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Using of GIS on field geology studies: An application on central-southern of Eskişehir

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ABSTRACT

Technological developments on Geographical Information Systems (GIS) make possible to use its applications on all departments of earth sciences. GIS based drill-hole data, lithological and structural maps are used integrated with field geolgy investigations in this study. The area where is bordered Batıkent-Yukarı Söğütönü districts on northwest and Vadişehir-Ihlamurkent districts on southeast is defined as study area. 44 water wells drilled by State Hydraulic Works (DSİ) are located in various points of Eskişehir region were transformed to GIS base. Geological cross-sections which were designed by drill-hole lithology are point out a disconformity zones between Paleogene and Neogene according to principle of lateral continuity. Neotechtonic researches on study area show thah right lateral strike slip shear zone dominates the region structurally. Searching these structural traces on the field and representing new field evidances by using GIS on the regions where there is no consensus stratigraphicly are the main purposes of the study. Geological map of the region where lies between Çankaya and Karapınar districts without consensus stratigrapichly was made by field observations on Miocene units. The other surface evidances include dilation fractures, strike-slip faults are support the idea which is suggested for Eskişehir region as right lateral strike-slip shear zone.

1. Introduction

The Geographical Information Systems (GIS), which allow the collection, analysis and storage of spatial data, can be used in all areas of geosciences. The integrated use of GIS on fields such as geology, geotechnics and seismology has become widespread in the last 20 years. Seyis et al. (2002), by taking into account the geological criteria have prepared a database Zonguldak coal basin on the GIS environment. Thanks to this database, the geological properties of coals of the region have become easily accessible and questionable. Kumsar et al. (2011) contributed to the control of urban development developing a geological and geotechnical urban information system in the GIS environment for Denizli province center. Tün et al. (2015) developed disaster management practices by interpreting earthquake data obtained from seismic networks in GIS environment. In this study, it is aimed to present new findings to the stratigraphy and neotectonic evolution of Eskişehir region by using GIS and field geology studies in an integrated manner. The study area, which consists mostly of the south of Eskişehir, is bordered by Batıkent-Yukarı Söğütönü districts in the northwest and Vadişehir-Ihlamurkent districs in the southeast (Figure 1).

The province of Eskişehir and its vicinity are located within the Anatolide platform, which is described by Ketin (1966) where all series between Paleozoic and Upper Cretaceous have been more or less metamorphosed and covered by an apparent angular unconformity and thick basal conglomerate by the lower Eocene. Okay (2011) defines that the

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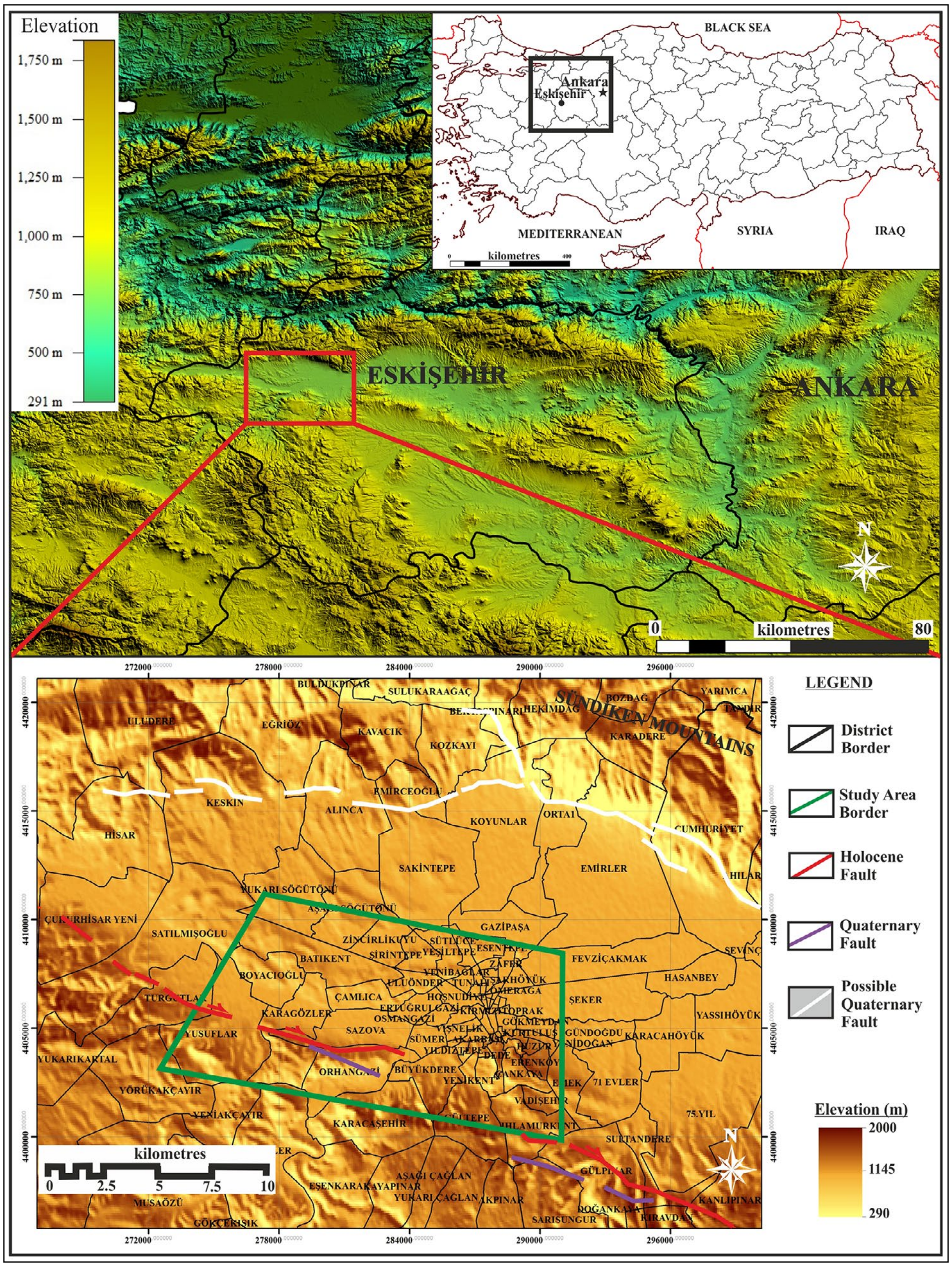

Figure 1- Morphology and location map of the study area [faults were projected from Emre et al., (2013)].

northern end of the Anatolide platform, which covers the study area, formed the portion which was located in subduction zone and again uplifted to the surface in the Late Cretaceous and named this region as the Tavşanlı Zone.

