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Geological properties of Güney formation (Ereğli - Ulukışla Basin, Niğde)

Ayfer ÖZDEMİR[a,b*] and Nurettin SONEL[c]

[a]*Helmholtz Centre for Enviromental Research, UFZ Department of Computational Landscape Ecology, 04318, Leipzig, Germany*
[b]*Ministry of Agriculture and Forestry, General Directorate of Water Management, Flood and Drought Department, 06560, Ankara, Turkey*
[c]*Ankara University, Faculty of Engineering, Department of Geological Engineering, Ankara, Turkey*

Research Article

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Ereğli - Ulukışla Basin, Güney Formation, Sandstone, Sedimantology, Stratigraphy, Petrography.

ABSTRACT

The aim of this study to determine stratigraphic, sedimentological and petrographic characteristics of the Upper Paleocene - Lower Eocene Güney formation in the Ereğli - Ulukışla Basin based on the lithological and environmental interpretations related to petroleum source and reservoir rock properties of it. For this purpose, the geological characteristics of the Güney formation and its relations with other units were followed by field observations and the unit was investigated by making a stratigraphic cross section from bottom to top. In addition, during the field studies, four (4) scaled stratigraphic sections (OSK) were formed and fifty - two (52) sandstone samples were taken from these OSKs. The Güney formation starts with conglomerates at the basement and continues as sandstone - shale alternation. The fact that the sand size material is more than the clay size material, the sandstone layers are thick (at least 2 m) around the Kardeşgediği station, the presence of channel fillings, slump structures, and pebbles indicate that the sequence shows convergent turbidite character. However, in the vicinity of Ovacık - Güney village and Tatlıpınar ridges, shales having an average layer thickness of 30 cm (thick) and sandstones up to 3 - 5 cm (thin) and shales are denser than sandstones show the formation has divergent character. The Güney formation transitions laterally and vertically overlies the agglomerate unit of the Ulukışla formation and turbiditic sandstone - shale units of the Halkapınar formation. The Aktoprak formation passes laterally and vertically over the Formation. Petrographic studies show that the formation sandstones are lithic arenite and feldspathic arenite and are deposited in the fore - arc basin.

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1. Introduction

The study area is located in the Ereğli - Ulukışla basin, between Ulukışla (Niğde) and Bor (Niğde) districts and İmrahor (Ulukışla) village (Figure 1). The outcrops in the Ereğli - Ulukışla basin have been investigated by many researchers in terms of stratigraphic, sedimentological and structural features. (Okay, 1955; Ketin and Akarsu, 1965; Demirtaşlı et al., 1973; Yoldaş, 1973; Baş et al., 1986; Nazik and Gökçen, 1989, 1992; Gürbüz et al., 2020; Akgün et al., 2020). The geology and petroleum possibilities assessment studies conducted in the Ereğli - Ulukışla basin show that there may be hydrocarbon formation in this basin (Dellaloğlu and Aksu, 1986; Sonel and Sarı, 2004). The Güney formation is transitional in a lateral direction with the Hasangazi formation, which is petroleum source rock and has been proven to be hydrocarbon (Sonel and Sarı, 2004). Although the Güney formation shows petroleum bedrock and reservoir rock characteristics; until now, the lithological features of the formation have not been studied in

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**Corresponding author: Ayfer ÖZDEMİR, ozdemir.ayfer@gmail.com*

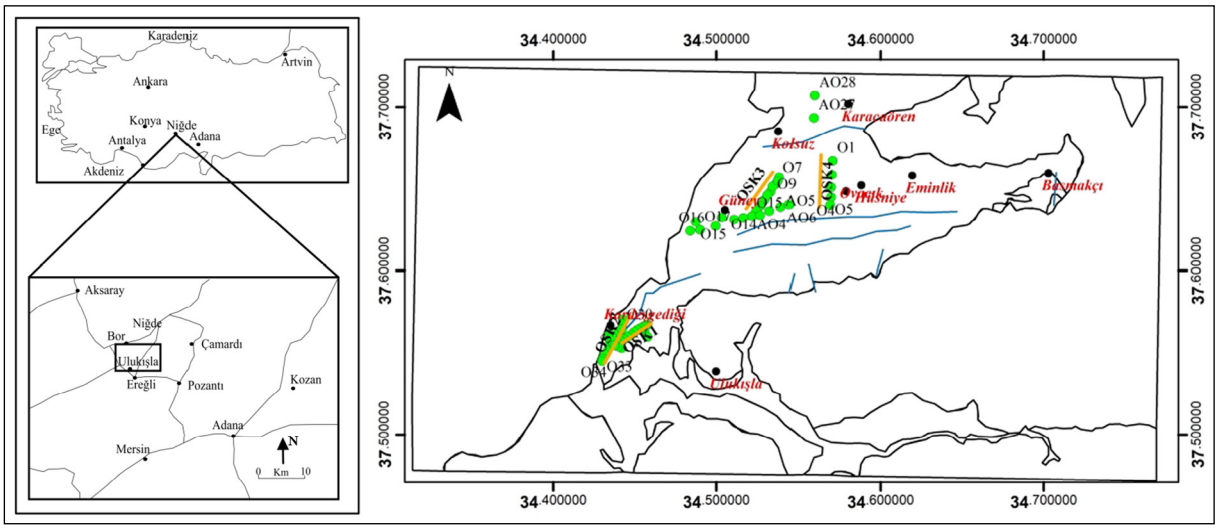

Figure 1- Study area location and sampling map.

detail from a geological perspective. The unit studied as the Güney formation was named Ovacık formation by Dellaloğlu and Aksu (1986) and Güney formation by Oktay (1982). The name given by Oktay (1982) was used because the place where the formation was best observed the Güney village in Ulukışla district. Oktay (1982) studied the Güney formation for the first time at the formation level. The researcher stated that the Güney formation was deposited by turbid currents and that the depositional environment of the formation was inside the volcanic island arc and the deep pits located around it and the slopes connecting the pits to the volcanic islands. In this study, the Early - Middle Eocene aged Serenkaya formation, which was examined within the Ulukışla group by Oktay (1982), was included in the Güney formation and examined as the basal levels of the Güney formation. The Serenkaya formation with the volcanics of the Ulukışla formation forms the transitional facies of the deep marine sediments of the Ovacık formation. In addition, the regions where Serenkaya formation is common are capable of forming reservoir rock for gas. The Ovacık formation contains deep marine shales and thin turbiditic sandstone bands. The areas where the channel fillings on the upper parts of the turbidite fan show reservoir rock features (Dellaloğlu and Aksu, 1986).

In this study, the stratigraphic, sedimentological, and petrographic properties of the Güney formation based on lithological and geological setting interpretations were investigated since the Güney formation shows petroleum source rock and reservoir rock properties. The units named and studied as the Serenkaya formation and Ovacık formation in previous studies were evaluated under the name of Güney formation in this study and the geological characteristics of the Güney formation were investigated by field studies and petrographic investigations.

2. Material and Method

Field and laboratory studies were conducted to determine the geological features of the Late Paleocene - Early Eocene Güney formation. The geological characteristics of the formation and its relations with other units were followed by field observations and the unit was investigated by making a stratigraphic section from bottom to top. In addition, four (4) measured stratigraphic sections (ÖSK) were prepared during the field studies and fifty - two (52) sandstone samples were taken from these ÖSK's. ÖSK study was carried out on the canal fillings surfacing at the Kardeşgediği Station of the Early - Middle Eocene aged Serenkaya formation which was stated to be in the Ulukışla group and the sandstone-shale facies where the typical section location of the Güney by Oktay (1982). Formation located in Tatlıpınar ridges. In addition, ÖSK study was carried out on the sandstone - shale unit defined as Ovacık formation by Dellaloğlu and Aksu (1986) in the north of Ovacık village. In order to define the petrographic characteristics of the sandstones, thin sections were made from fifty - two (52) hand samples (Figure 1) taken from the field and petrographic analyzes (grain

size, roundness, sorting, contact relationship, cement type and porosity type) were made under the optical microscope. Samples were defined according to Folk et al. (1970) classification. Source areas of the Güney formation were determined according to Dickinson et al. (1983). Petrographic examinations were carried out in Ankara University Faculty of Engineering Department of Geological Engineering.

3. Stratigraphy

Ereğli - Ulukışla Basin contains the different origins of geological units (Figures 2, 3). Sedimentary units started to form after ophiolite settlement in the Late Cretaceous period in the basin. The formation of these units took place continuously in the Late Cretaceous - Miocene time interval. The units filling the basin are clastic sediments, volcano - sedimentary units, carbonates, and evaporitic sediments. Lithofacies variations in horizontal and vertical directions are very common between units. In particular, there are lithofacies changes in lateral and vertical directions between Ulukışla, Halkapınar, Hasangazi and Güney formations (Sonel and Sarı, 2004). In order to better understand the stratigraphy of the Güney formation, which is the subject of this study, the stratigraphic characteristics of the formation and it`s under and above units are as follows.

3.1. Ulukışla Formation (KTu)

The formation was described by Demirtaşlı et al. (1973). The majority of the Ulukışla formation consists of agglomerate, andesitic lava flows, tuffs, tuffites and volcanic breccias, pillow lavas. All this volcanic material is interbedded with turbiditic sandstone, shear deposits and rarely limestone and shale.

According to Oktay (1982), The Ulukışla group forms the basis of the Ereğli - Ulukışla region. In this group, it is stated that there are shallow - deep sea sediments, undersea volcanics and dykes or shallow intrusions which have entered them from time to time. The researcher divided the Ulukışla group into Sansartepe formation, Serenkaya formation, Başmakçı limestone, Cehritepe syenite, Köyderesi trachyte, Karatepe limestone, Güney formation, Tayhacı andesite and Dikmendere trachytes.

The contact of the unit with the Halkapınar formation is transitive in lateral and vertical directions. The Ulukışla formation also displays a strong lateral and vertical transition with the Hasangazi formation and Güney formation. Due to the complex magmatic - sedimentary relationships of the formation, the thickness of the formation could not be determined. Its age is thought to be Late Cretaceous - Middle Eocene (Sonel and Sarı, 2004).

3.2. Halkapınar Formation (Th)

The formation was first named by Demirtaşlı et al. (1973). Halkapınar formation, which covers a large area, is the Paleocene - Early Eocene base of the Ereğli - Ulukışla Basin; It consists of marl, ophiolitic olistostrome, and generally Triassic limestone olistoliths including sandstone and agglomerates and syphilitic basalt lava interlayers.

Halkapınar formation covers the Kalkankaya formation concordantly. Halkapınar formation is laterally transitive to the west with Güneydağı formation and is located on the Güneydağı formation in the west of the region. Ulukışla formation is laterally and vertically transitive with Halkapınar formation.

3.3. Hasangazi Formation (Thz)

The unit was named as Koçak f ormation by Ketin and Akarsu (1965) and as Hasangazi formation by Demirtaşlı et al. (1973). Demirtaşlı et al. (1973) studied the formation by dividing it into three members. The formation is the Middle - Late Eocene age. It has a wide distribution and presents typical flysch facies feature in most places. It also contains canal fillings with massive, thick, sandstone - conglomerate lithology. Strong lithofacies changes are observed in the formation both in the lateral and vertical directions. The lateral continuity of sandstone and channel fill is not much. Very thin bedded sandstone - shale alternation in some places shows a flysch type lithology and a mechanism formed by turbiditic flows.

