Yerbilimleri, 32 (2), 151-170
Hacettepe Üniversitesi Yerbilimleri Uygulama ve Araştırma Merkezi Bülteni
Bulletin of the Earth Sciences Application and Research Centre of Hacettepe University

Geological Evolution of the Ulukışla Basin (Late Cretaceous-Eocene) Central Anatolia, Turkey

Ulukışla Havzasının (Geç Kretase-Eosen) Jeolojik Evrimi, Orta Anadolu, Türkiye

***Kemal ZORLU[1], Selim İNAN[2], Murat GÜL[3], Nurdan İNAN[2], Mehmet Ali KURT[4], Musa ALPASLAN[2]**

[1]Adıyaman University, Kahta Vocational School, Department of Architecture and City Planning, Kahta–Adıyaman/ TURKEY.

[2]Mersin University, Engineering Faculty, Department of Geological Engineering, 33343, Çiftlikköy–Mersin/ TURKEY

[3]Mugla University, Engineering Faculty, Department of Geological Engineering, 48000, Kotekli–Mugla/ TURKEY.

[4]Mersin University, Advanced Technology Education, Research and Application Center, 33343, Çiftlikköy–Mersin/ TURKEY

Geliş *(received)* : 24 Şubat *(February)* 2011
Kabul *(accepted)* : 11 Temmuz *(July)* 2011

ABSTRACT

The Ulukışla Basin (Central Anatolian, Turkey) developed between the Menderes-Taurides Platform and the Niğde-Kırşehir Metamorphic Massif. Evidence from the basin fill indicates that it evolved with asymmetric tectonics. An extensional phase (the Late Cretaceous-Late Paleocene) developed after subduction of the northern branch of Neotethyan Ocean. The narrow southern margin of Ulukışla Basin evolved over and in front of the Alihoca Ophiolites (remnant of the Neotethyan ocean floor) and it has been characterized with deposition of the agglomerates, limestone olistoliths, sandstones and mudstones in submarine slope to deep marine environment. At the same time, in the initially the relatively deep then shallow marine environment, broad northern part of the basin includes relatively fine-grained sandstones and mudstones overlying by reef limestone, which is interfingered with volcanic rocks. Depend on compressional phase (the Late Paleocene and Early Eocene), the basin evolved with the effect of regional tectonics; patch reefs formed over the volcanic highlands. In addition, volcanics interfingered with clastics that contain limestone and volcanic rock fragments. Basin evolution and inversion in this tectonic regime has been strongly influenced by deviations originated from overall northward motion of the African-Arabian plates. Other controls on the sedimentation and basin evolution are local tectonics, sea level changes and irregularity of basement topography.

Keywords: Basin inversion, compression, extension, intra-continental basin, Ulukışla basin.

ÖZ

Ulukışla Havzası (Orta Anadolu, Türkiye) Menderes-Toros Bloğu ve Niğde-Kırşehir Metamorfik Masifi arasında gelişmiştir. Havzaya ait dolguların sunduğu kanıtlar, havzanın asimetrik bir şekilde evrimleştiğini göstermektedir. Genişlemeli faz (Geç Kretase – Geç Paleosen) Neotetis Okyanusu kuzey kolu tabanının yitime uğraması sonrasında gelişmiştir. Ulukışla Havzası'nın dar güney kenarı, Alihoca Ofiyoliti (Neotetis Okyanus tabanı kalıntısı) üzerinde

K. Zorlu
E-posta : kemalzorlu.geol@gmail.com

ve önünde gelişmiş olup, deniz altı yamacından derin denize uzanan ortamlarda, aglomera, kireçtaşı olistolitleri, kumtaşları ve kiltaşlarının çökelimi ile karakterize edilir. Aynı anda, başlangıçta göreceli derin denizel sonrasında sığ denizel ortamda, havzanın daha geniş olan kuzey kısımları, volkanik kayaçlarla ara katkılı resifal kireçtaşlarınca üzerlenen ince-taneli kumtaşları ve kiltaşları içermektedir. Bölgesel tektonik şartların değişmesi ile gelişen sıkışma fazına (Geç Paleosen – Erken Eosen) bağlı olarak, volkanik yükseltiler ve/veya topografik yükseltiler üzerinde yama resifleri gelişmiştir. Ek olarak, volkanikler, kireçtaşı ve volkanik kayaç parçaları içeren kırıntılılarla ardalanmaktadır. Havza evrimi ve tektonik rejimdeki terslenme, Arap – Afrika plakalarının kuzeye doğru hareketlerinde oluşan sapmalardan güçlüce etkilenmiştir. Çökelme ve havza evriminde etkili olan diğer faktörler ise yersel tektonik etkiler, deniz seviyesi değişimleri ve temel topografyasının düzensizliğidir.

Anahtar Kelimeler: Havza tektonik rejiminin terslenmesi, sıkışma, genişleme, kıta içi havza, Ulukışla havzası.

INTRODUCTION

In the context of the tectonic evolution of Turkey and its surrounding areas, suture zones and the microplates separating these suture zones have played an important role (Şengör and Yılmaz, 1981; Görür et al., 1984; Göncüoğlu, 1986; Guezou et al., 1996; Görür and Tüysüz, 2001; Fig. 1A). The suture zones have been evolved as a result of the closing of northern and southern branch of the Neotethyan Ocean during the Late Cretaceous-Miocene time. The tectonic development southern margin of Eurasian Plate, the Menderes-Taurides Platform and marine realm between these two plates were highly influenced by northward movement the African and Arabian Plates (northern margin of the Gondwana; Golonka, 2004). It has been suggested that changes in the direction and velocity of relative motion of the African and Arabian Plates due to development of the Atlantic and Indian Oceans (Guiraud and Bosworth, 1997) controls the characteristics of the volcanism and sedimentary basin evolution in and around the Menderes-Taurides Platform.