Gözler et al. (1996) explained that the basement rocks in Eskişehir area consisted of pre-Jurassic metamorphics and Triassic ophiolites. It is mentioned in many studies that Paleogene is unconformably deposited on this basement and the Paleogene and Neogene rocks are covered by Quaternary (Gözler et al., 1996; Ocakoğlu, 2007; Orhan et al., 2007; Şengüler and Izladı, 2013; Usta and Kutluk, 2014). The region is tectonically restricted by the Eskişehir Fault Zone (EFZ), which is a right lateral strike slip fault with normal component in south (Şaroğlu et al., 1992; Barka et al., 1995; Altunel and Barka, 1998; Seyitoğlu et al., 2015) and bordered by a probable Quaternary fault system and lineament (Emre et al., 2013) between the Bozdağ and Sündiken mountains that extend generally in NW-SE directions in the north. In analyses carried out in the EFZ and its close vicinity; it is seen that there is a general consensus that the NW-SE trending shear zone shapes the structural geology of Eskişehir environment (Altunel and Barka 1998, Seyitoğlu et al., 2015).

2. Method

The study was carried out under the headings of GIS, Field Geology and Literature Survey. In the light of studies mentioned in the literature (Gözler et al., 1996; Ocakoğlu, 2007; Orhan et al., 2007; Şengüler and Izladı, 2013; Usta and Kutluk, 2014, Seyitoğlu et al., 2015), the stratigraphic relations, structural and tectonic traces of the geological units were investigated on the field. GIS studies consist of application steps of; i) the transformation of water drilling logs of DSİ into vector format in 1/1000 vertical scale, ii) the definition of point data by assigning coordinate to drilling logs in vector format and transferring them in to the GIS environment, iii) forming cross-section lines passing over point data and obtaining topographic sections of lines over digital elevation model (DEM), iv) the overlapping of the topographic cross-section generated in GIS environment with the vector-format drilling logs prepared on a scale of 1/1000, v) the completion of the design section and interpretation of the general geology criteria (lateral continuity, cross-cutting relationships, law of superposition) (Figure 2). Drilling data used in the study were distributed to various regions of Eskişehir province and obtained from 44 DSI water drilling logs and ASTERGDEM data with 30 m resolution.

3. General Geology of the Study Area

Geological evolution in Eskişehir region is considered to have been formed on the basement rocks which began to occur during the closure of Neotethys ocean in the Late Cretaceous (Göncüoğlu et al., 2000). The Paleotethyan relationship and Triassic age were also suggested for these basement rocks (Okay et al., 2002). It is known that the basement rocks are composed of rocks that show widespread blueschist metamorphism and serpentinized ultramafic rocks that overly them by tectonic contact (Okay, 2011). The region stratigraphically consists of Neogene and Quaternary, which relatively thins out towards younger units deposited on the metamorphic and ultramafic basement (Ocakoğlu, 2007). The basic rocks are overlain by the units of lower Eocene, upper Miocene and Pliocene in sequence (Gözler et al., 1996). The Pleistocene and all other rocks are covered by the Quaternary alluvium (Figure 3).

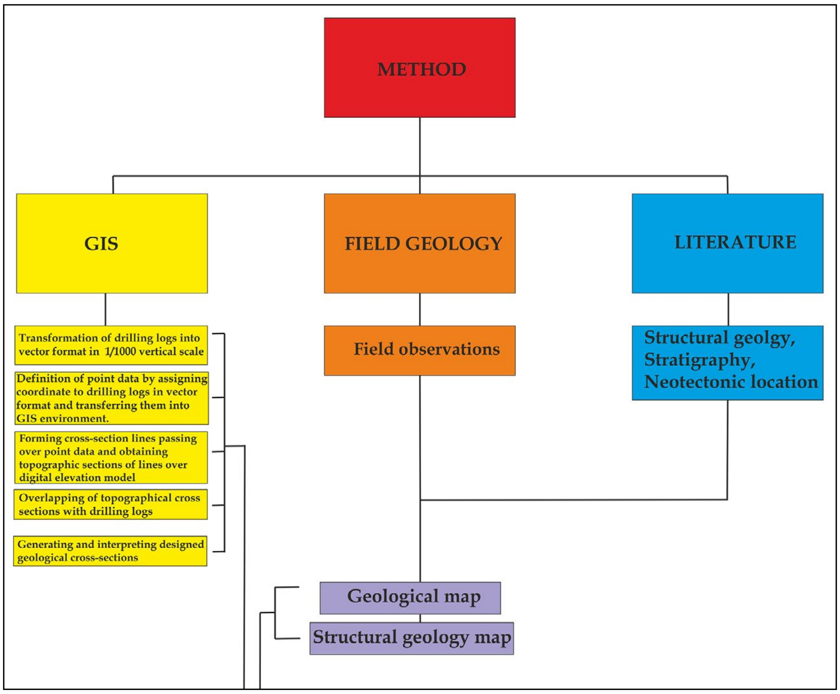

Figure 2- Flow chart of the study.

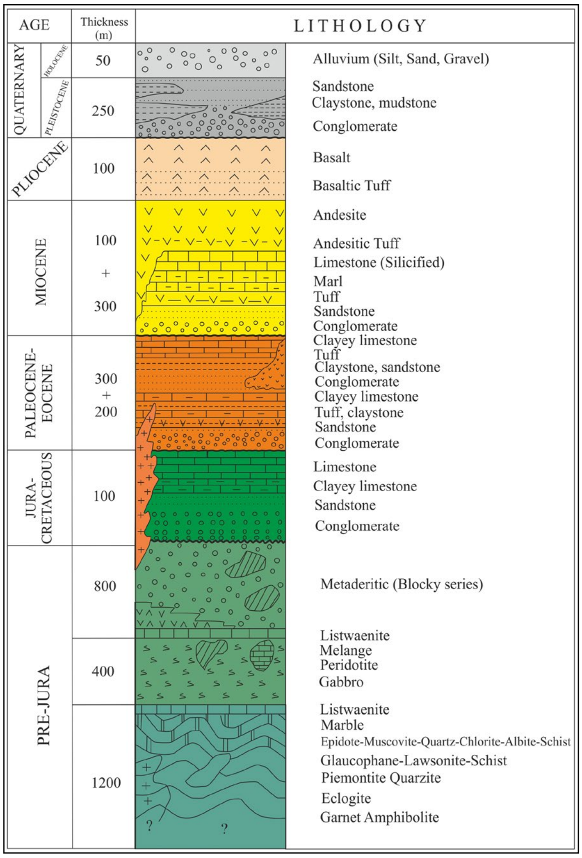

Figure 3- Generalized columnar section of Eskişehir and its vicinity [modified from Gözler (1996)].

The Mesozoic units located in and around Eskişehir are represented by radiolarites, radiolarian limestones, mudstones, serpentinite, diabase, limestone, schist blocks and occasionally serpentinized peridotite and partly metamorphosed diabases and gabbros (Gözler et al., 1996). Mesozoic units crop out with mudstones in the study area on a E-W extending hill between Karagözler and Sazova.

The Eocene, which unconformably overlies Mesozoic units present outcrops in south of Eskişehir with colors varying in red, dark pink, medium compacted, low-strength sandstone, conglomerate levels and the overlying pale yellow, low strength clayey limestones. The Eocene units in the region show clayey limestone layers over sandstone levels in the vicinity of Mamuca, while red-pink sandstone-conglomerate layers are common in the north of Aşağıçağlan and Kayapınar districts. The overall thickness of Eocene units is assumed to vary between 200-500 m.