3.4. Güney Formation (Tgü)

Güney formation was named as Ovacık formation by Dellaloğlu and Aksu (1986) and as Güney formation by Oktay (1982). Oktay's (1982) nomenclature is used in this study because the place where the formation is best developed is the Güney village of Ulukışla district. The Early - Middle Eocene Serenkaya formation, which was included in the Ulukışla group by Oktay (1982), was included in the

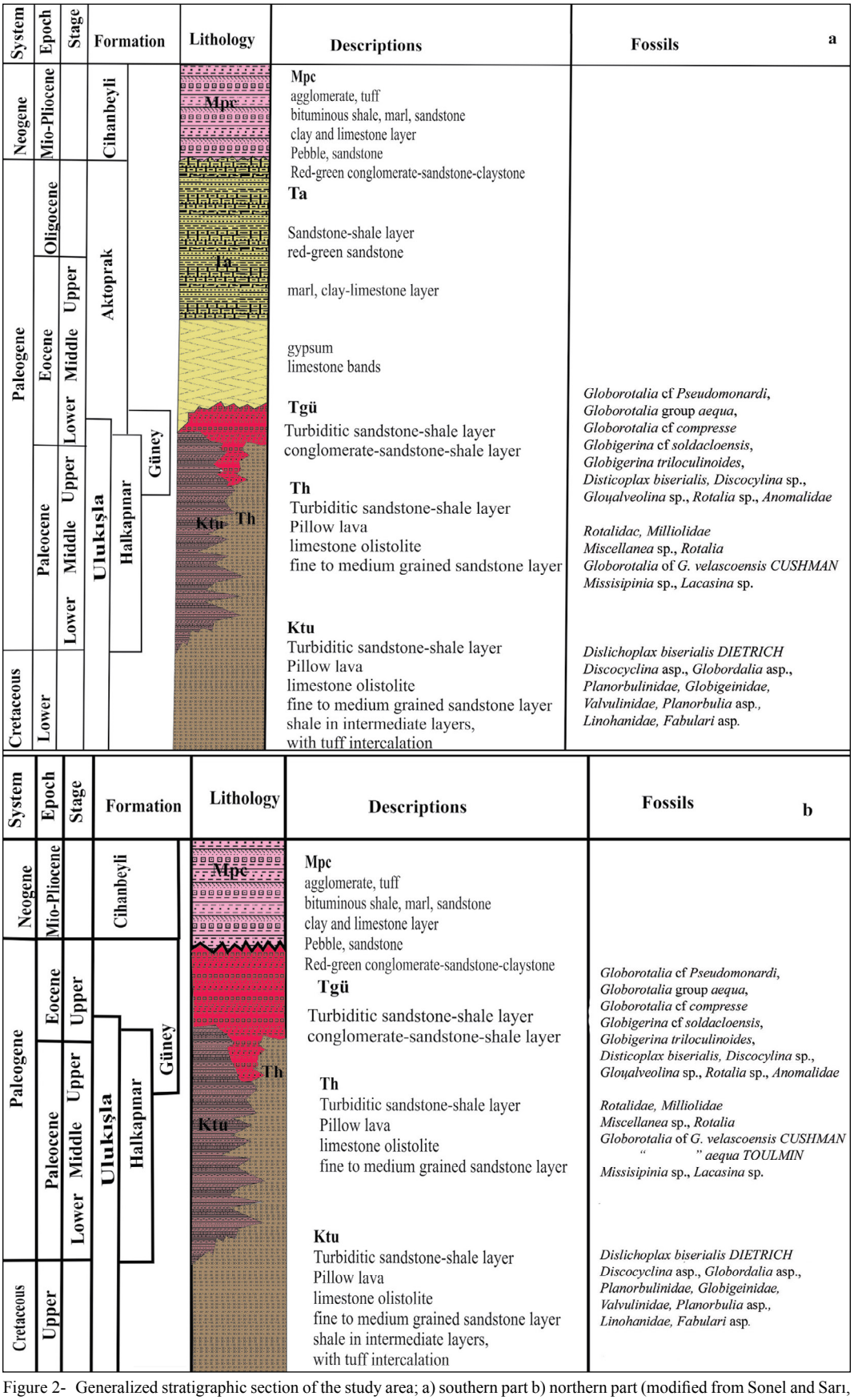

Figure 2- Generalized stratigraphic section of the study area; a) southern part b) northern part (modified from Sonel and Sarı, 2004).

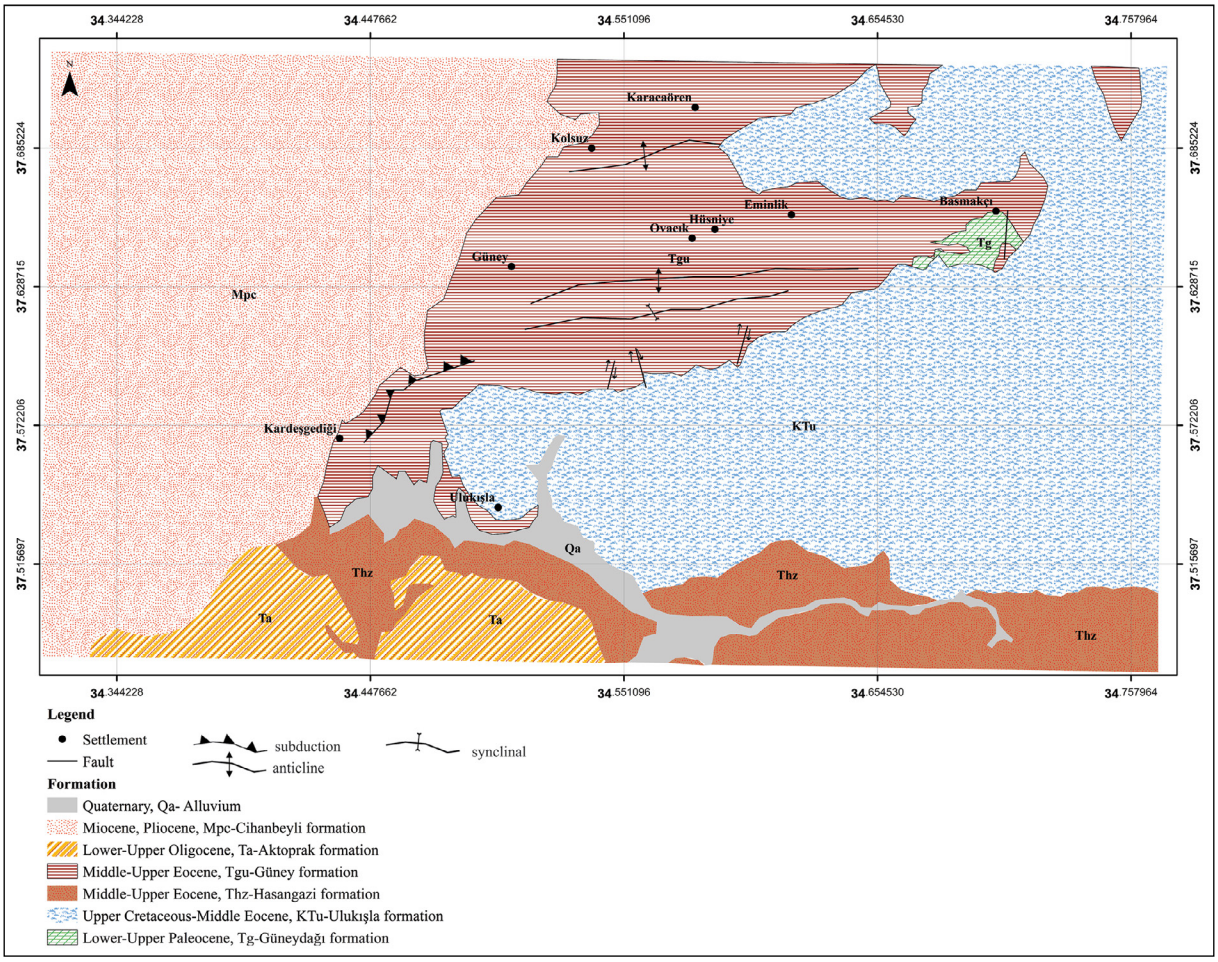

Figure 3- Geological map of the study area (modified from Sonel and Sarı, 2004).

Güney formation in this study, it was studied as the base levels of the Güney formation. It is observed in different facies and ages in typical location and southeast of Ulukışla (Oktay, 1982). Güney formation in typical location, it is composed of lenticular and blocky coarse conglomerate at the bottom and cyclically deposited and graded bedded conglomerate - sandstone - shale sequence at the top. The formation shows great variations in lithology and thickness. The Güney formation consists of a 365 m sandstone-conglomerate sequence around Ulukışla. It consists of a sandstone - conglomerate - shale sequence predominantly 90 m around Porsuk village in the east of Ulukışla and 160 m in the east of Çaykavak pass (on the Ulukışla - Niğde road). The unit is generally developed as a sequence of gray - coarse sandstone and shale and shows a thickness of approximately 800 m. In the north of Ulukışla, all of the material of the Güney formation is derived from volcanic and shallow intrusive type igneous and mostly consists of conglomerates. When the formation is evaluated considering Bouma (1964) turbidite environment interpretation; It is understood that the depth of the depositional environment differs from north to south and is generally deposited by turbiditic flows. Graded stratified channel fillings, shear deposits, and turbiditic sandstone alternations are common in the upper levels of the sequence. The lenticularity, large - scale cross - bedding and lateral rapid lithological changes observed in the coarse - grained clastics especially in the lower part of the sequence indicate a rapid deposition in shallow marine conditions. The change in the thickness and density of the sandstone - shale layers in the upper parts, the erosive - channeled formation of the conglomerate - sandstone - shale sequences in the transition towards each other and the presence of large cavity fill structures, the presence of graded bedding as the common internal structure, and the local sliding structures, the shallow marine deposition conditions over time indicates that the

environment is changing and the environment is deepening. Sandstone and shale densities are equal towards the north in the study area. The lower parts of the stack contain canal fillings. In this area, sandstone density is high, sandstone grains become coarse and shale density decreases. Therefore, the sequence shows convergent turbiditic character in this region.

In the study area, it is laterally and vertically transitive with the Güney formation, the Ulukışla formation and the Halkapınar formation. In the south of Ulukışla, the Güney formation is not encountered, in this area, the Hasangazi formation, which is the same age as the Güney formation, was deposited. The Aktoprak formation transitions laterally and vertically with the Hasangazi formation and the Güney formation and deposited on these units. The Miocene - Pliocene age Cihanbeyli formation sits unconformably over the Aktoprak formation in the south of the study area and on the Güney formation in the north. As a result of the nanoplankton biostratigraphy study conducted by Sınacı (2006) in Güney formation; determined *Discoaster multiradiatus* Zone (Tanesian), *Heliolithus ridelii* Zone (Tanesian), *Heliolithus kleinpellii* Zone (Late Selandian - Early Tanesian), *Fasciculithus tympaniformis* Zone (Late Selandian) Late Paleocene and *Tribrachiatus contortus* Zone (Late Eocene). Therefore, the age of the unit has been determined as Late Paleocene - Early Eocene.

