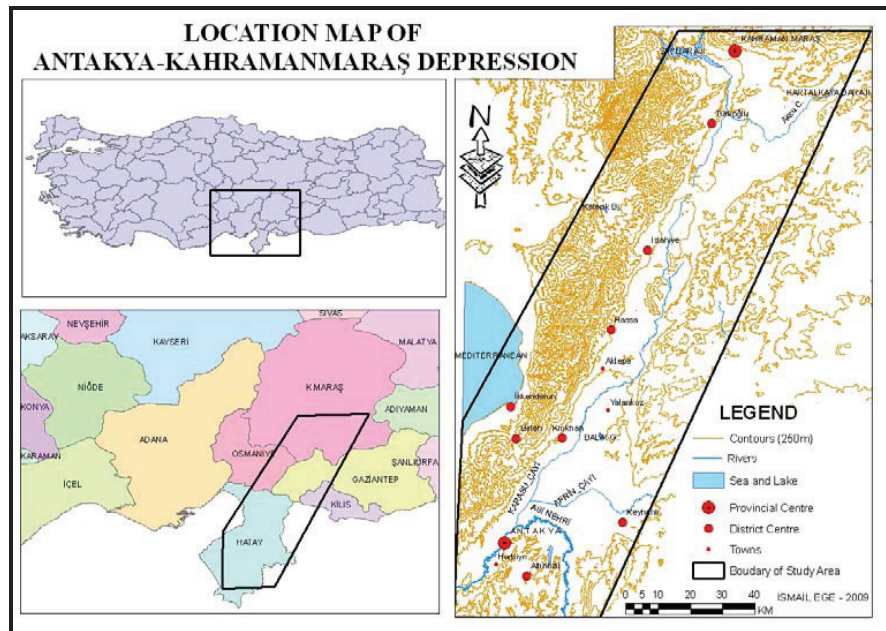


Fig. 1. Location Map of Antakya-Kahramanmaraş Graben Depression

The purpose of this study is to compare the old faults which were recognized by many geologists in the classical studies and the new faults identified by new techniques. Thus, shaping and fault morphology of this region will be explained. This study was conducted by using Remote Sensing (RS) and Geographical Information Systems (GIS). Firstly, filtering and adjoining process and some analysis were made, and then lineaments were identified by these techniques. The region is very rich in terms of fault morphology. It is also very active in earthquakes. Again, the most remarkable contribution of this study is the introduction of the methodology of RS and GIS in the depression areas.

### 1.2. Method

Firstly, the depression limits were determined by using 1:100.000 topographic maps and appertaining methodic studies [24; 25; 26; 27; 28] were investigated. Then, the digitization process was made by ArcGIS Desktop – ArcMAP program with 50 meters contours. The basins numerical elevation model was formed with these contour lines which were identified on the computer. We used programs such as ArcMap, TNTmips, MapINFO, Erdas and PCI Geomatica in this study. Finally, we chose whichever program was suitable for us at that stage. Some maps were digitized with ArcMAP 9.3 packet program. Topographic, geologic and hydrographic maps were prepared with this program. Topographic map scale was 1/25.000 and it was very detailed for this study (Figure 2).

3D physical map was generated from Digital Elevation Map data. Antakya-Kahramanmaraş depression in NE-SW direction can be seen clearly on this map. According to this map, the edges of depression were completely formed by faults. Directions of the rivers are in parallel with directions of the fault and fault morphologies. The western parts of Amanos Mountains are quite different. Slope characters are different between the west and the east.

Two Landsat 7 ETM satellite images numbered 174 - 034 and 174 - 035 were provided for this study. Making geometric and atmospheric adjustments, nine bands of the images were paired and joined together.

### 1.3. Tests/Calculations

Every band of Landsat 7 ETM satellite images was tested, but we couldn't have very clear results. Because we didn't have very detailed satellite images, we used raw dates which were digitized from 1/25.000 scale maps. DEM map was composed of contours map. Hydrographic, slop, aspect and tin maps were generated from digital Elevation Map. Different analyses were applied with GIS programs. Some lineaments were obtained with PCI Geomatica program and they were mounted on the Landsat 7 ETM satellite image.

## 2. Findings of the study

After the analyses, diagnosed faults were mounted on the physical map, so some morphologic features related to faults were shown very clearly on the edge of the depression area. The most important features of these are foothills triangle surfaces, shifted valleys, alluvial fans on the edge of the western part of depression etc. In some areas, alluvial fans can not be noticed easily because the edge of the western part of depression is covered with settlements. However, they are noticed very clearly in some areas, for example, between Aktepe and Hassa towns. Parallel faults and their shaping attract attention in this area.