The Miocene, which disconformably overlies the Eocene, cover large areas with conglomerate, sandstone, marl, limestone levels in the study area and in the south of Eskişehir. In west of the study area, it is possible to observe transitions between the green marl-limestone around Turgutlar-Yusuflar districts and the conglomerate-limestone levels in the central-east on highly elevated hills of Odunpazarı district.

The Pliocene, which covers very few area with respect to other units are represented by tuff and basalt units.

The entire study area to the north of the Sarisu River consists of Quaternary. The Quaternary in this area is composed of Pleistocene with lithologies of conglomerate, claystone, mudstone and sandstone and the Holocene cover (Figure 4).

The study area was assessed by broad literature survey, drilling logs and GIS based analyses (Figure 5). Field studies were carried out by using classical methods in an area of 10 km^2 restricted by Akarbaşı and Göztepe districts in northwest and Yenikent and Çankaya districts in southeast.

The most important tectonic element in Eskişehir region is the right lateral strike slip fault system, which extends between Uludağ in the northwest and Kaymaz (Eskişehir) in the southeast (Şaroğlu et al., 1992). A series of discrete faults in the stated area were mapped as the İnönü - Dodurga Fault Zone, the Eskişehir Fault Zone and the Kaymaz Fault Zone (Şaroğlu et al., 1992). The line, which is accepted as the northeastern border of the Western Anatolian block and the Central Anatolian block (Barka et al., 1995), was also mapped as the Eskişehir Fault (Şengör et al., 1985; Barka et al., 1995). Altunel and Barka (1998) defined the line formed by right lateral strike-slip fault between Uludag in the west and Kaymaz in the east as the Eskişehir Fault Zone (EFZ). In the study, the EFZ was defined as a trans-tensional zone based on detailed field analyzes in İnönü-Çukurhisar and Turgutlar Eskişehir segments. Seyitoğlu et al. (2015) stated that the Eskişehir region (Figure 6a) was shaped by the effect of right lateral shear zone along the 60 km long line of which its main axis is N60W as a result of field studies carried out around Bozüyük - İnönü in the northwest, Alınca-Muttalıp in the north, Kızılinler-Gökçekısık in the central-south, and Akçapınar in the southwest (Figure 6b).

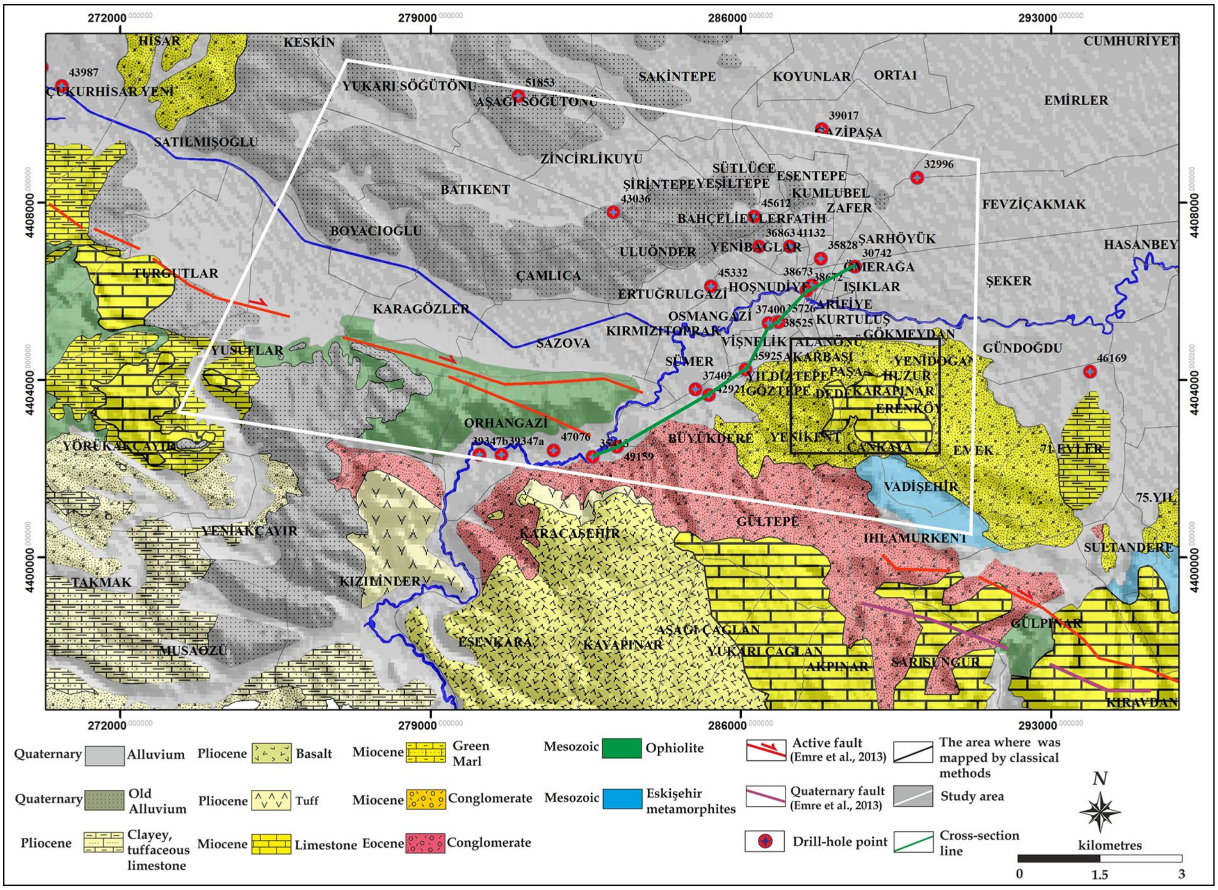

Figure 4- Geological map of the study area [modified from Gözler et al. (1996) and Orhan et al. (2007)].