3.5. Aktoprak Formation (Ta)

The formation consisting of evaporite and clastic was first named as Aktoprak formation by Demirtaşlı et al. (1973). The unit defined by Dellaloğlu and Aksu (1986) as Aktoprak is also the gypsiferous series defined by Blumental (1956) and corresponds to the Yalçındere, Emirler, Kurtulmuştepe and Kızılöz formations defined by Ketin and Akarsu (1965). The unit was divided by Demirtaşlı et al. (1973) into the Kurtulmuştepe member consisting of alternation of marl, clayey limestone, sandstone, and a red - green sandstone member. Oktay (1982) defined the unit as Zeyvegediği anhydrite and Kurtulmuştepe Formation. Gypsiferous - anhydrite units called Zeyvegediği anhydrites were shown within the Kabaktepe member of the Hasangazi formation by Demirtaşlı et al. (1973). The formation continues as anhydrites at the base and marl - clayey sandstone alternation upwards and consists of red - green sandstones at the top. The Aktoprak formation covers the Hasangazi formation conformably in the south and southwest of Ulukışla. The unit is not seen in the west and north of Ulukışla. The Güney formation, which is the same age as the Hasangazi formation, comes with lateral and vertical transitions in this region. On the other hand, young sediments of the Miocene - Pliocene age Cihanbeyli formation unconformably cover all units in the region. The age of the unit is Late Eocene - Oligocene (Demirtaşlı et al., 1973).

3.6. Cihanbeyli Formation (MPc)

The formation is named by Dellaloğlu - Aksu (1986). It overlies other old formations with an angular unconformity. It has a wide distribution over the units of both Ereğli - Ulukışla Basin and Tuz Gölü Basin. It starts with the alternation of red - green conglomerate - sandstone - claystone at the base. It then continues as conglomerate - sandstone alternation, consisting of clayey limestone, tuff, agglomerate and lava. The sediments forming the formation mainly consist of stream and lake units. It also contains uneconomic lignite veins and volcanic intercalations. There are bituminous levels with less thickness in some parts of the unit (Sonel et al., 1999). Grain size decreases towards the top and passes into marl and clayey limestones. Large - scale cross - stratification in the formation and lensing in clastics indicate the fluvial environment, while limestone and bituminous marls indicate the presence of a lacustrine environment. The age of the formation is Mio - Pliocene (Dellaloğlu and Aksu, 1986). Some researchers evaluated this unit under the name of Altaylar, Ulukışla, Beştepeler in formation degree (Oktay, 1982).

4. Findings

The Güney formation was measured at different locations in the research area and field observations were made on the sediments. Field observations and measured section data are as follows:

4.1. ÖSK - 1, 2: Kardeşgediği Station

ÖSK - 1 and ÖSK - 2 studies were carried out in the area between 37° 55’ - 37° 57’ north latitude and 34° 43’ - 34° 44’ east longitude around Kardeşgediği station and at an altitude of 1466 m. In this area, lithology is observed in the form of alternation of sandstone - shale - conglomerate - shale. The

sandstone unit is observed in two different lithologies. Fine - grained brown sandstones overlie the coarse - grained green sandstones. The layer thickness and grain size of the sandstones increase in the south - north direction. Green colored sandstones are fed from volcanic material and generally contain serpentine and orthoclase minerals. Coarse - grained pebble - sized serpentine, radiolarite and basalt fragments are observed in the light brown colored sandstone unit. The dark green shale unit with thin lamination lies on top of the sandstone unit. The layer thicknesses of shales vary from thick to thin. As one goes towards the east, the slopes decrease and they become closer to the horizontal. Sandstone shale alternation creates a small scale slump structure, sandstones are dark gray, and shales are dark green - blackish. Conglomerate consists of coarse and blocky at the bottom, lenticular graded at the top, more or less rounded, large and small basalt, andesite, serpentine grains. The lower parts of the conglomerates are serpentine, and the upper parts are basalt. Dark gray (almost black) shales are observed between sandstone - conglomerate units. There is a groove filling structure between the conglomerates and shales overlying the shale unit. Light colored sandstones are layered together with igneous rock composition conglomerates. The diameter of the grain sizes in conglomerates is about 10 - 15 cm and this size decreases to 2 - 3 cm in the west direction. Therefore, the grain size varies from east to west and conglomerates are channel fill (Figure 4). The measured stratigraphic section made in the study area is shown in Figure 5.

According to the petrographic examinations made on thin sections of 20 samples taken from this area (samples between Ö23 and Ö43); light brown in color; The grain size of the fine grained sandstone samples varies between 0.6 - 2.8 mm and the average grain size is 1.6 mm. The cement type between grains is about 4% clay cement and the porosity type is intergranular. Light brown fine grained sandstones, except for Ö29 sample, are moderately sorted and slightly rounded. In the sample Ö29, the sandstones are well sorted and rounded, the grain size varies between 0.2 and 1.2 mm. In this example, the clay cement content is 8%.

Particle size varies between 0.3 and 5.2 mm in samples taken from sandstones containing light green

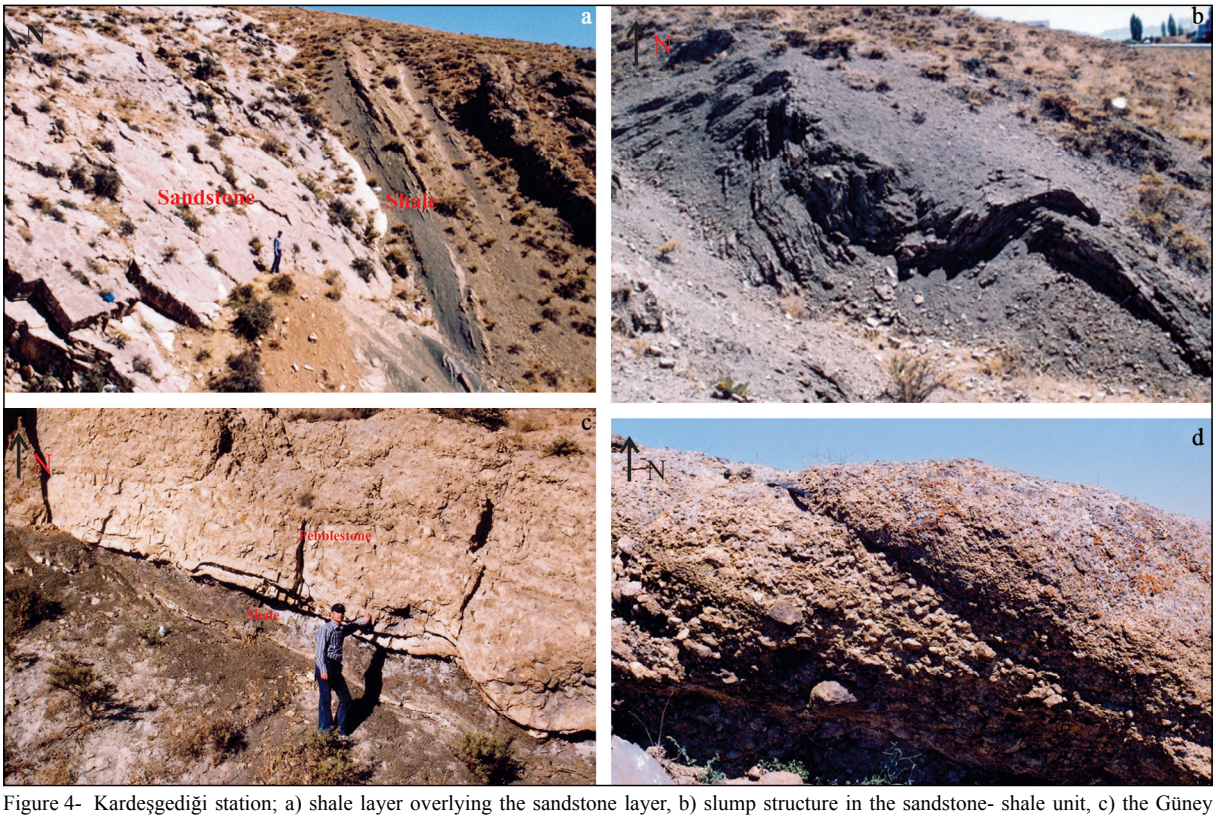

Figure 4- Kardeşgediği station; a) shale layer overlying the sandstone layer, b) slump structure in the sandstone- shale unit, c) the Güney formation channel fill, groove fill structure between two units, d) Güney formation channel fill, normal grading in east - west direction in conglomerates (Özdemir, 2006).

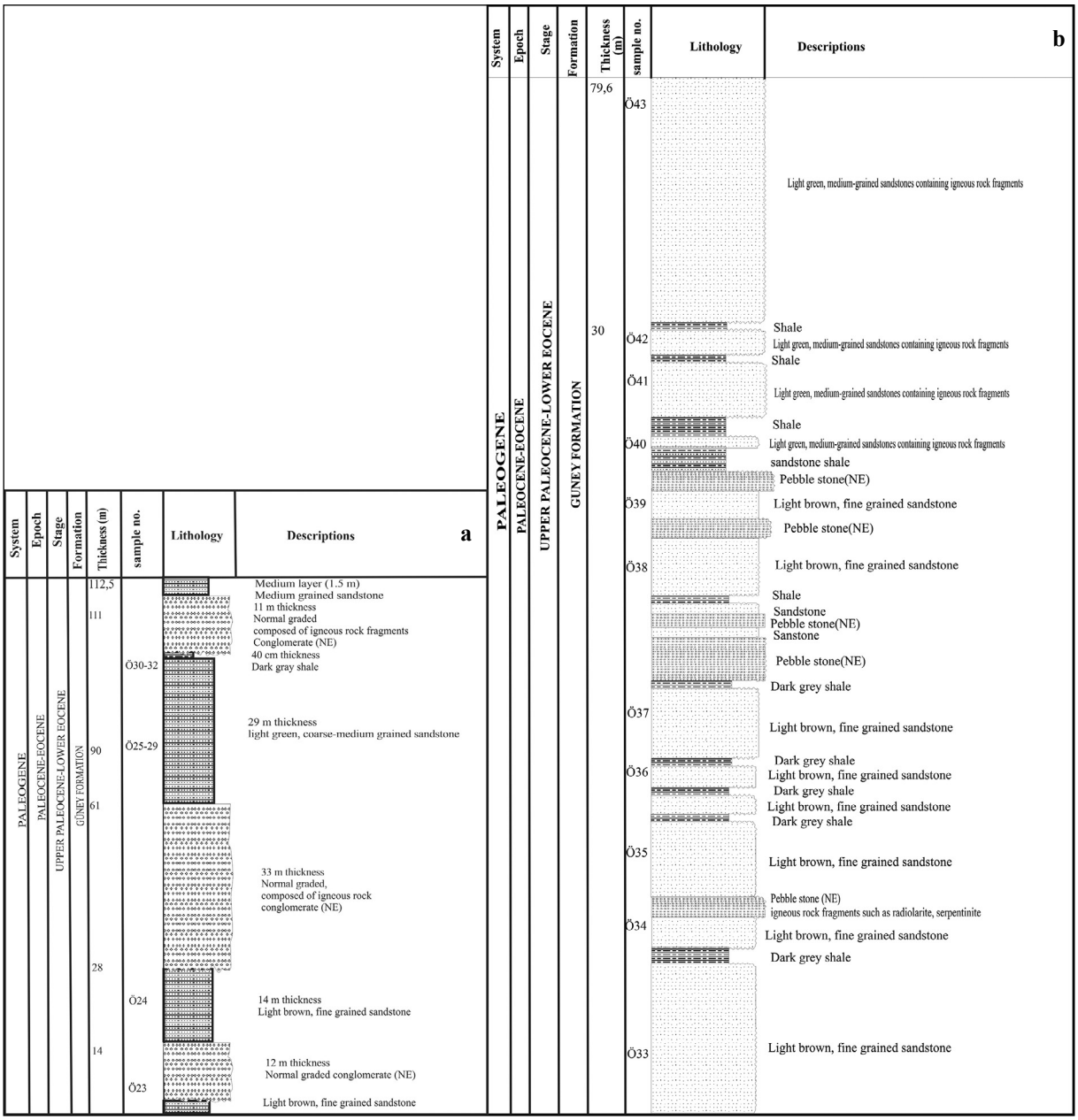

Figure 5- a) Around the Kardeşgediği station: measured stratigrapfic section of the Güney formation (ÖSK - 1), b) south of the Kardeşgediği station: measured stratigraphic section of the Güney formation (ÖSK - 1) (Özdemir, 2006).

medium - grained igneous rock fragments. Sandstones are slightly rounded and medium - poor graded. The samples contain approximately 4% clay cement. The contact relationship between sandstone grains is tangential and the type of porosity is intergranular.