It is known that many sedimentary basins were developed on the Menderes-Taurides Platform during the Late Cretaceous-Tertiary (Okay et al., 2001; Gürer and Aldanmaz, 2002). Tuzgölü, Sivas, Çankırı-Çorum, Kırşehir, Haymana and Ulukışla Basins are the main basins (Fig. 1B). Earlier researches have improved numerous basin models. For example; the Haymana and Tuzgölü Basins are fore-arc basin (Görür et al., 1984) or remnant oceanic basin (Yılmaz et al, 1997; Görür et al., 1998); the Sivas Basin was interpreted as a piggy-back basin (Cater et al., 1991) or intra-continental basin (Poisson et al., 1996) and while the Çankırı-Çorum Basin is collision or piggy-back basin (Koçyiğit and Beyhan, 1998).

The Ulukışla Basin is situated at the southeastern edge of Central Anatolian Basins. This basin is restricted by the Niğde-Kırşehir Metamorphic Massif to the north; the Bolkar Carbonate Platform (formed the central part of Menderes-Taurides Platform) to the south; the sinistral Ecemiş Fault Zone to the east; and the Tuzgölü Basin to the west (Fig. 1B). Clark and Robertson (2002) implied that the Maastrichtian–Late Eocene Ulukışla Basin has carried a great importance for understanding the tectonic and sedimentary evolution of the Early Tertiary basins of Central Anatolia. There are also numerous studies on this basin, for example Oktay (1982), Özgül (1984), Robertson and Dixon (1984), Yetiş (1984), Yetiş and Demirkol (1984), İşler (1988), Nazik and Gökçen (1989), Göncüoğlu et al. (1991), Çevikbaş and Öztunalı (1992), Görür et al. (1998), Clark and Robertson (2002), Akgünlü (2003) and Alpaslan et al. (2004, 2006).

Similar to other Central Anatolian Basins, a range of models have been also suggested for the evolution of Ulukışla Basin. Some researchers offered as a fore-arc basin model (Görür et al., 1984, 1998), some of them suggested a back-arc basin model (Demirtaşlı et al., 1984), others proposed island arc model (Oktay, 1982; Baş et al., 1986). Clark and Robertson (2002) offered a transtensional basin model, which occurred as a result of the extensional tectonic regime. Alpaslan et al. (2004) offered the rifted intracontinental basin model. All of these studies clearly recognize that basin evolution and sedimentation were strongly controlled by