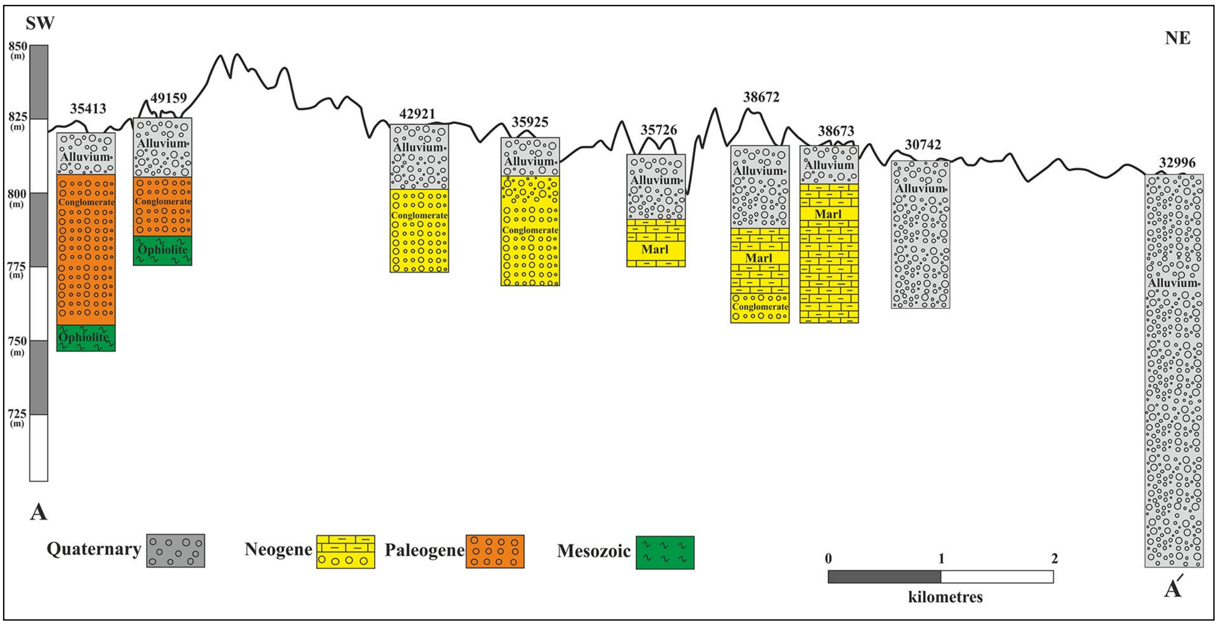

Figure 5- Topographic section of the study area with SW-NE direction and lithology logs of the drillings on the section.

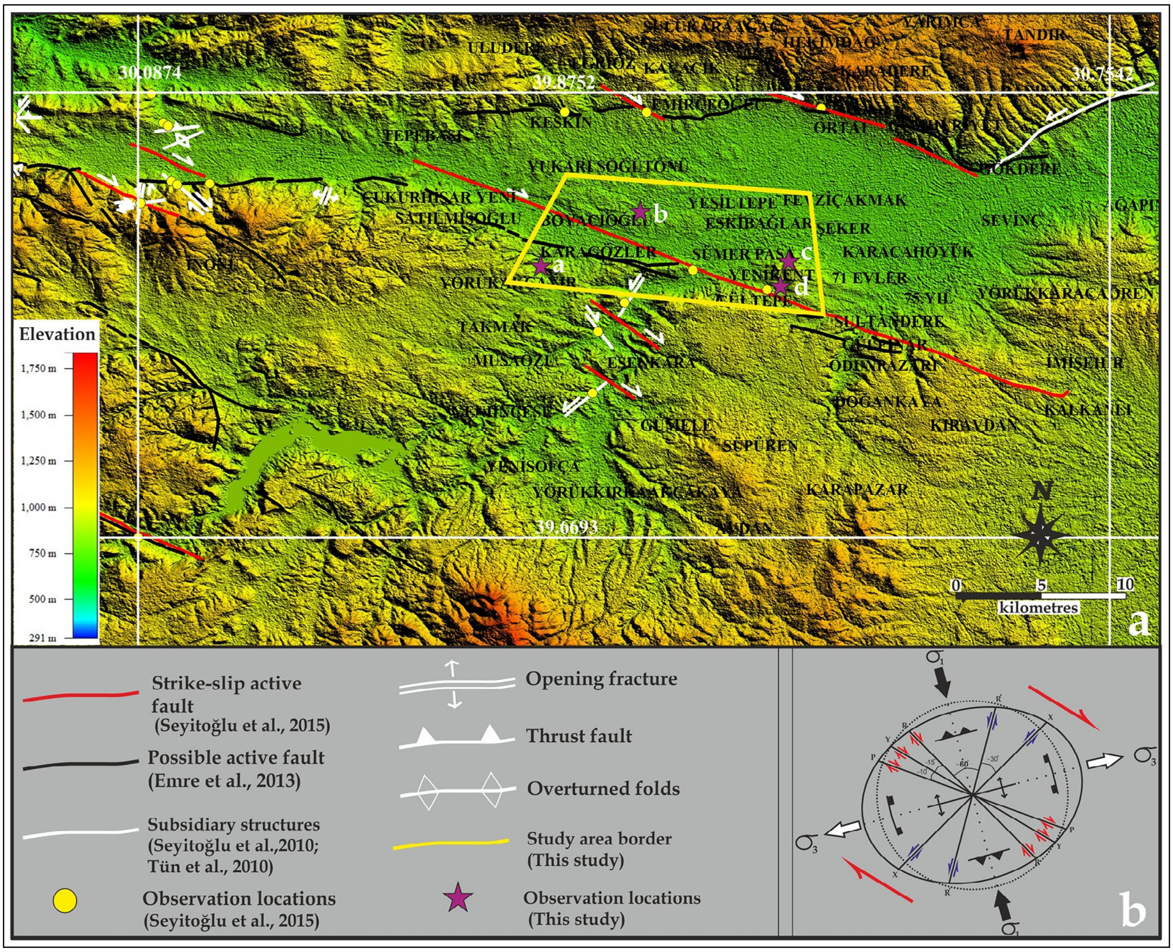

Figure 6-a) Structural geology map of Eskişehir region (modified from Seyitoğlu et al., 2015) and b) deformation axes proposed for Eskişehir region (Seyitoğlu et al., 2015).

The main structures likely to occur in simple shear zones (Figure 7) are; Y (corresponding to the main fault), R1 and P fractures that move in the direction of the main fault, and R2 and X fractures that move in opposite direction with the main fault. The internal friction angle (Φ) determines the geometry of the secondary faults with the main fault. Riedel shears (R1) develop at an angle of approximately Φ/2 with the main fault, while the opposite Riedel shears (R2) develop at an angle of approximately 90- Φ/2 with the main fault. When, Φ is considered to be approximately 300-400; then R1 fractures are expected to develop with the main fault at angles of 150-200, and R2 fractures at angles of 750-700 (Tchalenko and Ambraseys, 1970; Sylvester, 1988). The P fractures develop as symmetrical forms of R1 fractures with respect to the main fault (Woodcock, 1986).

It is sporadically possible to observe the traces of structures developed by NNW-SSE directional compressional and ENE-WSW directional extensional mechanism on the field in Eskişehir region. Approximately, at 1 km southeast of the Yusuflar district (Figure 8a), the presence of fracture sets varying from N30W to E-W are remarked in the green marl-limestone (Figure 8b) units (Figure 8c). The absence of opening in carbonate fillings in E-W extending fractures in the stratigraphically older green marl unit from these two units of which their ages are regarded as Miocene (Figure 8d) shows that the tectonic activity forming the sets in this direction does not continue today.