As a result of field observations, OSK studies and petrographic investigations in this area, sand size material is more than clay size, sandstones are slightly rounded and medium - poorly graded, fine - medium grained sandstone layers are thick (at least 2 m), channel fillings, slip (slump) structures and the presence of conglomerates indicate a shallow marine sedimentation environment, indicating that the sequence has convergent turbidite character.

4.2. Around Hantepe

A field study was conducted in the area around Hantepe between 37° 57’ north latitude and 34° 47’ east longitude. In this area, light green, thin laminated shales are observed, and light green shales transition

into light - brown - beige shales. Shale dominance is quite higher compared to sandstones. The upper surfaces of the shales are altered. The transition of thin - bedded shales, which are brown due to ironoxidation, to a light green - colored thick - bedded state indicates the regime change. At the contact between the Güney formation and the Ulukışla formation, the slope of the shales is almost vertical and striking NE. Thickness decreases from bottom to top. The shales of the Güney formation transitions laterally to the agglomerates of the Ulukışla formation. Agglomerates are composed of matrix - supported volcanic material of very coarse size, generally consisting of basalt and andesite grains (Figure 6).

4.3. Near Karalar Station

A field study was conducted in the area around Karalar Station between 37° 62' north latitude and 34°48' east longitude. Sandstones observed in the

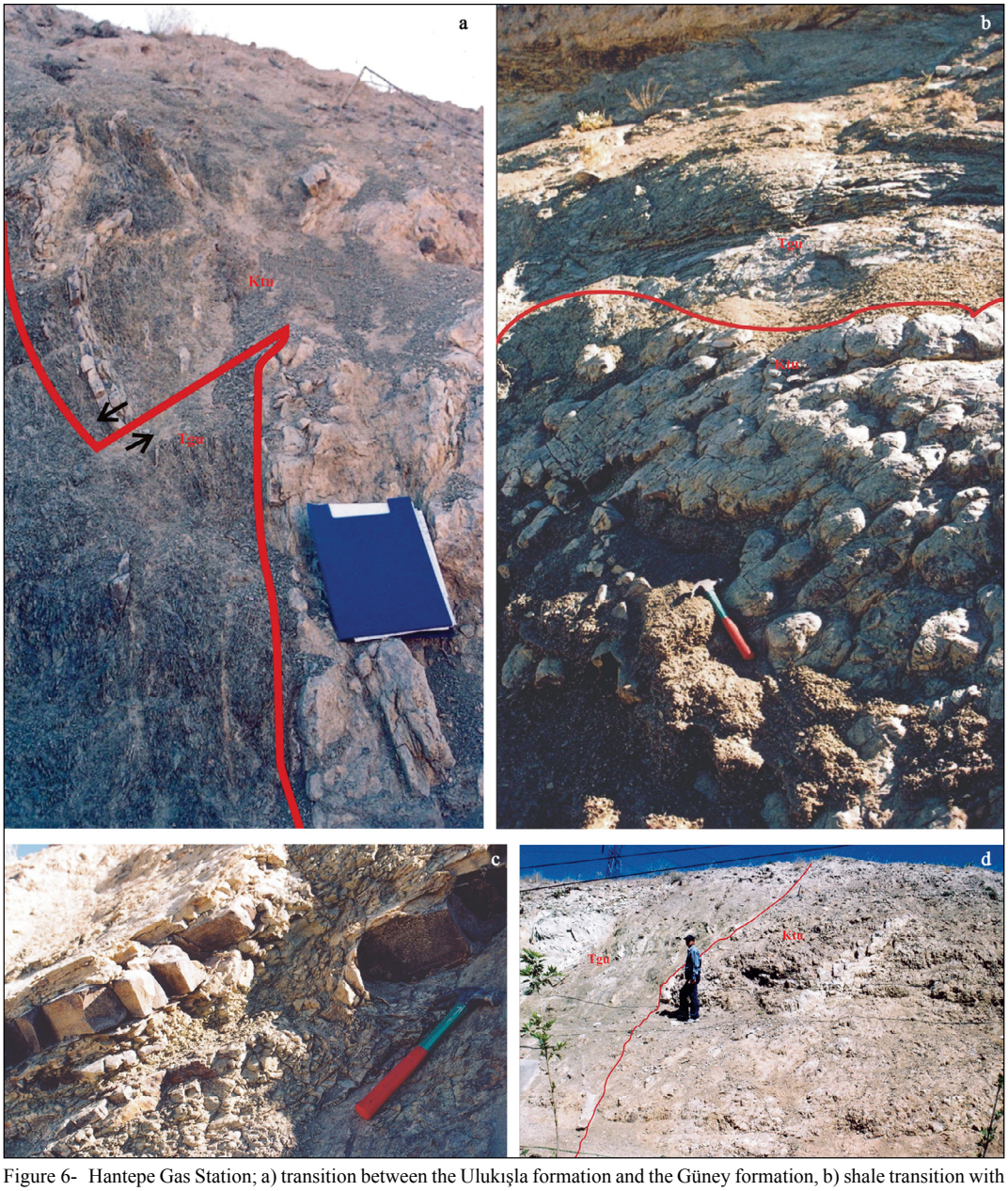

Figure 6- Hantepe Gas Station; a) transition between the Ulukışla formation and the Güney formation, b) shale transition with agglomerate unit at the contact between the Ulukışla formation and the Güney formation, c) close view of shales, d) chale transition with agglomerate unit at the contact between the Ulukışla formation and the Güney formation (KTu: Ulukışla formation, Tgü: Güney formation) (Özdemir, 2006).

area are very fragile, light brown in color, fine grained and their upper surfaces are red - brown due to iron oxidation. Mica and calcite grains are observed in the sandstones. Sandstone layer thicknesses vary from south to north from a thin layer to a thick layer. This thickness difference in the bedding shows the regime change during the storage of sandstones. The depositional environment of the sandstones becomes shallow from south to north.

In the petrographic examinations made on samples Ö16 and Ö17 taken from this area, sandstone sample Ö16 has a grain size between 0.4 and 1.2 mm and shows a slightly rounded medium degree of grading. In this example, the sandstone grains show tangential contact relationship, and the cement type between the grains is clay and is about 12%. Sandstone sample Ö17 has sandstone grain size between 0.2 and 1.2, well sorted and rounded. In this example, the contact relationship between sandstone grains is complete and the clay cement content is 8%. Intergranular pore type was determined in both samples. The Cihanbeyli formation unconformably overlies the Güney formation in the west of the region (Figure 7).

4.4. ÖSK - 3: Tatlıpınar Ridges

ÖSK - 3 study was carried out in the area between 37° 63' - 37° 66' north latitudes and 34° 52' - 34° 54' east longitudes on the hills of Güney village Tatlıpınar, at an altitude of 1523 m. This measured cross-section is on the Güney Village road 2 km inland from the Adana - Niğde Road and Hüsniye junction. An alternation of green shale and brown sandstone is observed in this region. Shale layer density is higher than sandstone layer density. Shale layers are very thinly laminated, sandstones are cracked and brittle as a result of alteration. Calcite veins are seen between the layers. The layer thickness of the shales is 30 cm on average, and the thickness of the sandstone layers varies from approximately 25 - 30 cm to 3 - 5 cm (Figure 8). Sandstone - shale units have formed syncline - anticline - syncline fold structures from north to south. Ovacık syncline is seen in this area. The measured stratigraphic section of the region is presented in Figure 9. Sandstone samples taken from this area are dark green and dark gray, fine to medium grained. Petrographic studies of sandstone samples between AÖ - 1 and AÖ - 6 show that the sandstone grain sizes vary between 0.1 and 1 mm, and the grains have a slightly rounded, medium graded and the intergranular contact relationship is tangential. In these examples, the intergranular cement type contains clay and is approximately 10%. Sandstone samples between Ö6 and Ö15 have grain sizes varying between 0.2 and 1.4 mm. Sandstone samples except for samples Ö11 and Ö15; medium-poorly sorted and slightly rounded. Samples Ö11 and Ö15 are rounded and well sorted.

Figure 7- Transition between the Cihanbeyli formation and the Güney formation (MPc: Cihanbeyli formation, Tgü: Güney formation) (Özdemir, 2006).

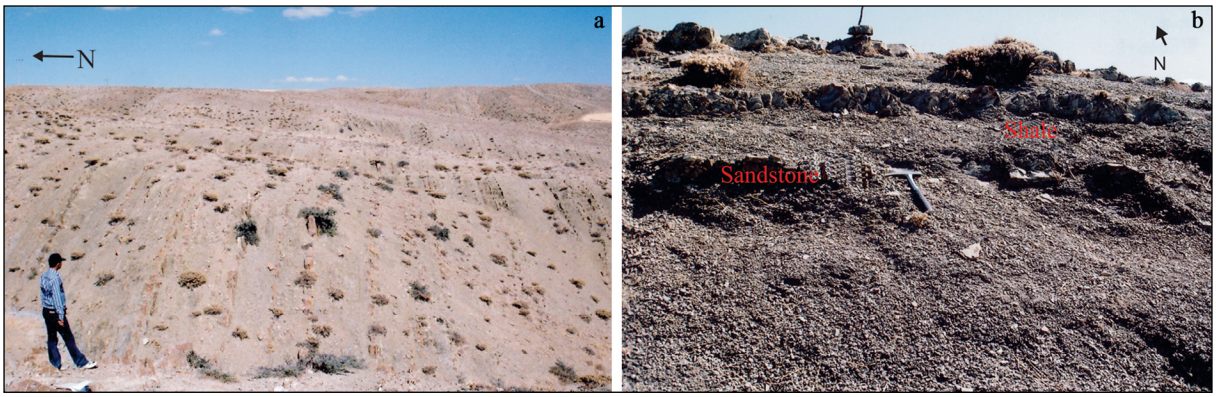

Figure 8- The Güney formation sandstone - shale unit; a) Tatlıpınar ridges, b) North of the Tatlıpınar ridges; sandstone - shale unit close view (Özdemir, 2006).

The clay cement content is lower than other samples and is approximately 4%. Field observations, ÖSK studies, and petrographic investigations in this area show that the deposition environment has deepened and the sequence is divergent turbidite facies.

4.5. ÖSK - 4: Around Ovacık Village

ÖSK - 4 study was carried out in the area between 37° 57' north latitude 34° 47' east longitude around Ovacık Village, at an altitude of 1631 meters. The Güney formation exposed on the slopes in this area consists of sandstone - shale units. Sandstone layers are about 5 cm thick. Shale layers are thicker than sandstone layers. As one goes from the Ovacık village from south to north, the thickness of the sandstone layers increases and the thickness of the shale layers becomes thinner (Figure 10a). This indicates sediment input into the environment together with turbidite currents and indicates that the depositional environment of the unit becomes shallow from south to north. In the north of the area, the transition between Ulukışla formation and Güney formation can be observed (Figure 10b). The measured stratigraphic section made in Ovacık village is shown in Figure 11.