Width of the Graben area, both sides of which have been shaped by faults, is not the same everywhere (Figure 3). The largest area where there is a plain called Amik Plain is between Antakya, Kırıkhan and Reyhanlı (Photo 1). However, the closest area is the Fevzipaşa area. The cause of this difference has geared to tectonic. It affected direction of the valleys and their lengths. Drainage systems and bends of valleys are related to tectonic movements. Valleys of Amanos Mountains are very short and curved in the east. Some valleys were formed in the fault lines as Delibekirli, Hassa streams. These indicate tectonic evidences and fault morphology in the study area.

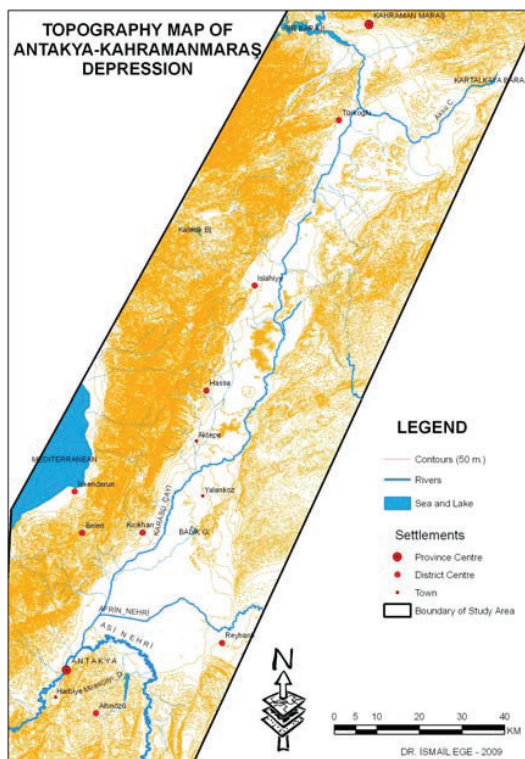


Fig. 2. Topographic Map of Antakya-Kahramanmaraş Depression

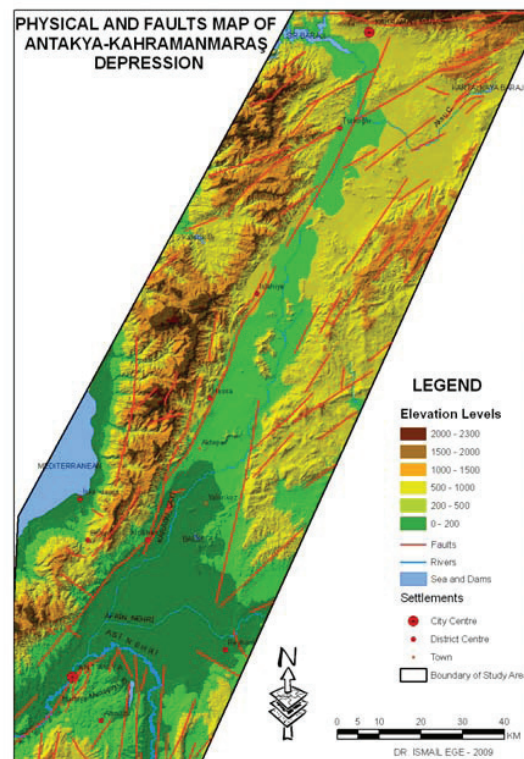


Fig. 3. Physical and Faults Map of Antakya-Kahramanmaraş Depression

East of graben consisted of plateaus (Figure 3-4). Faults which run parallel have divided these areas. Rivulets emerged in the weak points where there are small fault lines. Valleys generally lie in the NE-SW directions (Figure 4).

When we look at the profiles in the east-west direction, faults are seen very clearly (Figure 5). As it can be seen from the profile, main fault is quite apparent on the west part of both Kırıkhan and Hassa (Figure 5-Photo 1).

Lineaments analyses were done using PCI Geomatica program from Digital Elevation Map (DEM). Possible false lineaments were identified manually. Different parameters were tested in these analyses. So, the most suitable parameter was used to find faults.

After the analyses, probable faults identified were compared with those of old studies. Old faults which were compiled from the early studies were marked as existent faults and those identified in this study were marked as probable faults (Figure 5). So, tectonic geomorphologies of the study area were presented in this study. According to the new analyses, old faults and new faults overlap by 70 %. Recently discovered faults are very important in this study.

Some of the recognized faults were also observed in the fields. The most characteristic and the youngest fault is the Antakya fault in the front of Habibi Neccar mountain (Photo 2,).