In observations made in clayey carbonate deposits and the overlying older alluvial units in the vicinity of the Çamlıca district (Figure 9a), (Figure 9b); the direction of opening fractures observed in light yellow-beige colored, medium strength, clay and carbonate containing unit varies between N30W / N-S (rotation measurement was performed in 21 fractures) (Figure

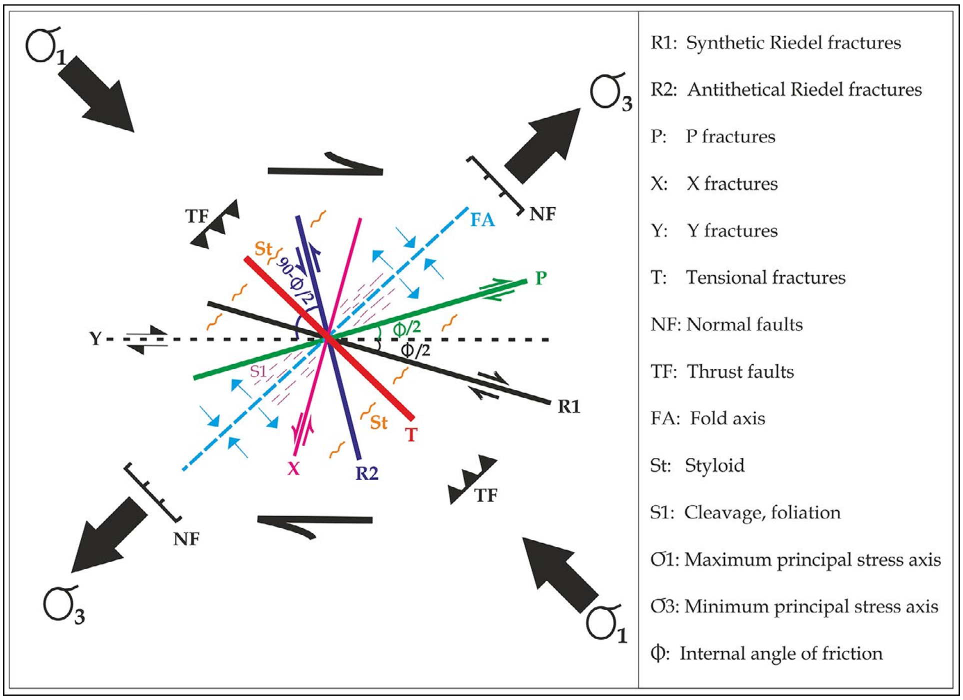

Figure 7- Possible structures likely to occur in simple shear zones (Harding, 1974; Bartlett et al., 1981; Hancock, 1985)

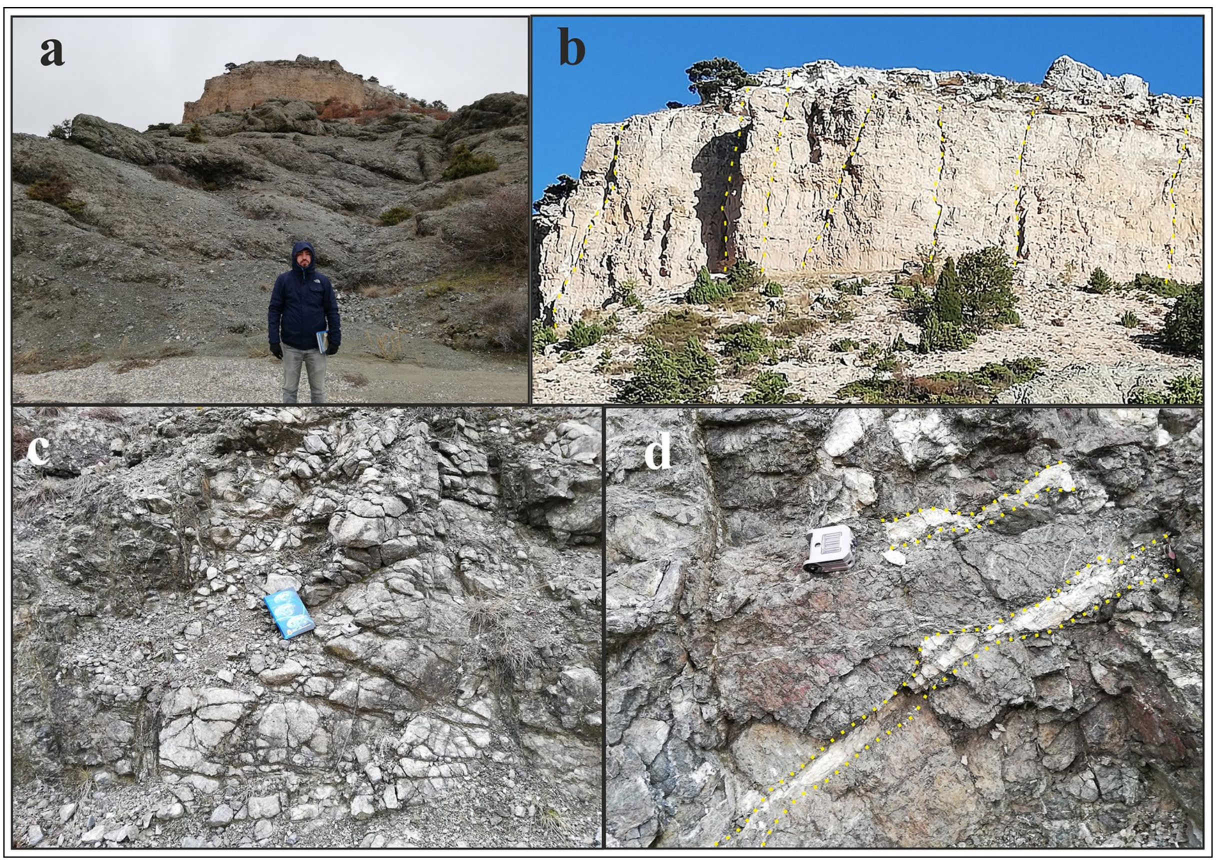

Figure 8- a) Green marl and limestone units showing traces of crustal deformation around the Yusuflar district, b) E-W trending fractures in the limestone unit, c) N30W / E-W fractures in the green marl unit and d) E-W trending, carbonate-filled fractures in the green marl unit (location: see Figure 6a: a, look direction of photos: ENE).