Sandstone grain sizes vary between 0.2 and 1.1 mm in petrographic examinations on sandstone samples taken from this area up to Ö1 - Ö5. Except for the sample Ö5, the sandstones are slightly rounded and medium-poorly sorted. Although samples Ö1 to Ö4 have a clay and iron content of about 10%, the clay cement content of sample Ö5 is about 6%. The pore type of all samples taken from this area is intergranular.

4.6. Adana - Niğde Road

A field study was conducted on the Adana - Niğde road between 37° 69' - 37° 71' north latitudes and 34° 56' east longitudes. Dark brown shale units and light brown sandstone units are observed in this area. The units are in NE direction and their dips are almost vertical. Shales are very fragile, very fine grained, and sandstone units are very hard, thick bedded, coarse grained.

Sandstone - shale - conglomerate units are observed around Taşpınar Gediği, and the slope of these units has increased according to the slope of the units on the previous Adana - Niğde road. There are shale layers between thick bedded, dark gray and medium grained sandstone units. Calcite filling is observed between layers of sandstones. Petrographic studies of sandstone sample AÖ27 taken from this area show that the grain sizes of sandstone varied between 0.5 and 2.2 mm, medium grading, rounded and clay cement content is approximately 10%. The contact relationship between sandstone grains is tangential. In this area, the Cihanbeyli formation comes on the Güney formation. However, the contact border of the Aktoprak formation with the Güney formation is not clear.

Very fine grained, dark gray sandstone and dark gray - blackish shale units are observed at the Karacaören road junction. Sandstone layers are thicker than shale layers. Sandstone thickness decreases towards the upper levels (Figure 12). Petrographic studies on the AÖ28 sample taken from this area show that the grain size of sandstone varied between 0.2 mm and 2.7 mm,

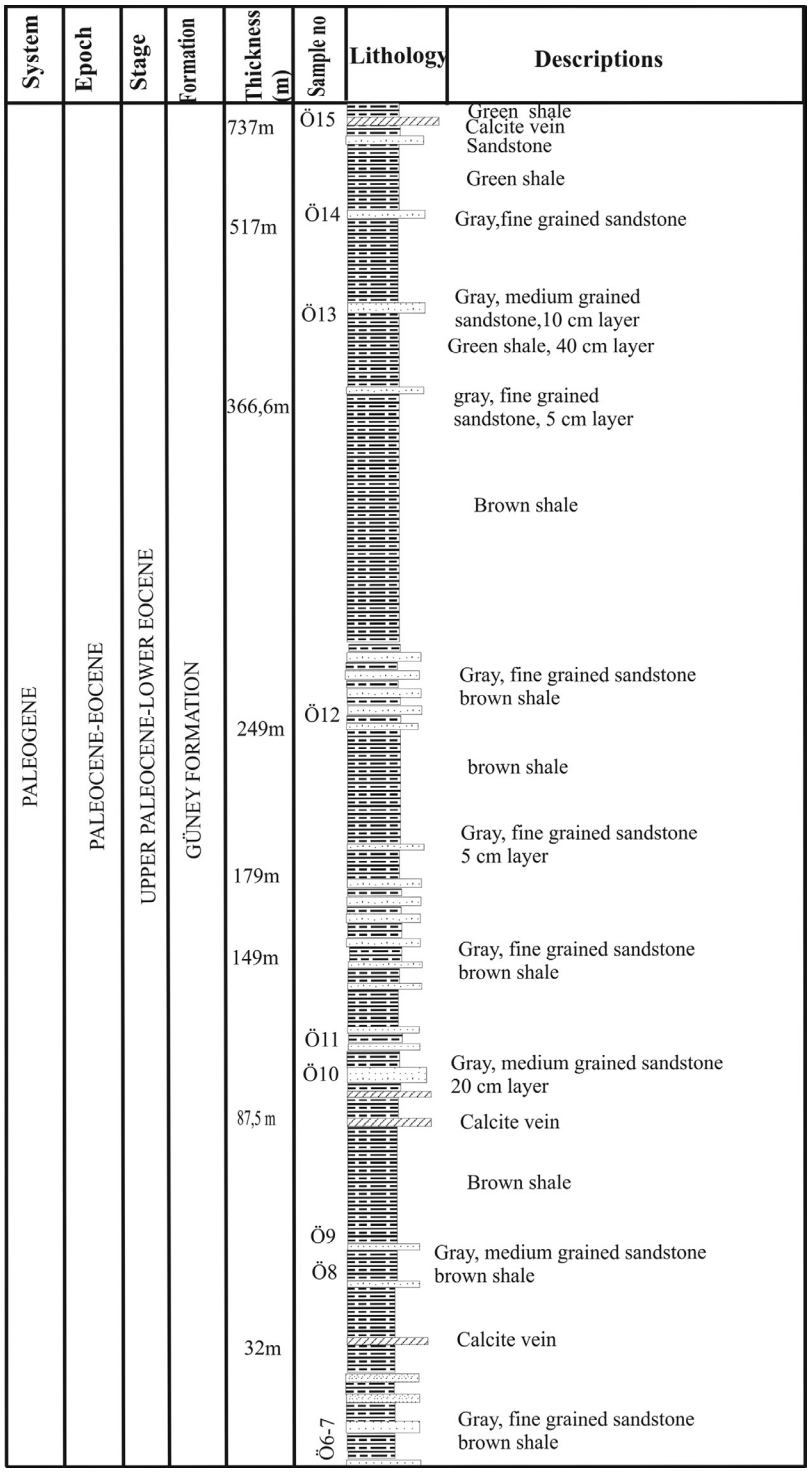

Figure 9- Measured stratigraphic section of Tatlıpınar ridges in the Güney formation (ÖSK - 3) (Özdemir, 2006).

the intergranular contact relationship is tangential, less rolling and medium grading.

The formation shows great variations in lithology and thickness. Lenticularity observed in the coarse - grained clastics in the lower part of the sequence, Large - scale cross - bedding and lateral fast lithological changes indicate a rapid deposition in shallow - deep marine conditions. The change in thickness and density of sandstone - shale layers in the upper parts,

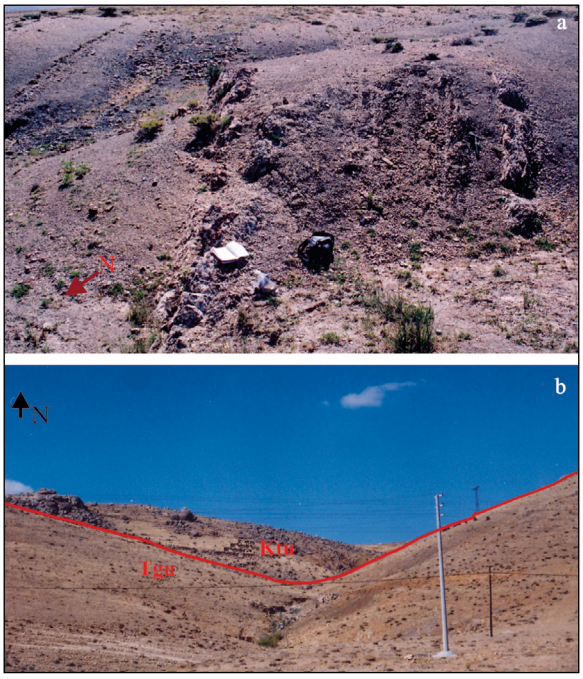

Figure 10- a) Close view of the Güney formation sandstone unit around Ovacık village, b) transition between the Güney formation and the Ulukışla formation (Ktu: Ulukışla formation, Tgü: Güney formation) (Özdemir, 2006).

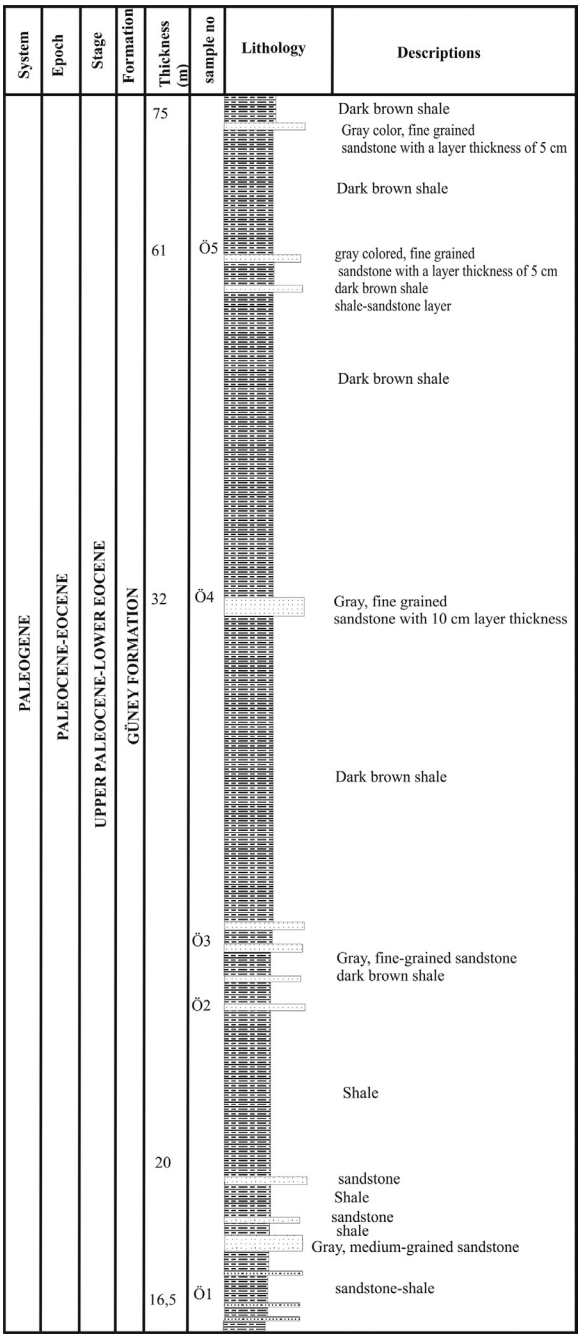

Figure 11- The Güney formation, measured stratigraphic section north of Ovacık village (ÖSK - 3) (Özdemir, 2006).

the erosional - channeled formation of conglomerate-sandstone - shale sequences towards each other and the presence of large hollow fill structures, the presence of gradual bedding as common internal structure and the shallow marine deposition conditions have changed over time, indicates that the environment is getting deeper. The Güney formation consists of a 365 m sandstone - conglomerate sequence around Ulukışla, 90 m thick around Porsuk village in the east of Ulukışla, 160 m sandstone - conglomerate - shale sequence in the east of Çaykavak pass (on the Ulukışla - Niğde road). In the north of Ulukışla, all of the material of the Güney formation is derived from volcanic and shallow intrusive type magmatics and consists mostly of conglomerates. Graded bedded channel fillings, shear deposits, and turbiditic sandstone alternations are common in the upper levels of the sequence.