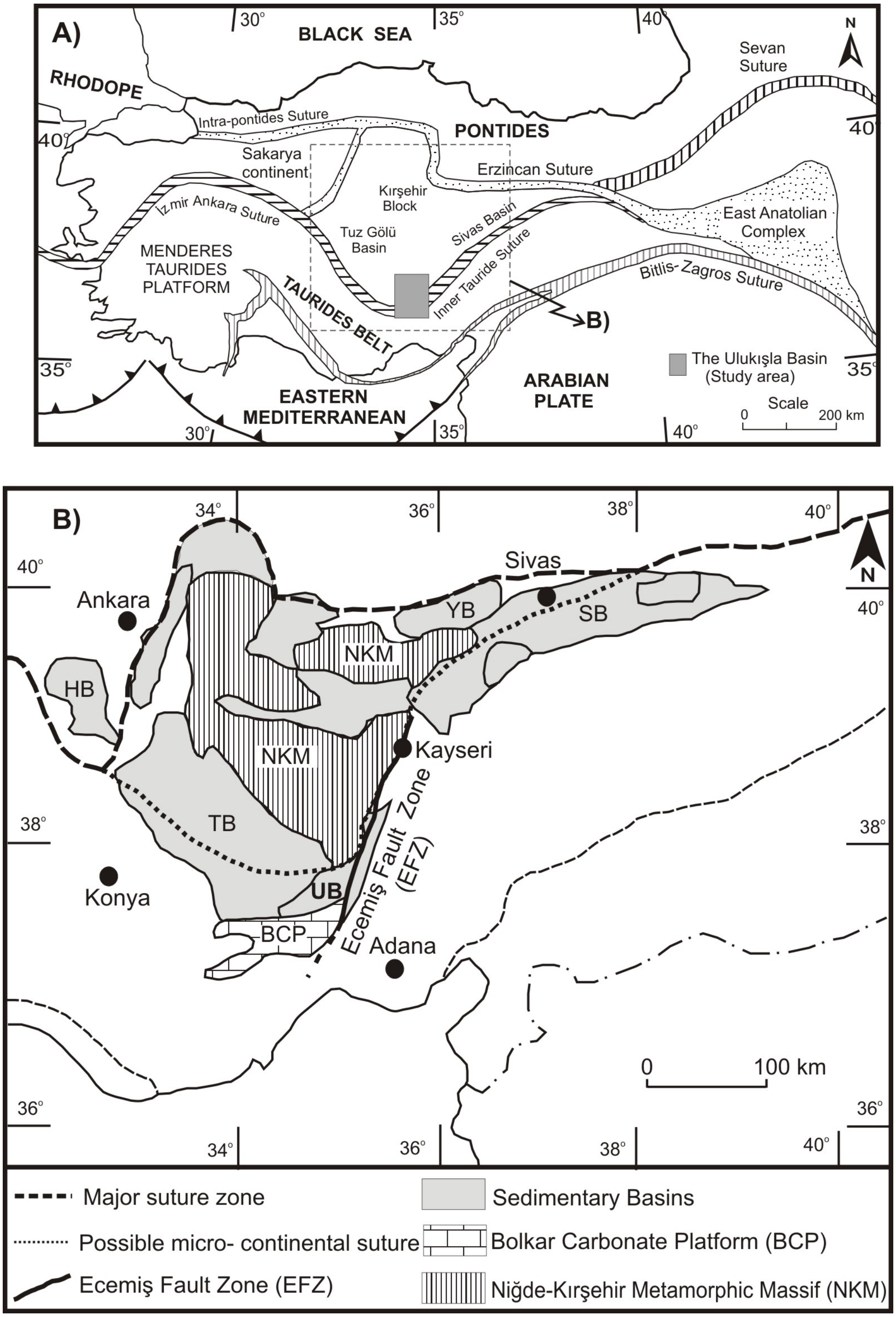

Figure 1. A) Main tectonic sutures of the Middle Eastern Alpides (modified after Guezou et al., 1996). B) The main sedimentary basins in the Central Anatolian Block. TB: Tuzgölü Basin; UB: Ulukışla Basin; KB: Kırşehir Basin; YB: Yıldızeli Basin; CB: Çankırı-Çorum Basin; SB: Sivas Basin; HB: Haymana Basin; BCP: Bolkar Carbonate Platform; NKM: Niğde-Kırşehir Metamorphic Massif (after Clark and Robertson, 2002).

Şekil 1. A) Orta Doğu Alpid kuşağa ait ana tektonik kenet zonları (Guezou vd., 1996'dan değiştirilmiştir). B) Orta Anadolu bloğunda yer alan ana sedimanter havzalar. TB: Tuzgölü Havzası; UB: Ulukışla Havzası; KB: Kırşehir Havzası; YB: Yıldızeli Havzası; CB: Çankırı-Çorum Havzası; SB: Sivas Havzası; HB: Haymana Havzası; BCP: Bolkar Karbonat Platformu; NKM: Niğde-Kırşehir Metamorfik Masifi (Clark ve Robertson, 2002'den alınmıştır).

tectonism and volcanism during the Late Cretaceous-Eocene. Aim of this study is to determine sedimentary features of the Ulukışla Basin controlled by extensional and compressional tectonic regime and to reveal the development of the basin within the global tectonic frame.

GEOLOGICAL SETTING

The stratigraphy of Ulukışla Basin has been assigned to in three major geologic units by Alpaslan et al. (2004) based on previous geologic studies. These are; 1) Pre-Upper Cretaceous geologic units: the Bolkar Carbonate Platform (the Permian to Late Cretaceous; Demirtaşlı et al., 1984), the Niğde-Kırşehir Metamorphic Massif (the Lower Paleozoic-Lower Cretaceous), the Alihoca Ophiolites (the Upper Cretaceous); 2) Upper Cretaceous-Eocene geologic units: the Ulukışla Formation, which has been detail examined in this study, includes deep sea sediment, volcano-sedimentary units and shallow marine carbonates; 3) Post Eocene geologic units: various type volcanites, evaporites and continental sedimentary rocks (Figs. 2 and 3).

The Niğde-Kırşehir Metamorphic Massif, located in the northern boundary of the Ulukışla Basin, includes quartzite, gneiss, amphibolites, marble, mica schist, dolomitic marble, cherty limestones, granodiorite, monzonite and syenite intrusives (Çevikbaş and Öztunalı, 1992). Whitney and Hamilton (2004) showed that the high-grade basement rocks of massif are polymetamorphic character in metamorphism age of the Late Cretaceous. The southern part of Ulukışla Basin includes the Alihoca Ophiolite and the Bolkar Carbonate Platform. The Alihoca Ophiolite consists of serpentinized peridotite, pyroxenite, ultramafic cumulates, gabbro, microgabbro and dyke complex (Alpaslan et al., 2004). Some researchers have linked this body to the Pozantı-Karsantı Ophiolite that was derived from the Northern Neotethyan Ocean and was thrust onto northward edge of the Menderes-Taurides Platform (onto the Bolkar Carbonate Platform; Demirtaşlı et al., 1984; Çevikbaş and Öztunalı, 1992; Polat and Casey, 1995; White et al., 1996; Clark and Robertson, 2002, 2005). The Bolkar Carbonate Platform consists of crystallized limestones and marble intercalated with shale and dolomites (Demirtaşlı et al., 1984). The relations between the Niğde-Kırşehir Metamorphic Massif and the Alihoca Ophiolites or the Bolkar Carbonate Platform have not been observed in the study area.

The Upper Cretaceous-Eocene deposition in the Ulukışla Basin has been investigated under the different formations name by several previous researcher (e.g. Demirtaşlı et al., 1984; Çevikbaş and Öztunalı, 1992; Clark and Robertson, 2002, 2005). However it is thought that all of these formations deposited in the same marine environment, so all of them can be evaluated under same name, the Ulukışla Formation. This formation mainly contains fine to coarse-grained clastic rocks, volcano-sedimentary sequences and reef limestones. Akgünlü (2003) identified the Shallow Benthic Zone (SBZ) 13-14-15 biozones in these sequences and implied that bottom part of the sequence deposited in restricted basin with normal salinity, sandy-clayey upper part was deposited in “inner shelf of open sea” environment. Calk-alkaline and shoshonitic dykes consisting of monzonite, trachyte and diorite intruded into this formation during and after the sedimentation (Alpaslan et al., 2004; Kurt, 2004; Alpaslan et al., 2006; Kalelioğlu et al., 2009; Figs. 2 and 3). Four logs were measured in this formation in order to determine the certain depositional settings (Fig. 2). Lithological properties of the logs are going to be explained following section in detail. The east-west trending thrust faults and symmetrical folding are commonly seen in the Ulukışla Formation (Fig. 2). Furthermore, the Ulukışla Formation is also cut by the northeast-southwest trending sinistral strike-slip faults related with the Ecemiş Fault Zone.