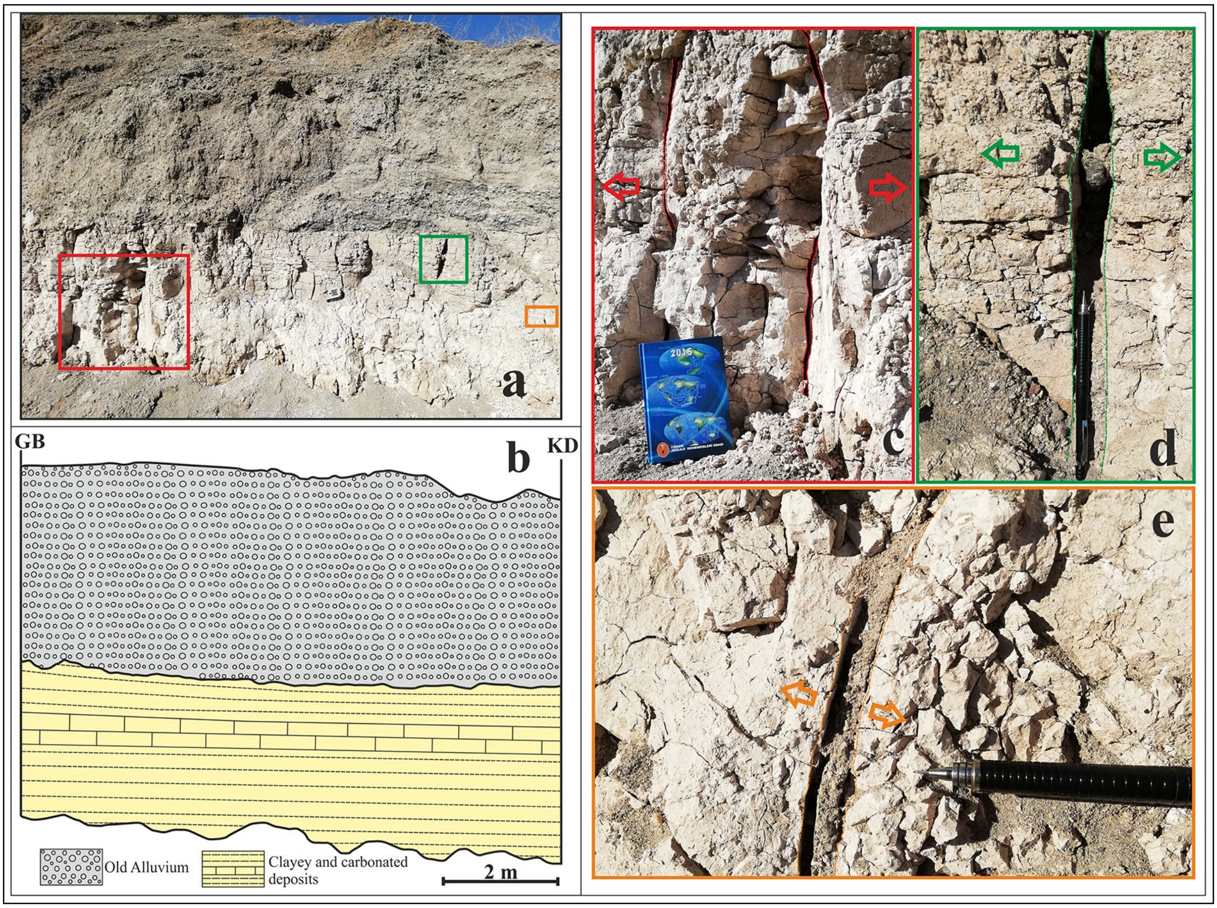

Figure 9- a) The older alluvium which overlies clayey and carbonated sediments in the vicinity of Çamlıca district, b) the stratigraphic relationship of clayey carbonate sediments and older alluvial units, c) opening fractures developed in N30W direction, d) opening fractures that developed in N-S direction and e) opening cracks developed in E-W direction and bear more center fill compared to other fractures (location: see Figure 6a: b, look direction of photos: NE).

9c) and forms systematic fracture sets. These sets can be observed in an area of approximately 20 km^2. The fact that the central opening in fracture systems are clearly observed, which developed in N20W/N-S directional interval (Figure 9d) and the openings are not completely covered with alluvial fill, indicate that the tectonic activity in the region continues to date. In addition to the indicated directions, the E-W trending fractures in the region (rotation measurement was made in 4 fractures) are also observed (Figure 9e).

The separation of Miocene clay and carbonate bearing sediments and Miocene conglomerates with a N40W/78SW directional plane (Figures 10a and 10b) contains field data related to probable faulting on surfaces observed around the Karapınar district. The fault related surfaces are also observed in the area between Büyükdere and Ihlamurkent districts, where EFZ is not continuous. To the east of the plane, which cut NE dipping, medium compacted clay, conglomerate and sandstone alternation with a strike of N10W/82NE, there is observed a different lithology, which is red-dark pink colored, poor to medium compacted, clay-silt grain sized and bear carbonate fillings in places (Figures 10c and d). The geometry on this surface (the cross cutting relationship, the appearance of units in different lithologies, the clays observed on the plane and no significant fall or rise in the topography) point out to a probable strike-slip fault mechanism. There is not observed enough field data to determine the types of F1 and F2 fault planes. F1 and F2 planes, which are assessed on the right lateral shear zone proposed for Eskişehir (Seyitoğlu et al., 2015) (Figure 11a), correspond to R/ and the geometry of Riedel shears, respectively. However, whether these planes cut the Quaternary can be considered as a matter of discussion (Figure 11b).

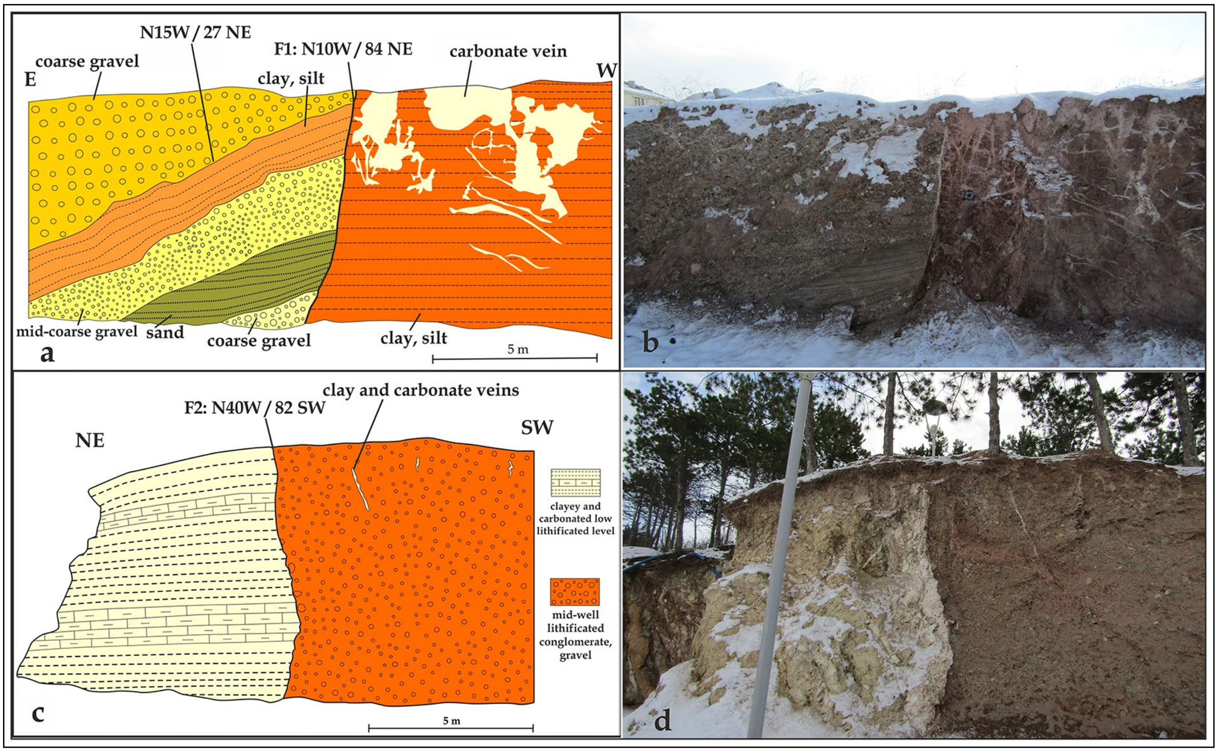

Figure 10- a) Plane with a dip direction of N10W in south of Çankaya district (F1) and its relationship with geological units, b) the field photograph of F1 plane; look direction: S, c) N40W directing plane (F2) and its relationship with geological units around Karapınar district and d) the field photo of F2 plane; look direction: EES (Location see Figure 6a: d and c).