5. Petrography

Fine sections obtained from fifty - two (52) sandstone hand specimens taken from the formation were petrographically examined under microscope, and their grain size, grain roundness, grading, contact relationship, cement type and porosity type characteristics were determined. The average grain composition was evaluated according to the percentage of feldspar, quartz, rock fragments and secondary mineral content. In petrographical studies, sandstone samples taken from south - north direction in the study area show a grain size distribution from thin to coarse. The sandstones are of medium maturity and medium - poorly sorted texturally. Generally dense textured, partially well sorted, rounded. Matrix generally consists of clay and its content is around

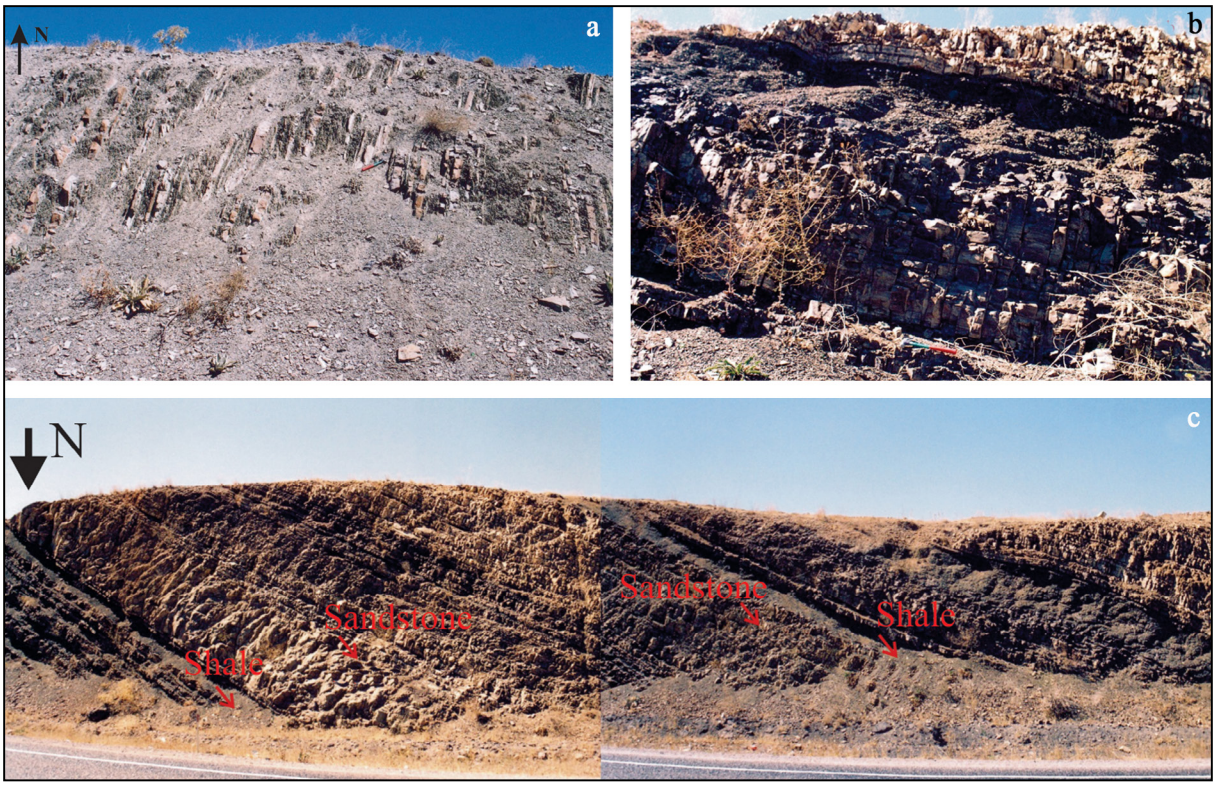

Figure 12- a) Sandstone - shale units of the Adana - Niğde road Güney formation, b) Karacaören road junction, the Güney formation sandstone - shale alternation, c) Karacaören road junction, the Güney formation sandstone - shale alternation (Özdemir, 2006).

10% on average. Clay + Fe matrix content is on average 4%. Iron oxide and carbonate cement were also observed in sandstone thin section samples, and they are found together with clay cement. Tangential growths were observed in quartz grains in sandstone sections (Figure 13).

The Güney formation's average grain composition; Total quartz varies between 11 - 65%, monocrystalline quartz 4 - 45%, polycrystalline quartz 5 - 40%, feldspar 28 - 15%, rock fragments 28 - 85%, secondary mineral content is between 2 and 4%, these are mica and epidote (Table 1). According to the Folk et al. (1970) classification, sandstones are feldspathic lithicarenite and lithicarenite (Figure 14).

6. Source Areas of the Güney formation

Considering the average grain composition of the Güney formation, Dickinson et al. (1983); it occurred in the undissociated arc and regenerated orogenic provenance (Figure 15). According to Dickinson and Suczek (1979), it is between the undivided arc, active island arc and continental crust. Arc ridges are partially eroded. The depositional areas, inside trenches, front of the arc, behind the arc, and local basins in the volcanic belt. These basins indicate that the source area of the Güney formation is an unallocated arc and deposited in front of the arc.

Thrust complexes deform oceanic sediments and lavas, the collision orogen coexists with the continental blocks and the basin in front of the folding - faulting belt. In the arcs in front of the continental block, suture belts occur between the magmatic arc and disappearing arc basins. The regenerated orogenic provenance areas are between trench axes in arc - trench systems and volcanic elevation. Sediments were deposited from the folded - faulting zone towards the fore basin, between the trench and the trench-arc from the thrust complex (Dickinson and Suczek, 1979). The Güney formation, located in the regenerated orogenic provenance resource area, shows that the sandstones were deposited in front of the arc (Figure 16).

An island - arc extending east - west has formed around Ulukışla (Oktay 1982). Ulukışla, Hasangazi and Halkapınar formations were fed from the materials derived from this island arc. These formations formed behind and in front of the island arc (Özdemir, 2006).

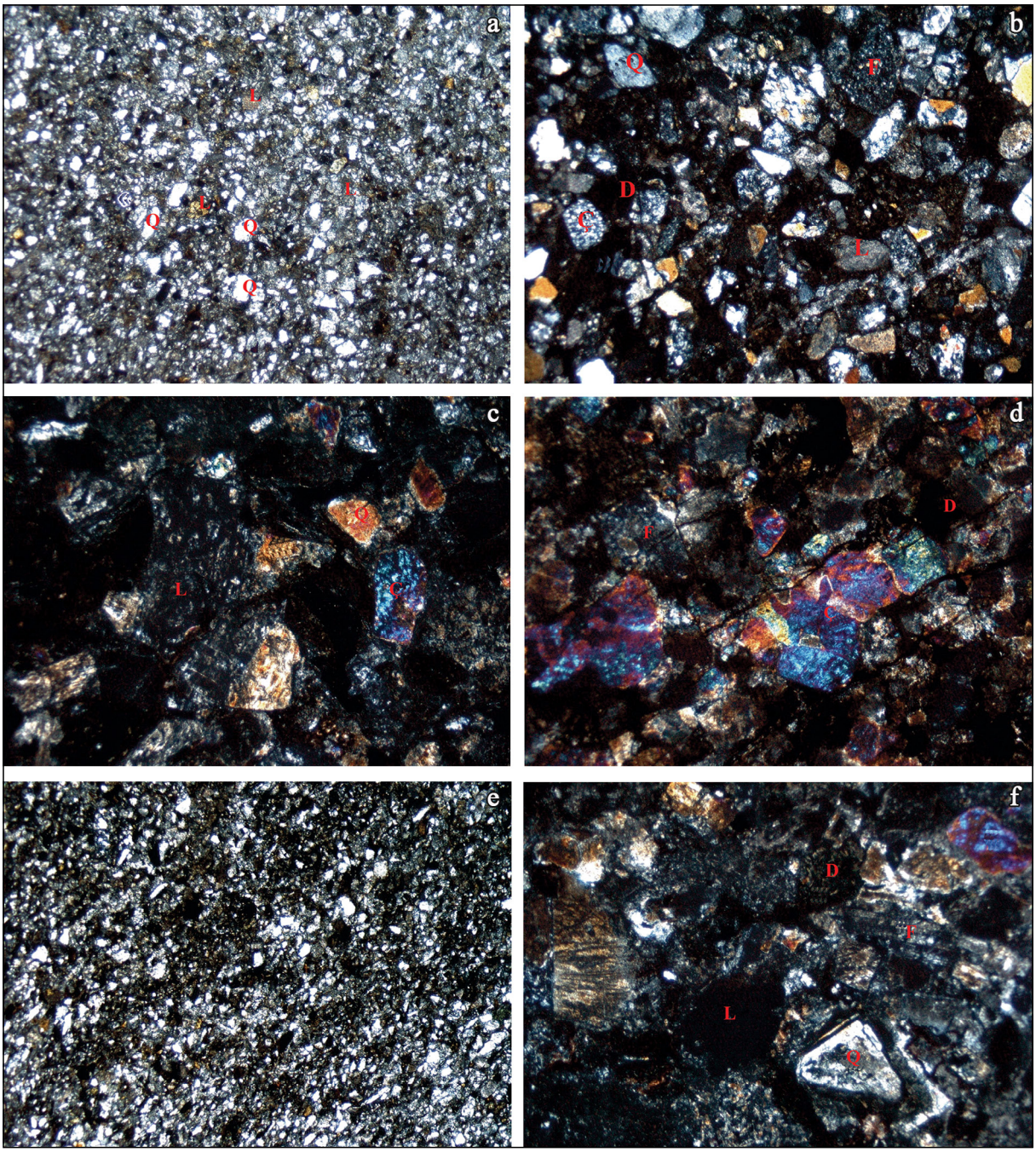

Figure 13- Güney formation sandstone; a) crossed nicols view of thin section of sample Ö5, sandstones are moderately sized and slightly rounded (10X), b) Crossed nicols view of thin section of sample Ö9, sandstones are slightly rounded and medium sorted (10X), c) crossed nicols view of thin section of sample Ö2, sandstones are slightly rounded and poorly sorted (10X), d) sample Ö33, thin section crossed nicols view, sandstones are slightly rounded and poorly sorted (10X), e) Nicol image of sample thin section no Ö5, sandstones rounded and well sorted (10X, f) crossed nicols view of thin section of sample Ö25, tangential growths in quartz grains (10X) (D: iron oxide cement, L: lithic piece, Q: quartz, F: feldspar, Ç: chert) (Özdemir, 2006).

Table 1- Güney formations grain composition (Özdemir, 2006).