The first post-Eocene unit is the Oligocene Zeyvegediği Anhydrite including turbiditic sandstone (Nazik and Gökçen, 1989; Figs. 2 and 3). The Miocene continental deposits include limestone and marl alternations, conglomerates, siltstone and mudstone alternations (Nazik and Gökçen, 1989). These sediments mainly crop out along the Ecemiş Fault Zone (Ketin and Akarsu, 1965; Yetiş, 1984). The Pliocene polygenic conglomerates and reddish - greenish sandstones unconformable overlie the older

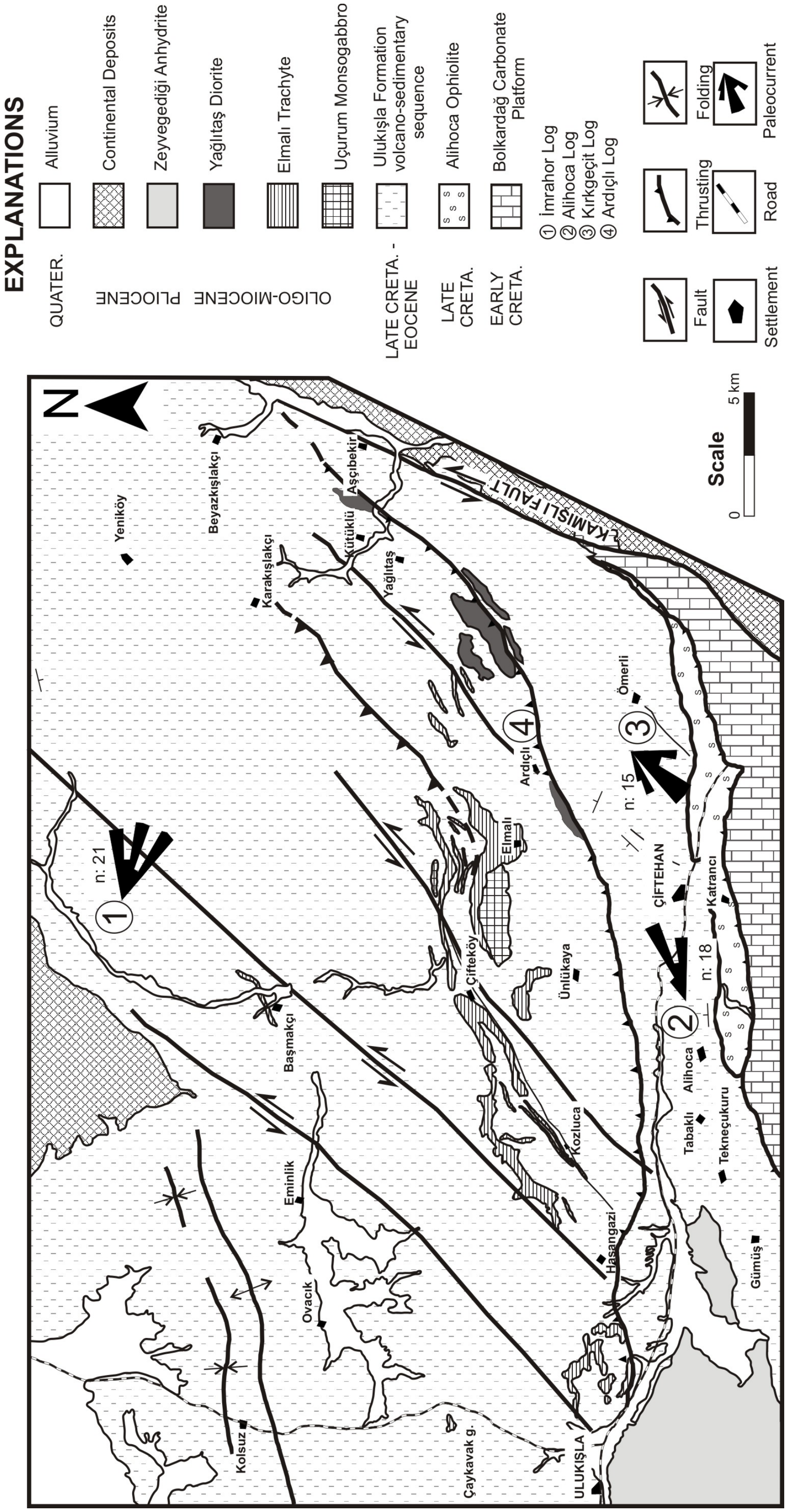

Figure 2. Geological map of the study area (Alpaslan et al., 2004).
Şekil 2. Çalışma alanının jeoloji haritası (Alpaslan vd., 2004).