Because depression areas were deposited alluvial materials; we think that there are a lot of covered faults under



the deposition (Figure 6). But now, we cannot see these. Parallel faults starting immediately next to the plain are a kind of evidence for it. Young volcanic area which is near Hassa and called “Hassa leçeleri” show the relationship between deposition and covered faults. Some new tectonic and geo-archeological studies show the faults on the historical rampart on the plain. Some building walls were shifted by faults [25]. It was mentioned in the same study that the Asi river changed its bed due to active tectonic.

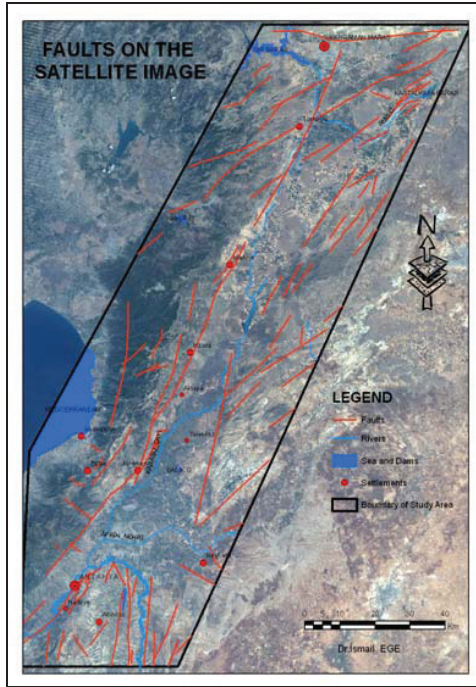


Fig. 4. Faults Map of Antakya-Kahramanmaraş Graben

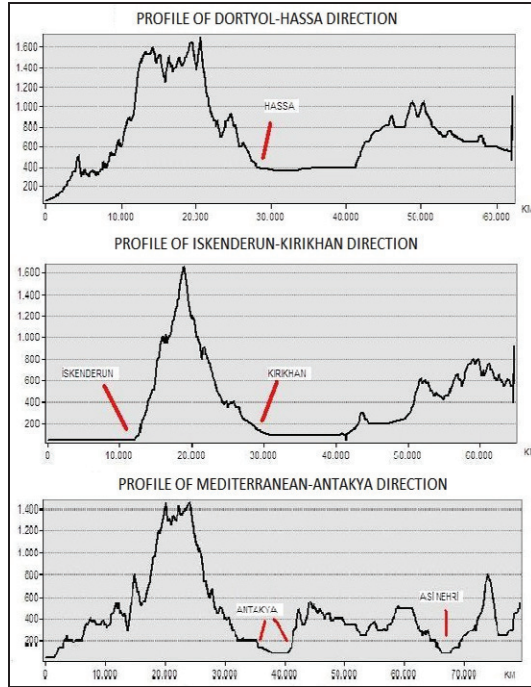


Fig. 5. Profiles of Antakya Kahramanmaraş Graben, Direction from East to West



Photo 2. Antakya fault between in the front of Habibi Necar Mountain and Antakya City, Photo 1. Amik Plain (the largest area between Kırıkhan and Reyhanlı)



Photo 3. Antakya fault is shown that it is located northeastern of Antakya city. It cuts Pliosen and before Pliosen stones (normal fault action)

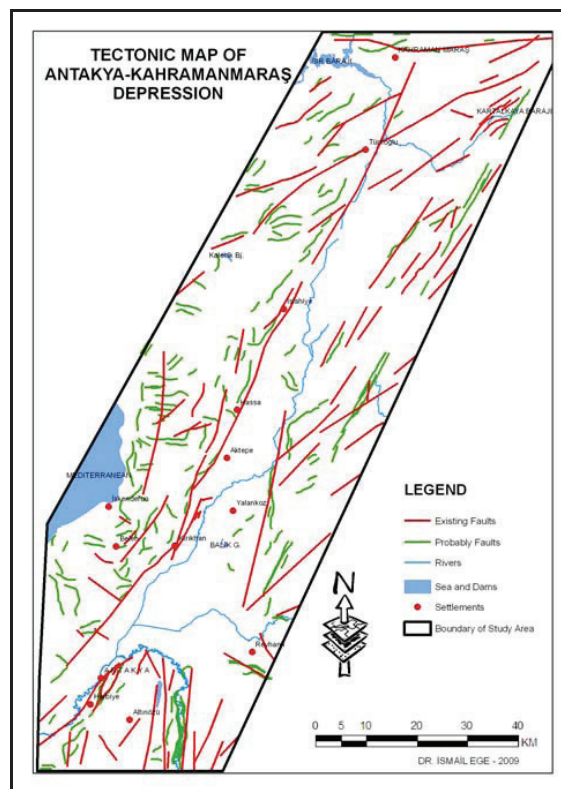


Fig. 6. Tectonic Map of Antakya-Kahramanmaraş Graben

Drainage system was obtained using TNTmips program from digital elevation map (DEM). It was seen that generally the crooked drainage types were common in this area (Figure 7). This suggested that fault morphology was common in this area. Lineaments are observed very clearly on the drainage maps. We can see very close relationships between lineaments and drainage systems.