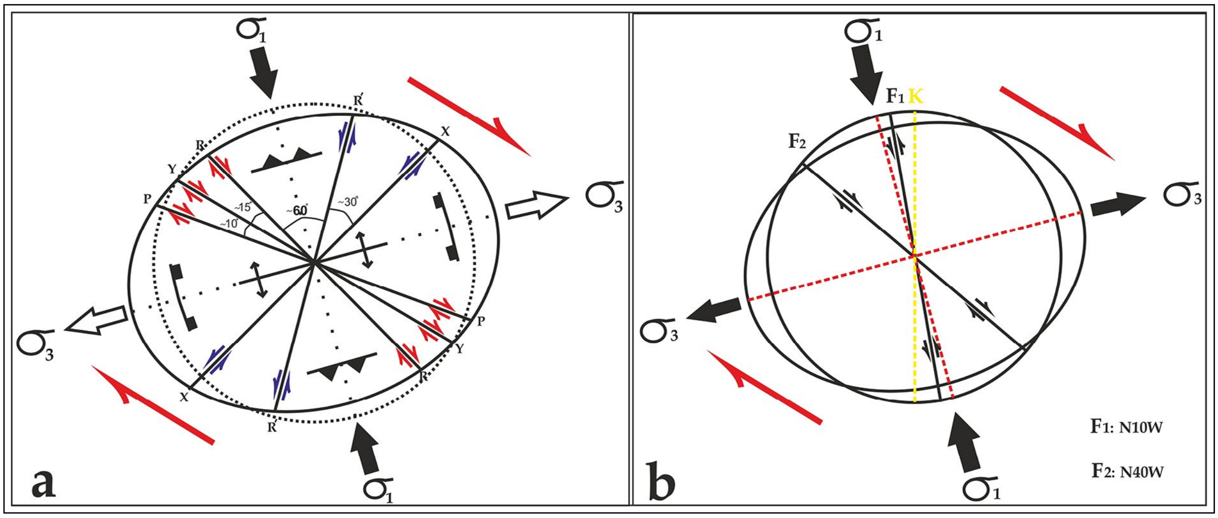

Figure 11- a) Right lateral strike-slip shear zone (Seyitoğlu et al., 2015) that shapes Eskişehir surround and b) locations of F1 and F2 planes which shape the region in the shear zone.

4. Discussions

There is not observed any consensus on the stratigraphic relations of Miocene units and the Miocene-Pliocene transition in the central-south region of Eskişehir. When geological maps in the literature are examined; the distribution of the Miocene conglomerate (Orhan et al., 2007; Ocakoğlu, 2007) and Pliocene limestone (Şengüler and Izladı, 2013; Usta and Kutluk, 2014) units in the region in Akarbaşı-Alanönü districts and in the vicinity of Çankaya-Göztepe districts located at further south seems to be open to discussion. In order to present new findings to the general geology of the region, the field studies were carried out using classical methods in an area of approximately 10 km^2 which is bordered by Akarbaşı and Göztepe districts in the northwest and Yenikent and Çankaya districts in the southeast. The ages of units in field studies were taken as reference from Gözler et al. (1996).

The oldest unit in the identified region is composed of red colored, medium-well cemented Miocene conglomerates which sporadically crop out between Yenikent and Karapınar districts. The conglomerates are unconformably overlain by the carbonate bearing clayey sediments. As going towards south at higher latitudes through a line formed between Karapınar and Çankaya districts, it is possible to see the transitions of pale yellow-beige, medium-strength clayey-limestone that overly the carbonate bearing clay level and the beige-white well-strength limestone that overly the clayey limestone level (Figure 12).

Data obtained from field observations indicate the fault mechanism between Karapınar and Akarbaşı districts during Miocene. These are the presence of conglomerate pebbles cemented by clayey-limestone unit in the northeast of the Yenikent district (Figure 13a), the horizontal transition from conglomerate to clayey-limestone (Figure 13b), the separation of conglomerate and carbonate clay units with a N40W/78SW (Figure 13c) and the fact that this plane does not cut the younger limestone levels at higher elevations (Figure 13d).