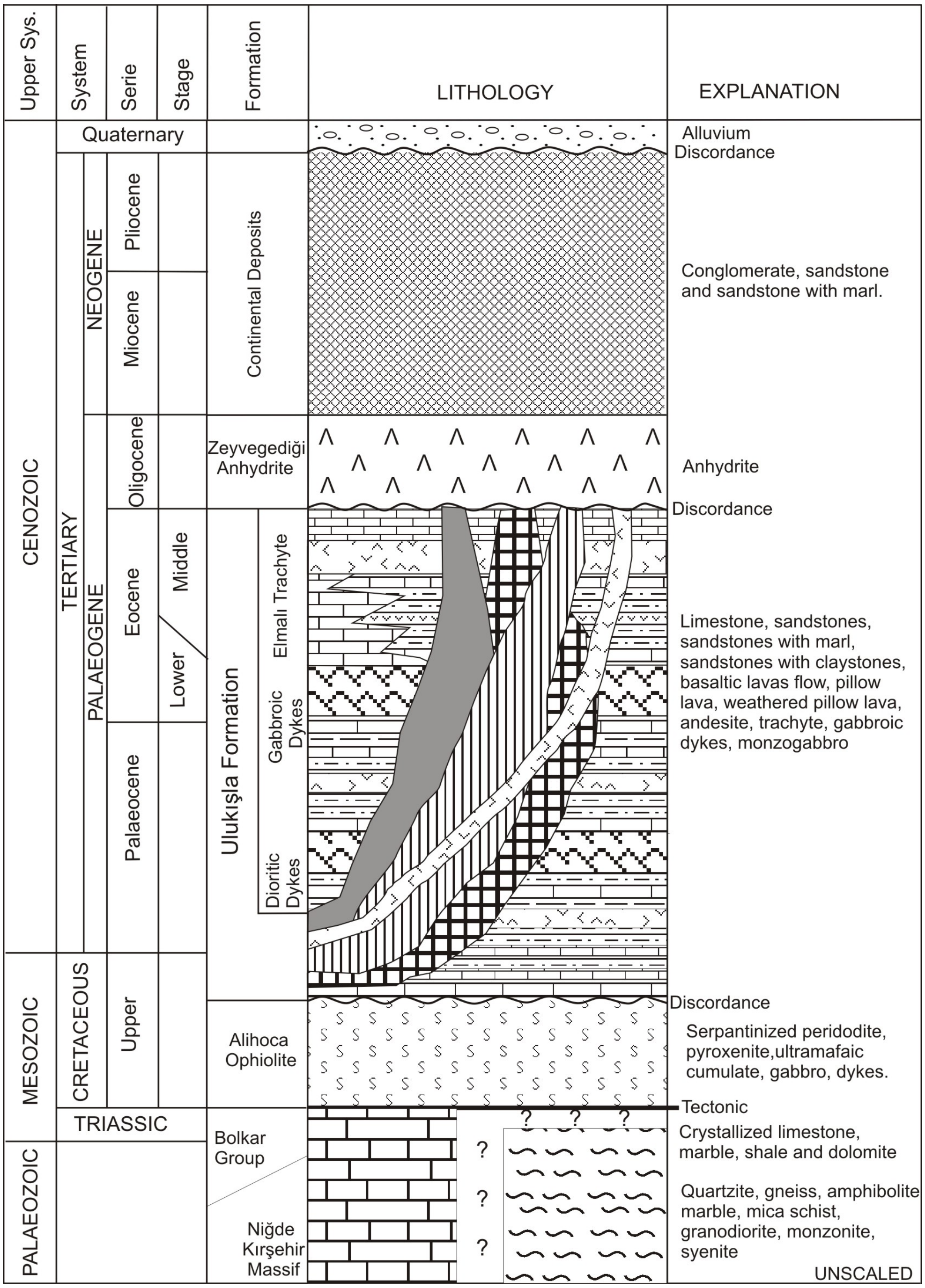

Figure 3. Generalized stratigraphy section of the study area (Alpaslan et al. 2004; Kurt, 2004).
Şekil 3. Çalışma alanının genelleştirilmiş stratigrafi kesiti (Alpaslan vd., 2004; Kurt, 2004).

units (Çevikbaş and Öztunalı, 1992). The Quaternary alluvial deposits cover the all older geologic units.

SEDIMENTOLOGY OF THE ULUKIŞLA FORMATION

The Ulukışla Formation displays various sedimentary facies in different parts of the basin.

The Imrahor log on the northwest margin (Figs. 2, 4 and 5); the Alihoca log on the southern margin (Figs. 2 and 6); the Kırkgeçit log (Figs. 2 and 7) and the Ardıçlı log in the central part of the basin (Figs. 2 and 8) were measured in this formation. The sandstone and limestone samples were collected for petrographical and paleontological purposes. The sandstones are named by using of Pettijohn et al. (1987), while the limestones are classified according to Dunham (1962) and Embry and Klovan (1972). The eight different facies have been separated according to lithology, geometry, sedimentary structures and fossil contents. These are; Distal Fan Turbidite (DFT), Middle Fan Turbidite (MFT), Proximal Fan Turbidite (PFT), Slope Facies (SF), Open Shelf Facies (OSF), Back Reef (BR), Reef Core (RC) and Volcano-sedimentary sequence (VS). The initial fourth facies are mainly including clastics with different size. The latter three are formed by carbonates. The last one includes volcanic material alternated with sedimentary rocks. The properties of the facies are evaluated in interpretation section of each log based on different researchers.