Sample No.	%Qt	%Qm	%Qp	%F	%Rock fragments	%Secondary mineral
AÖ-1	60	45	15	8	30	2
AÖ-2	60	45	15	10	30	
AÖ-3	60	45	15	10	30	
AÖ-4	65	50	15	5	28	2
AÖ-5	20	14	6	4	76	
AÖ-6	60	25	30	10	30	
AÖ-7	55	40	15	10	25	
AÖ-8	55	40	15	10	25	
AÖ-9	55	40	15	10	35	
AÖ-10	60	35	25	8	32	
AÖ-11	55	30	40	10	35	
AÖ-12	50	40	10	2	40	
AÖ-15	17	9	8	3	80	
AÖ-16	12	4	8	5	80	
AÖ-17	50	15	35	10	40	
AÖ-18	15	5	10	5	80	
AÖ-19	11	6	5	4	85	
AÖ-20	13	10	8	75	4	
AÖ-21	41	30	11	4	55	
AÖ-22	40	25	15	8	48	4
AÖ-23	45	15	30	5	50	
AÖ-24	50	40	10	10	40	
AÖ-25	30	5	25	5	65	
AÖ-26	30	20	10	15	55	
AÖ-27	60	45	15	10	30	
AÖ-28	60	50	10	8	32	

Sample No.	%Qt	%Qm	%Qp	%F	%Rock fragments	%Secondary mineral
Ö1	55	45	10	10	35	
Ö2	55	45	10	10	35	
Ö3	55	45	10	10	35	
Ö4	55	45	10	10	35	
Ö5	55	45	10	8	35	2
Ö8	60	45	15	10	30	
Ö9	62	40	22	8	30	
Ö10	40	25	15	10	50	
Ö11	40	25	15	10	50	
Ö12	40	25	15	10	50	
Ö15	40	25	15	10	50	
Ö16	20	4	16	5	75	
Ö17	35	30	5	10	55	
Ö22	40	25	15	5	55	
Ö27	30	25	15	10	60	
Ö28	33	18	15	7	60	
Ö29	40	35	5	5	55	
Ö30	30	25	5	10	60	
Ö31	30	25	5	10	60	
Ö32	40	10	6	10	50	
Ö33	40	30	10	8	52	
Ö34	30	25	5	5	65	
Ö35	50	40	10	5	35	
Ö36	50	40	10	5	45	
Ö39	20	13	12	5	75	
Ö40	30	20	10	5	65	
Ö41	20	15	5	5	75	
Ö43	15	10	5	5	80	

7. Discussion

Ketin and Akarsu (1965) and Demirtaşlı et al. (1973) stated that the Ereğli - Ulukışla Basin is in the form of an asymmetrical rift. According to the researchers, the basin burial and rift formation started in the Maestrichtian and Paleocene. In the Late Cretaceous, the function of the subduction zone, which provided ophiolite settlement to the south of the region, ended and a new subduction zone in the basin began to dip towards the north. For this reason, the magmatic function is observed in the basin in the form of submarine volcanism trending east - west in the Late Cretaceous or Early Paleocene. As a result of the submerged plate, its movement throughout the Paleocene, and its partial melting, an island arc developed in an east - west direction around Ulukışla. Some parts of the arc emerged in the form of volcanic islands in the Early Paleocene. These formed two separate belts from Ulukışla to the east, south and north of Eminlik. In the Late Paleocene, especially in the north of the island arc, with the end of magmatism, clastic material started to come from both the islands

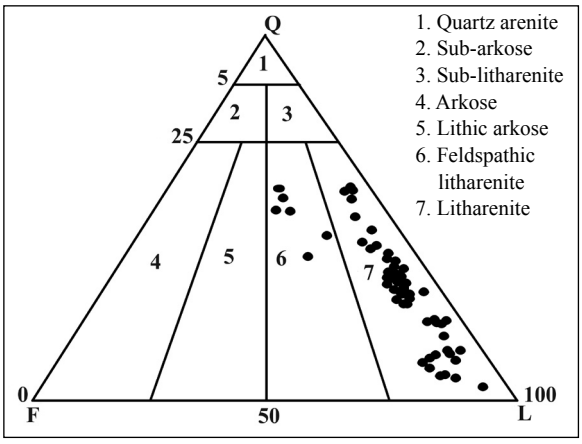

Figure 14- According to Folk et al. (1970) Sandstones Classification (Q - Quartz, F - Feldspar, L - Rock fragment) (Özdemir, 2006).

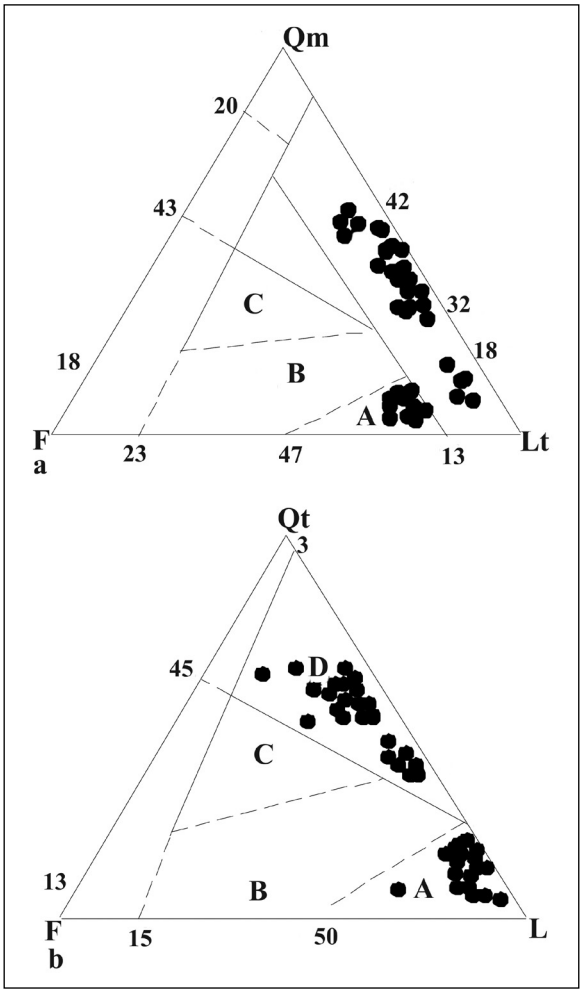

Figure 15- The diagrams which showing the average grain composition of sandstones; a) QmFLt diagram, b) QtFLt diagram (Qm- monocrystalline quartz, Qt- total quartz grains, F - feldspar and Lt - total lithic parts). Provenance (source) areas (Dickinson vd., 1983): A - unallocated arc, B - arc (partially separated). C - separated arc and D - regenerated orogenic provenance (Özdemir, 2006).

above the water and possibly from the western part of the Tuz gölü basin - as well as with turbidite flows. In the Early Eocene, the section north of the island arc of the basin folded into a land. Oktay (1982) stated that this event also caused the end of the volcanic activity in the southern part of the island arc and the Güney formation to begin to deposit, and also stated that the Güney formation was deposited in the deep trenches between Bolkardağı and Ulukışla while the conditions in the region were continuing unchanged in the Middle Eocene. Although Oktay (1982) claims that the depositional environment of the Güney formation is the deep trenches in and around the volcanic island arc and the slopes connecting these trenches to the volcanic islands, as a result of the evaluation made by considering the average grain composition in this study, it is revealed that the deposition environment of the formation is in front of the arc.

Turbidites are observed in two types according to the current density. Sediments formed in high - density flows are generally thicker - bedded, low - graded, coarser - grained, relatively poorly graded, with little internal laminates, and their bottom structures are either undeveloped or slightly developed. Sediments with fine - bedded, fine - grained, well - developed vertical grading and sorting, well - developed laminated, small - scale cross - bedding are formed by the low - density turbid flow. Bouma (1964) divided the ideal layer structure that the regime (energy / power) of a turbid current can create into five structural sections; massive grade gravel (Ta), laminated sand (Tb), cross- laminated sand (Tc), laminated stack (Td), laminated mud (Te). A turbidite stack cannot always have its ideal structure because the energy of each flow is different and the energy is not constant even within the same flow regime. Turbidite deposits accumulated away from the source area (in the direction of the sea) or below the slope are missing from the bottom, Ta; Ta, Tb; Ta is Tb, Tc and Ta, Tb, Tc, Td sections are the missing parts. Top eroded successions are observed as Ta; Ta; Tb; Ta; Tb; Tc, and Ta, Tb, Tc, Td. Tb, Tc, Td, Te; Tc, Td, Te; Td, Te; Te; sections are missing. Such a sequence is a sequence formed by a second turbidite stream eroding a previously deposited turbidite sequence and close to the source of sediment (inland direction). When a complete turbidite sequence is missing from both top and bottom; They are observed as layers missing from the bottom and eroded from the top. These stacks

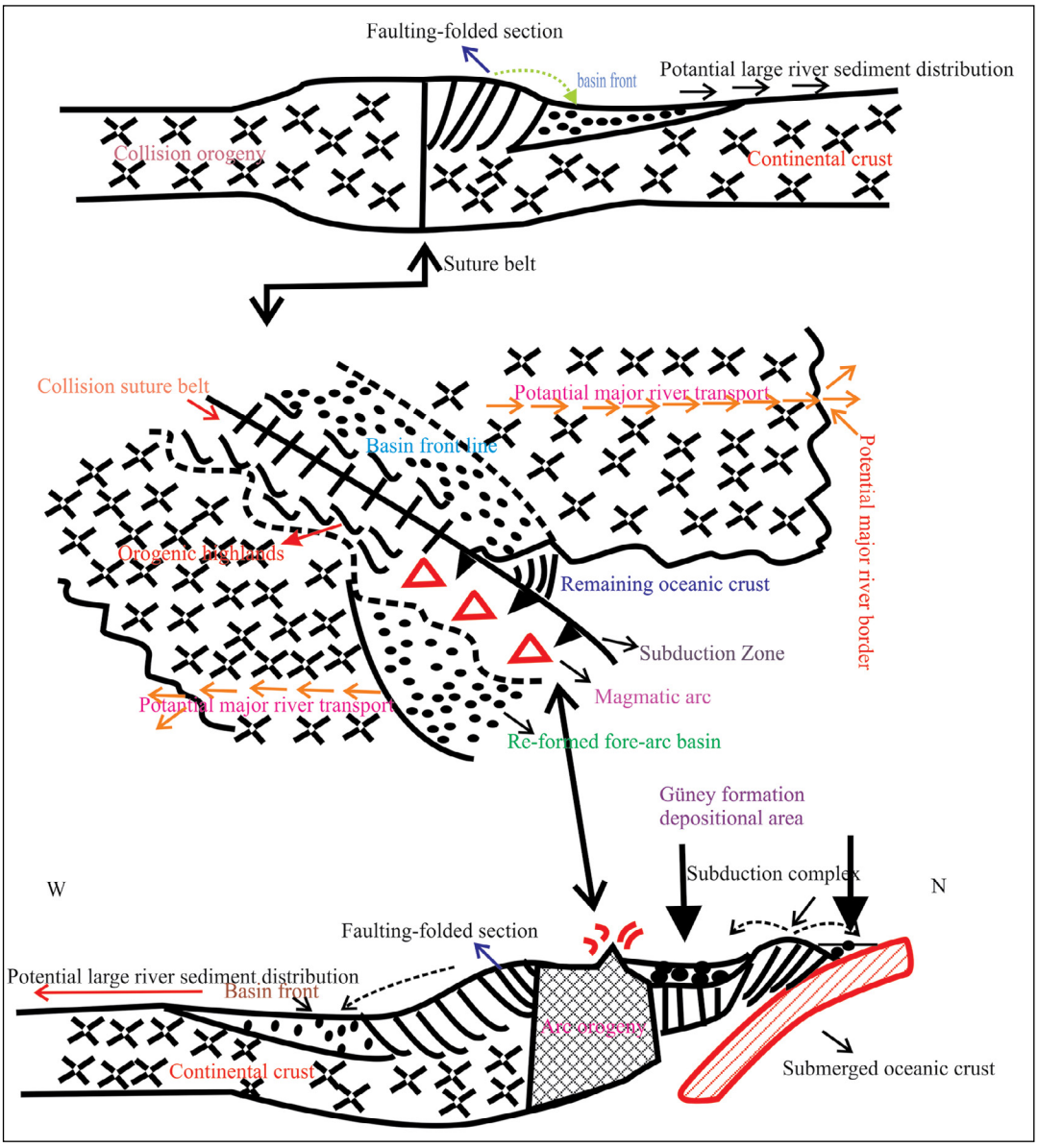

Figure 16- Basins associated with regenerated orogenic provenance. The shape seen at the top; collision orogen, bottom figure; The arc orogen shows the basin and front basin currents, the fore-arc basin and trench are well developed within the active trench system. The areas indicated by arrows at the bottom show the sediment distribution derived from the faulting-folded area and the thrust complex (Dickinson and Suczek, 1979) (N:North, S: South).

can consist of Tb; Tb, Tc; Tb, Tc, Td and Td sections. These sequences can be deposited both near and far from the source of sediment (Mutti, 1992). The ÖSKs prepared as a result of the field studies carried out in the Ovacık village, Tatlıpınar ridges, point to the Bouma succession, which is missing from the bottom and eroded from the top. However, at the Kardeşgediği station, the Güney formation has the Ta and Tb series of the Bouma sequence, and it outcrops here as being sculpted from the top.