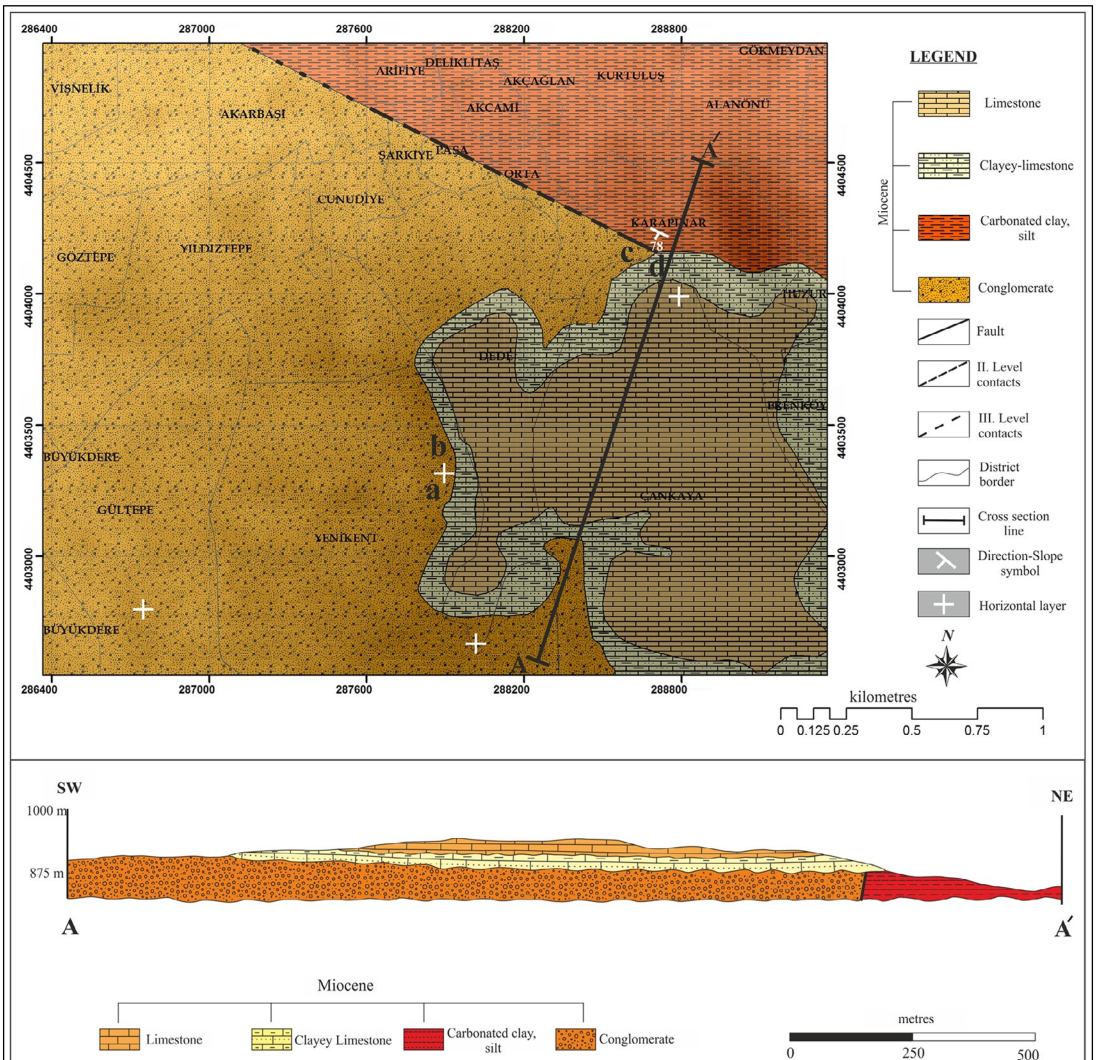

Figure 12- Geological map of the Eskişehir central-south and the geological cross section of the study area.

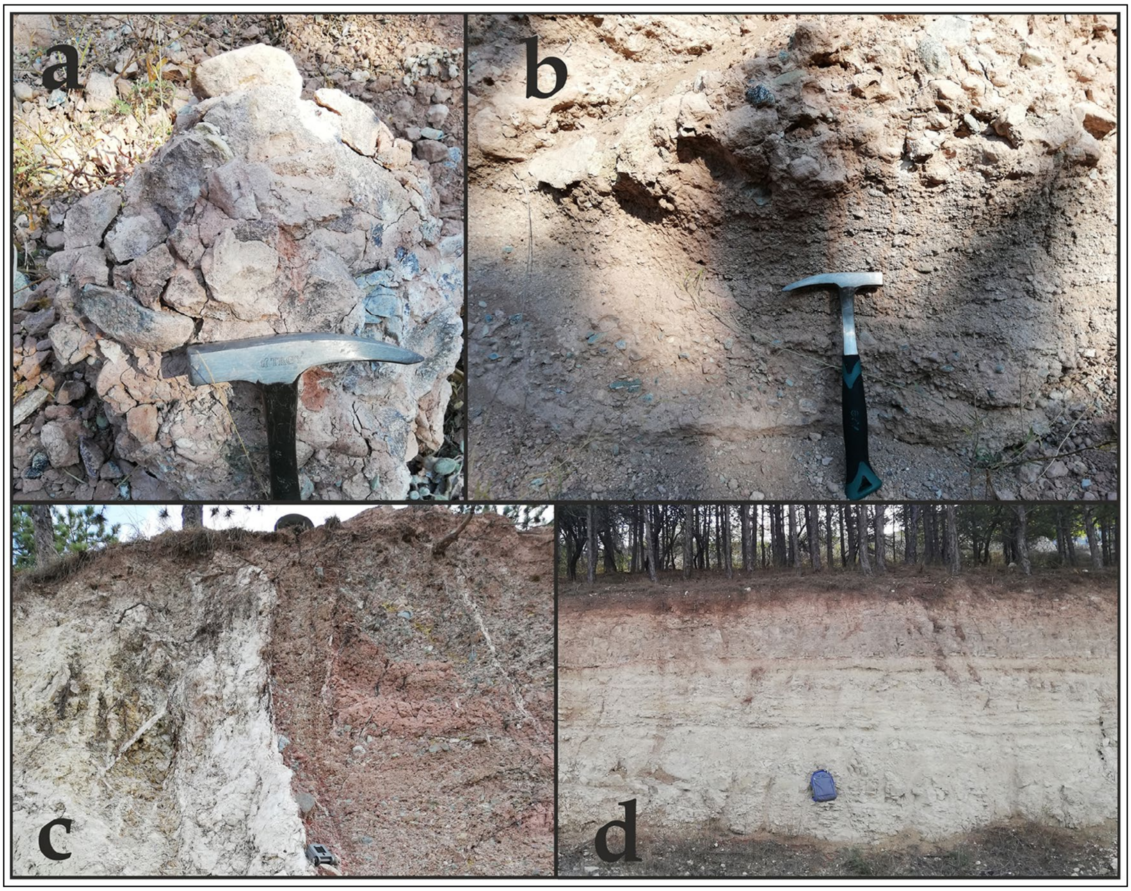

Figure 13- a) Clay and carbonate cemented conglomerate pebbles, b) clayey limestone which unconformably overlies pebble-conglomerates, c) conglomerate and clayey-carbonated units with an angle of 78° between them and d) clayey limestones that have no traces of fault (Location: see figure 12).

5. Conclusion

Total of 44 water drilling points, which were distributed to various regions of Eskişehir province and opened by DSI, were transferred to GIS environment. The analyses of points transferred to the GIS environment were carried out on the transverse geological cross sections. As a result of analyzes carried out by general geological principles (lateral continuity, cross cutting relationship, law of superposition), it is observed that there is no stratigraphic and geological consensus in an area of approximately 10 km^2 restricted by Akarbaşı and Göztepe districts in the northwest and Yenikent and Çankaya districts in the southeast. The studies in this area were carried out with the principle of transferring the classical geological mapping methods to GIS environment. As a result of completed field and GIS studies, the stratigraphic relationships of Miocene units in the study area were evaluated through field data. The carbonate-bearing clay levels deposited on conglomerate and the clayey limestone and limestone levels deposited on them, respectively, can be observed in the field. The horizontal transitional contact between the conglomerate-clayey limestone levels observed in the vicinity of Yenikent district, to be cut in the direction of N40W with dip amount of 78° in the Karapınar district (close to vertical) is the characteristic of field data for a fault that may develop at this point. Although the mentioned plane conforms to the proposed Riedel shear geometry for the region, the current activity of this plane could not be determined from field data due to the absence of Quaternary units in the region. In the Eskişehir region, where neotectonic activity is thought to be shaped by the effect of right lateral shear zone, the structural traces of this activity have been investigated by field studies. The opening cracks observed in Quaternary units in N-S direction around Çamlıca-Batıkent districts and the planes having the geometry compatible with the R and R' planes developed on the Vadişehir-Ihlamurkent-Karapınar line support the right lateral strike-slip shear model proposed for the neotectonic activity of the Eskişehir region.

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