Northern Margin: Imrahor Log

Description: The basal part of the log (260 m) consists of alternations of yellow-grey (weathering color) sandstones and grey-green, laminated mudstones and unconformably overlies the basalt. The sandstone / mudstones ratio ranges from 1/8-9 to 1/2-3 (abundantly Te and lesser extent Td Bouma sequences; Bouma, 1962). The sandstones are mainly lithic arenite in composition. The quartz and muscovite grains are rich in near the bottom, while volcanic rock fragments and opaque minerals increase towards top of the section. Lamination is common sedimentary structures in the mudstone parts, while in addition to lamination, load cast, flow mark, groove mark and ripple mark were found in the sandstones. The muscovite, quartz and opaque minerals have been found in the sandstone in the lower part of section, while volcanic rock fragments were found in the upper part. The main palaeocurrents directions of clastic facies of the log were measured from the flute and groove marks, and vary between 80° and 128°. These initial sequences classified under the DFT facies. Five meters thick debris including sandstone, mudstones and limestone fragments, were observed in between 260 and 265 m of section. This possibly slumped section classified under the SF facies. Following fossil assemblages were found in the limestone thin section. Benthic foraminifera: *Gyroidinella manga* LE CALVEZ; Planktic foraminifera: *Acarinina* cf. *broedermanni* (CUSHMAN & BERMUDEZ), *Morozovella* cf. *subbotinae* (MOROZOVA), *Globigerina* sp., *Globigerinatheka* sp., *Catapsydrax* sp. (Figs. 4 and 5). This section is overlain by the uniform beds of limestone and mudstone. Then, nearly 10 m thick wackestone-packstone type limestone (Back Reef Facies: BR) is observed. 3.5 m thick packstone-bindstone beds (Reef Core Facies: RC) are overlain by the 1 m thick basalt flow that starts with limestone fragments bearing basalt level. This level is followed by the 5 m thick wackestone (BR). Upper part of this level includes basalt pebble. These limestones contain; Benthic foraminifera: *Idalina sinjarica* GRIMSDALE, *Anomalina* sp., *Daviesina* sp., *Discocylina* sp., *Pfendericonus* sp., *Planorbulina* sp., *Miscellanea* sp., Milliolidae, Corals: *Litharaeopsis subepithecata* (OPPENHEIM), *Goniopora* cf. *elegans* (LEYMERIE), Algae: *Amphiroa* cf. *propria* (LEMOINE), *Archaelithothamnium* cf. *johnsoni* ASTRORILLI, *Corallina* cf. *abundans* LEMOINE, *Distichoplax biserialis* (DIETRICH), *Archaelithothamnium* sp. and echinoids. This thick limestone level is overlain by the 2.7 m thick basalt level that contains iddingisitized olivine, pyroxene, plagioclase, volcanic groundmass and calcite fillings in cracks. The upper part of the log contains 1.5 m thick sandy cream color, medium bedded wackestone and 6.5 m thick wackestone (BR). This level includes; Benthic foraminifera: *Miscellanea* sp., *Pyrgo* sp., *Triloculina* sp., Miliolidae; Algae: *Amphiroa* sp., *Amphiroa* cf. *propria* (LEMOINE), *Distichoplax biserialis* (DIETRICH), *Archaelithothamnium* sp., bryozoans and ostracods.

Interpretation: Initial 260 m thick fine-grained clastics deposited in relatively deeper marine environment (comparing to uppermost part of the log). These finer-grained sediments covered vast areas in the northern part of the

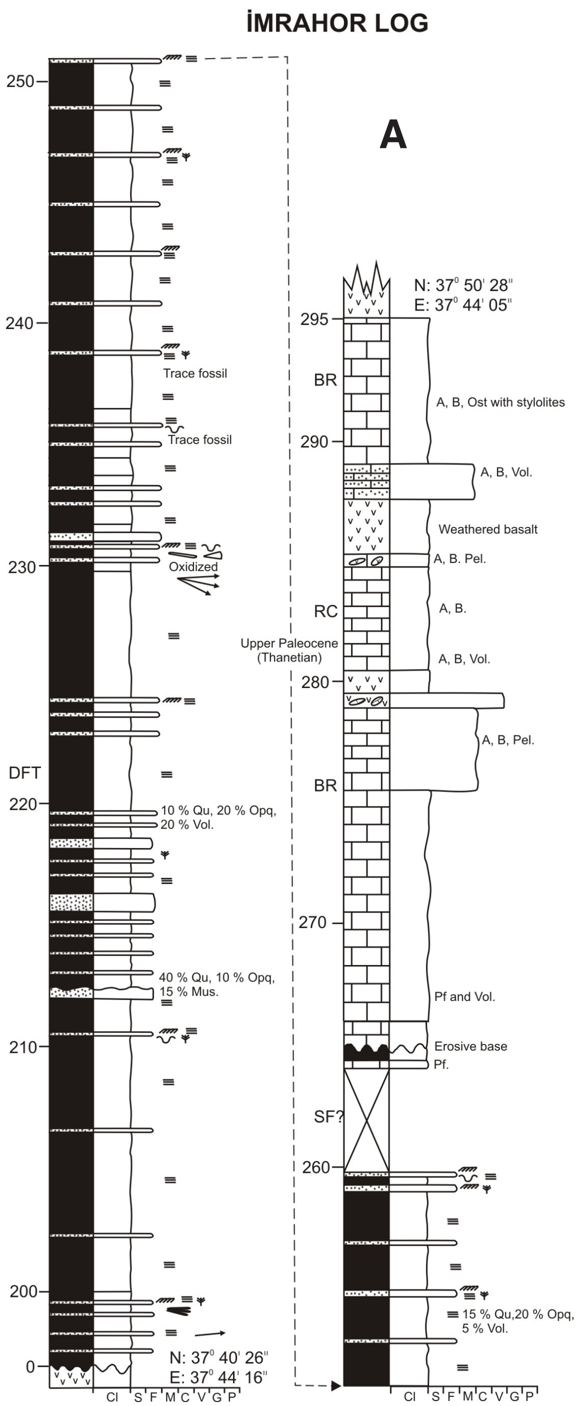

Figure 4. A) Imrahor Log measured in the northern margin of the Ulukışla Basin. *B)* Explanations for all logs.

Şekil 4. A) Ulukışla Havzası'nın kuzey kenarından ölçülmüş İmrahor kesiti. B) Tüm kesitler için açıklamalar.