As you can clearly see in figure 6, East Anatolia Fault (EAF) was formed on the fault line in the south of Kahramanmaraş city. We can probably say that it continues under deposition in the Türkoğlu plain. Bends of rivulets and rivers indicate the extension and direction of the faults. Fault morphology was shaped according to these systems (Photo 3).

Faults which were formed in the south of depression area and, their directions and relationships with drainage systems can be seen very clearly in figure. One remarkable factor is that the flow route of Asi River was confined by faults. Also, another factor is that Asi River continues in the different systems to the east (Dead Sea Fault System and

Zone) and west (Cyprus Arc System and Zone). Again, rivulet bends show the relationship between tectonism and drainage system.

### 3. Conclusions and Suggestions

Study area was digitized from 1/25.000 scale maps. So, Digital Elevation Map consisted of these counter maps. Lineaments analysis was performed using DEM. After the analyses, it was found that lineaments were compatible with the existing faults. They were marked on the maps as possible faults. Thus, faults reflecting the neo-tectonic characteristics of the study area were introduced in the Antakya-Kahramanmaraş depression.

Drainage maps were created by using DEM data. There is not a typical drainage system, but generally crooked drainage system is common in the study area. This shows the fault morphology in here. It is thought that there are a lot of covered faults under the deposition in Amik Plain.

Despite depression as the main feature, the fact that Antakya-Kahramanmaraş graben area is located in the intersection of East Anatolia Fault system, Dead Sea Fault system and Cyprus Arc systems has contributed to the formation of many different features in the study area. Especially, in the east part of the study area, it has been split by the faults even though it is a horst area. Rivulets emerged in the parallel fault lines.

Fault morphology of the study area was introduced in this study, so this area is very active in terms of fault activity. The risk of earthquakes is high. This should be taken into account and selection of routes and settlements needs to be made carefully. Further detailed studies and analyses are needed for this region. These studies will be made by using Remote Sensing (RS) and Geographical Information (GIS). Again, some geomorphologic indices can be done in this region.

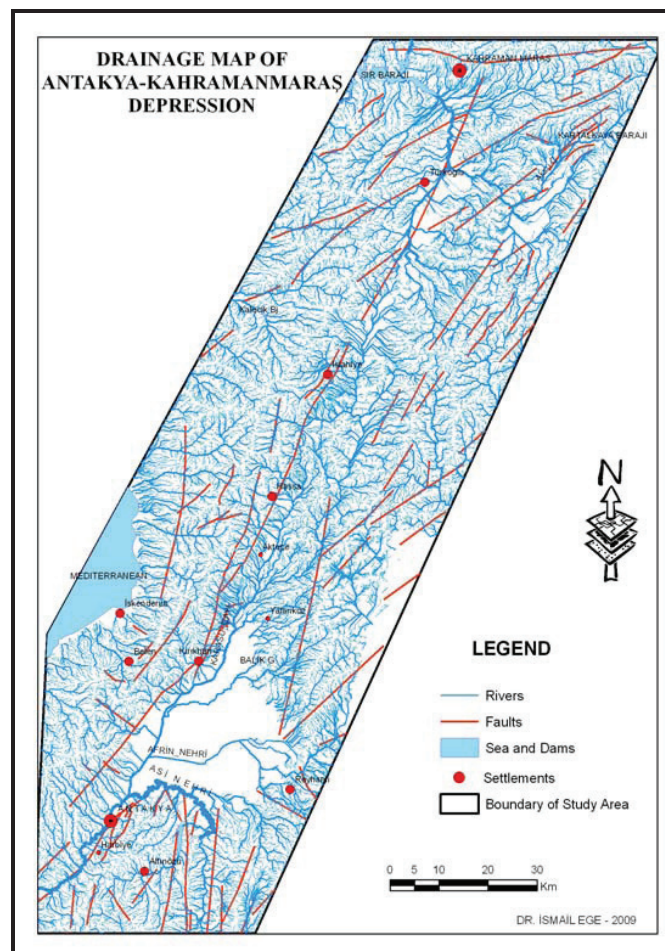


Fig. 7. It is shown that map indicates relationships between faults and drainage system of Antakya-Kahramanmaraş Graben



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