According to Walker (1978), the alluvial fans on which the turbiditic facies assemblages are located are divided into three parts, namely inner fan, middle fan and outer fan, according to lithofacies assemblages. Convergent turbidites are deposited in the upper fan. The matrix is in the size of sand. Thick bedded, coarse sandstone, pebbly sandstone and conglomerates are widely observed. Conglomerates are generally well rounded, in quite different sizes and mostly grain supported. Sandstones are generally coarse - grained

and cross - bedding is quite common. Stratified fine-grained sediments are observed in the outer range, where sediments with divergent turbidite character are deposited.

ÖSK - 1, 2, 3 and ÖSK - 4, which are made in the Güney formation and are correlated with each other; (From Hantepe to Ulukışla - Niğde road, along the Karacaören road junction) from bottom to top shale - volcanic rock- added conglomerate - fine grained sandstone - medium grained sandstone - shale - gray, fine - grained sandstone - shale - gray - colored, fine -grained sandstone in the form. The stack is developed in turbidite facies. At the Kardeşgediği Station (ÖSK - 1, ÖSK - 2), the sand size material is more than the clay size material, the sandstone layers are thick (at least 2 m), the channel fillings, slump structures and pebbles show the convergent turbidite character. However, in Tatlıpınar Ridges (ÖSK - 3) and Ovacık-Güney village (ÖSK - 4) shales have an average layer thickness of 30 cm (thick) and sandstones up to 3 - 5 cm (thin). Shales are denser than sandstones, which show divergent turbidite features (Figure 17, 18).

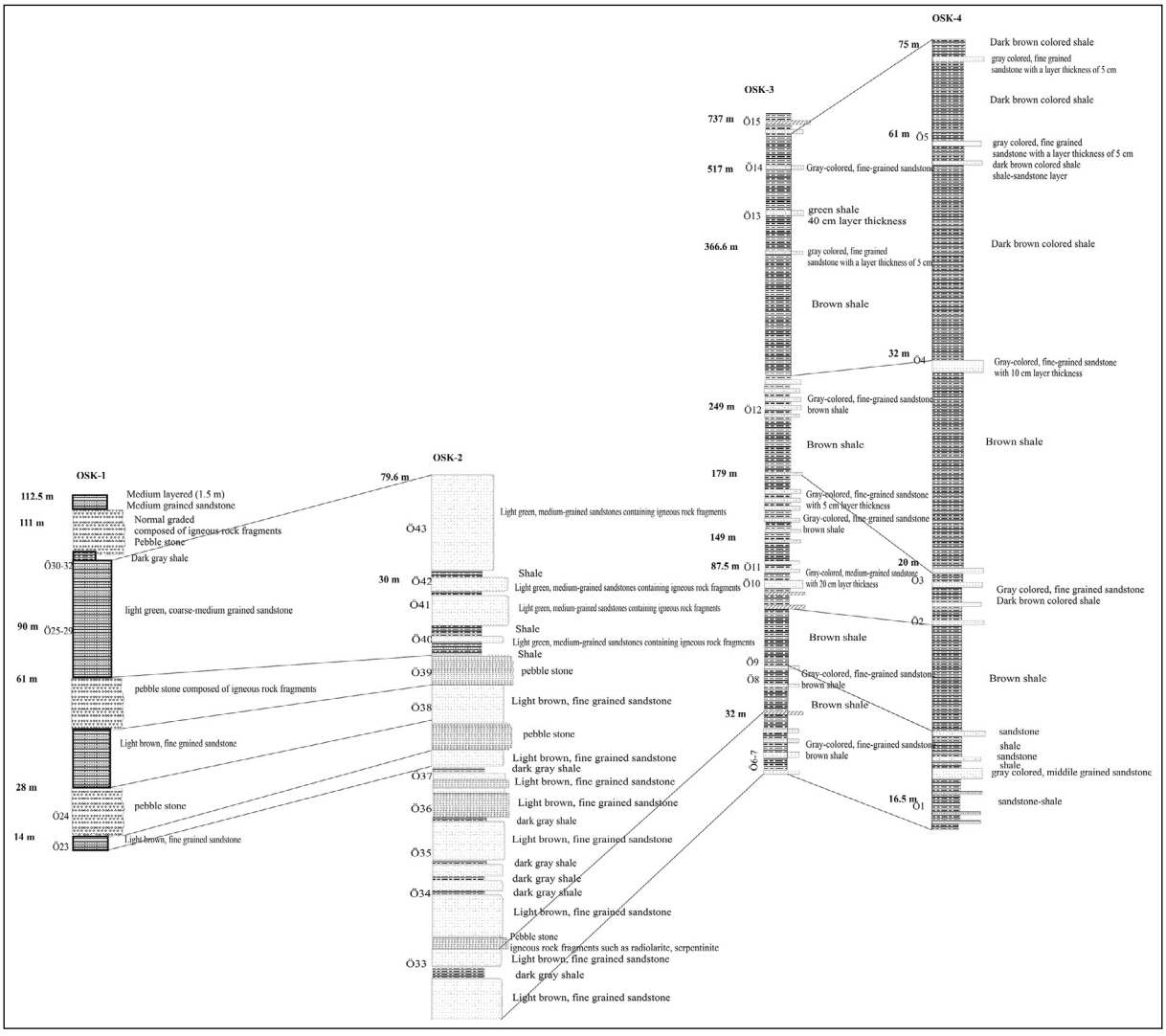

Figure 17- Correlation of ÖSK's in the study area.

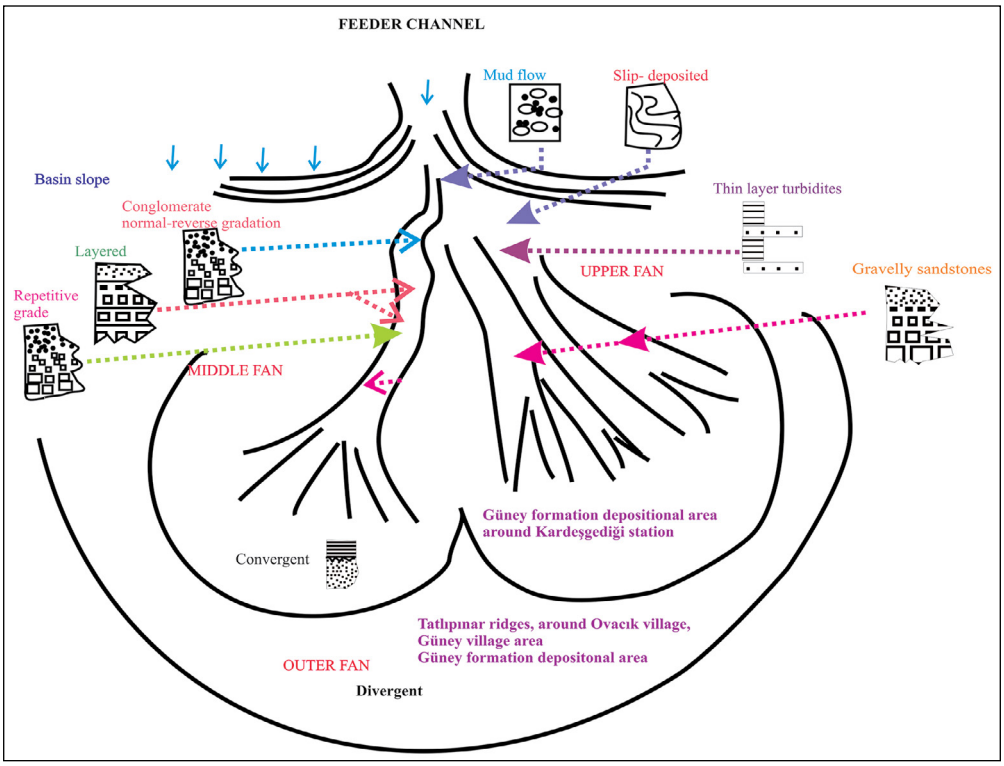

Figure 18- Turbidite fan model (Walker, 1978).

8. Results

In previous studies, the units referred to as Serenkaya and Ovacık formations were investigated under the name of Güney formation considering their distribution and location in the region. It has been observed that the Güney formation starts with lenticular conglomerates at the base and continues as sandstone - shale alternation.

In the study area, there is the Late Cretaceous - Middle Eocene Ulukışla formation at the basement. Paleocene - Early Eocene Halkapınar formation is laterally and vertically transitive with the Ulukışla formation. The Güney formation overlies these formations by transiting laterally and vertically with the Ulukışla and Halkapınar formations observed at the basement. The Late Eocene - Oligocene aged Aktoprak formation comes over the Güney formation by transitioning in lateral and vertical directions. The Miocene - Pliocene aged Cihanbeyli formation overlies these units unconformably.

ÖSK - 1, 2, 3 and ÖSK - 4, which are made in the Güney formation and are correlated with each other; (From Hantepe to Ulukışla - Niğde road, along the Karacaören road junction) from bottom to top shale - volcanic rock - added conglomerate - fine - grained sandstone - medium - grained sandstone - shale - gray, fine - grained sandstone - shale - gray - colored, fine - grained sandstone in the form. The stack has been deposited by turbiditic flows.

The lower parts of the sequence contain channel fillings and the sandstone density is high, so it presents a convergent turbiditic character. Sandstone and shale densities are equal towards the north in the study area. In the upper parts of the sequence, channel fillings are again observed, and the sandstone grains become coarse and their density increases, while shale density decreases. Therefore, the upper levels are seen in the convergent turbiditic character.

The unit is generally developed as a sequence of gray - coarse sandstone and shale, with a thickness of approximately 800 m. Due to the sandstone - shale - conglomerate - shale alternation lithology of the unit as a result of the ÖSK - 1 and ÖSK - 2 study performed at an altitude of 1466 m in the area between 37° 55’ - 37° 57’ north latitude and 34° 43’ - 34° 44’ east

longitudes around Kardeşgediği station, the sequence is in convergent turbidite character in this area. Güney village, on the hills of Tatlıpınar between 37° 63' - 37° 66' north latitudes and 34° 52' - 34° 54'east longitudes, 1523 m high ÖSK - 3, around Ovacık Village, between 37° 57' north latitude and 34° 47' east longitude, 1631 meters high ÖSK - 4 study was carried out. According to the studies of ÖSK - 3 and ÖSK - 4, the Güney formation consists of sandstone-shale units. The sequence reflects the divergent turbidite character in these areas.

Sandstone samples collected from the study area are lythic arenite and feldspathic arenite according to Folk et al. (1970) classification.

According to Dickinson et al. (1983) in the data we obtained from petrographic investigations, the Güney formation sandstones are found in the arc and regenerated orogenic provenance zones, whose source areas are not separated. According to Dickinson and Suczek (1979), these regions show that the Güney formation's depositional area is in front of the island arc.

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