Ulukışla Basin. The Bouma divisions and sedimentary structures of this part indicated that the distal turbiditic characters (Mutti, 1992). The mudstones were characterized the lower energetic environment that permit the deposition from suspension in pelagic and hemipelagic environment (Prothero and Schwab, 1996). The fine-grained sandstone levels were characterized the low-density turbidity current in this quiet environment (Prothero and Schwab, 1996). The high muscovite and quartz contents of the lower part are possible indicators of feeding from the Niğde-Kırşehir Metamorphic Massive. Then uplifting of the northern margin cut off this source and volcanic rocks became a subsequent source (Figs. 4 and 5). After this level, debris including possibly slumped mudstones and sandstones may indicate the slope environment. Then, limestones intercalated with volcanics. The fossil assemblages of the limestone and facies characteristics indicate reef environment. Initially planktic foraminifera bearing wackestone (BR) then depend on a shallowing of the environment coral and algae bearing bindstone (RC) deposited. Limestone facies evolved depending on energy level and sea level fluctuation (Fournier et al., 2004). Red algae and coral bearing bindstone deposits developed in the higher energetic environment of reef that is called as reef core (Heckel, 1972; Gül and Eren, 2003). The wackestone and packstone around the bindstone reflect sedimentation in quieter water (Strasser and Strohmenger, 1997; Gü, 2007). Then, this environment become back reef, reef limestone deposition was ceased by volcanic rock developments. The fossil assemblage of reef limestone indicates the Upper Paleocene (Thanetian) age. Thus, the fine-grained clastic sediment in the lower part of the reef limestone section must be older this time.

Southern Margin: Alihoca Log

Description: This log mainly composed of coarse-grained clastic rocks and overlies unconformable the Upper Cretaceous Alihoca Ophiolites (Fig. 6). It starts with nearly 40 m thick, red, brown and greenish colored agglomerates that include various grain sized basalt

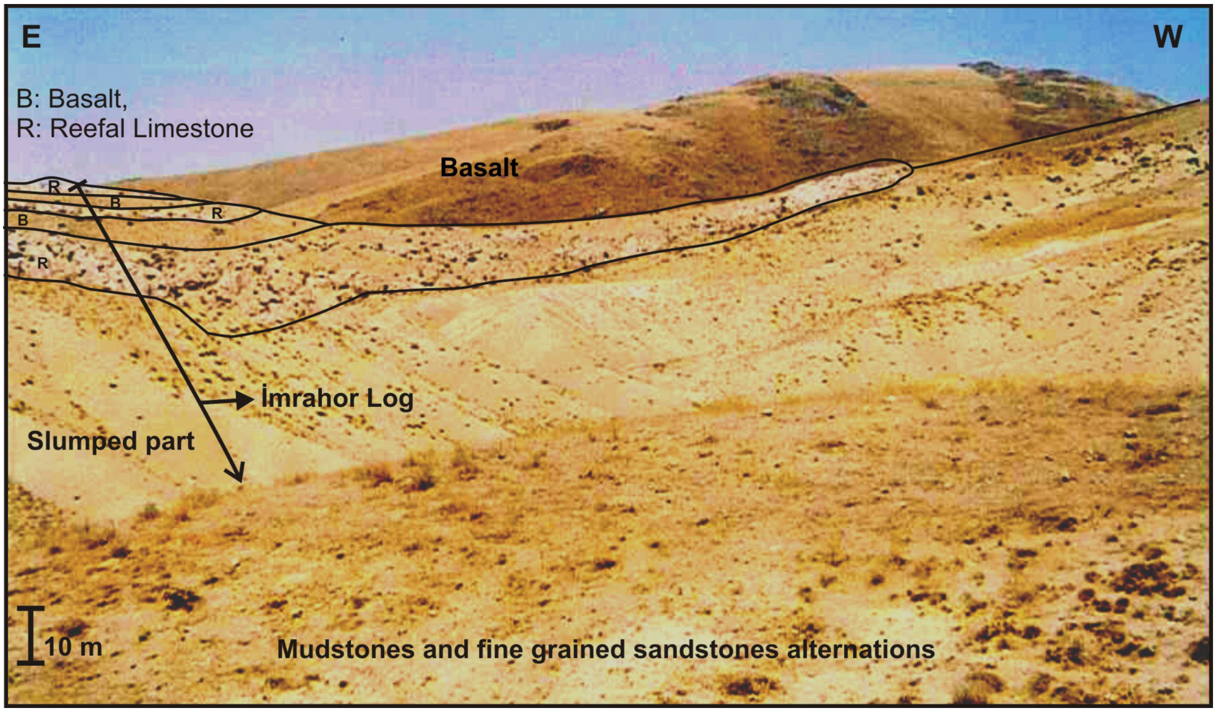

Figure 5. Field photos of the upper part of the İmrahor Log (section line shows the uppermost of the İmrahor log).
Şekil 5. İmrahor kesitinin üst kesimine ait arazi fotoğrafları (kesit çizgisi İmrahor kesitinin en üst bölümünü gösterir).

and andesite pebbles (VS). Then wackestone overlies the irregular upper surface of the agglomerate. After this level 150 m thick cover including agglomerate and limestone fragments were observed. The last agglomerate level of this section is overlain by the lithicarenite including chert-slate-volcanic rock fragments. This normal graded sandstone is followed by slumped sandstone and mudstones (SF). Nearly ten meters thick erosive based pebble-granule bearing conglomerates and normal graded volcanic rock pebbles bearing conglomerates (MFT) overlie the thin to medium bedded cream colored limestones. This limestone classified as mudstone and wackestone that contain intraclast and planktic foraminifera (Globigerinidae). Then nearly hundred meter thick clastic deposits are observed. Laminated, green colored mudstones are alternated with yellow-grey colored medium and thin-bedded, medium and fine-grained lithicarenite and lithicwacke type sandstones (DFT). Those sandstones contain quartz, chert, radiolarite, limestone, volcanic and ophiolite rock fragments with varying

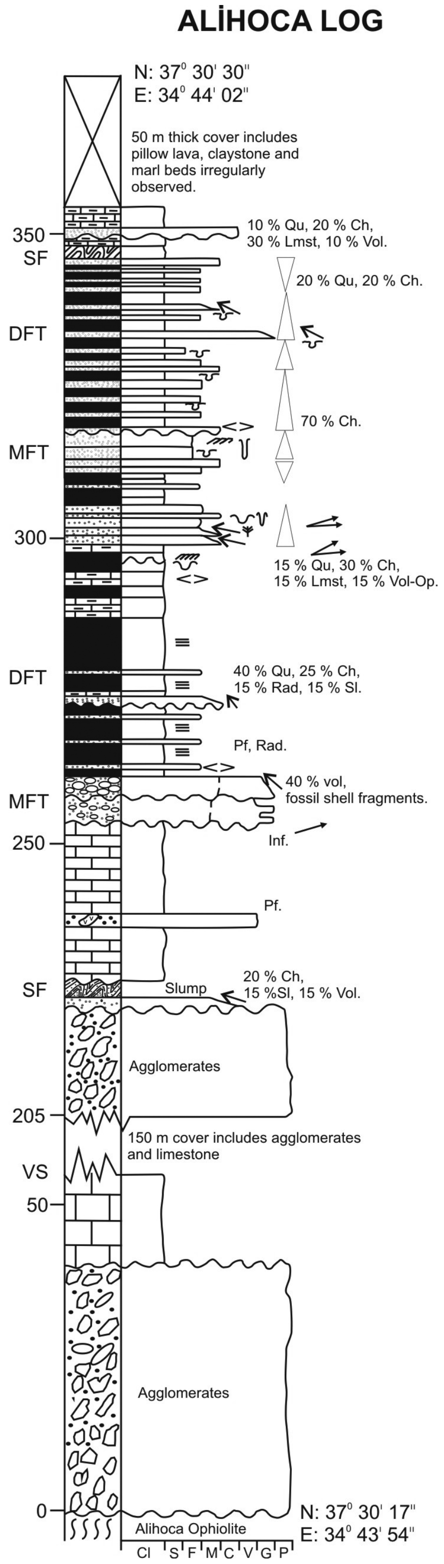

Figure 6. Alihoca Log measured in the southern margin of the Ulukışla Basin.
Şekil 6. Ulukışla Havzası'nın güney kenarından ölçülmüş Alihoca kesiti.

ratio. Load structure is common sedimentary structure, while ripple mark, burrow structure, erosive base, normal grading and flute mark are other sedimentary structures. The palaeocurrent directions measured from imbricated clasts and groove and flute marks flow ranges between 50° and 95° (Fig. 2). Locally marl levels are found in between the mudstones. Then the section is ended with slumped mudstone and sandstone, erosive based sandstone and marl (SF). At the top of the section nearly 250 m thick basalt and 5-6 m thick red colored mudstones were observed.

Interpretation: the southern margin of the Ulukışla Basin is tectonically more active than the northern margin. The agglomerates and limestone alternations indicated that volcanic activity effect on shallow marine sedimentation. Intense volcanic activity with an excess volcanic rock fragments gave way to deposition of agglomerates, during the subsequent quiet period mudstone-wackestone deposited (Strasser and Strohmenger, 1997; Fournier et al., 2004; Gül, 2007). Intraclast content pointed out that the local high energy level of environment. The sandstones and mudstones may indicate the middle-distal submarine fan (MFT-DFT) deposition (Mutti, 1992). The Td and Te are abundant; this mudstone dominant part indicated the deposition in low energetic environment and suspension in pelagic and hemipelagic environment that evaluated under distal fan environment (Mutti and Ricci, 1972; Shanmugam, 2002). Normally graded Ta and Tb are locally found in the section that indicates the excess sediment input and high energetic environment than the Imrahor section and point out the middle fan turbiditic environment (Mutti and Ricci, 1972; Shanmugam, 2002). The grain composition of the sandstones indicates polymictic nature of source area. Previous researchers (Clark and Robertson, 2002; 2005) mentioned submarine volcanic activities in the Ulukışla basin. The agglomerate and slump deposits were developed depend on fragments supplied from those volcanic. The limestone deposited during the quiet environments.

Southern Part of Central: Kırkgeçit Log

Description: This log overlies the basalts and andesites (Fig.7). It starts with marl-quartzarenite-mudstone alternation that is cut by basalts (VS). After the 5 m thick covers, abundantly mudstone and siltstone, basalt and marl were observed. Before the nearly 35-40 m thick andesite and pillow lava-andesite, andesite and marl alternations, slumped mudstone and fine-grained sandstone (SF) were found. After the volcanics, grey-green colored, laminated, *Morozovella* sp. bearing, nearly 80 m thick mudstones (DFT) deposited. These mudstones are overlain by the *Morozovella gracilis* BOLLI bearing wackestones. Then a hundred seventy meter clastic sequence deposited. Several fining upward sequences were differentiated in this section. Each sequences starts with the pebble conglomerates and ends with the normal-graded sandstone (coarse to fine-grained sandstone) and coarse to medium-grained sandstones (MFT). Initial part sandstones are classified as a lithicwacke including slate, chert, andesite, basalt and limestone fragments with varying ratio. Those limestone fragments are the fragments derived from the Upper Paleocene (Thanetian) reef limestone. Reverse-graded clastic (PFT) is only found in between the 230 and 250 m of section. The general paleoflow pattern, measured from imbrications, varies between 183° and 250° (Fig. 2). Those clastic sequences are laterally pinching out inside the planktic foraminifera bearing mudstones and locally limestone. The laminated, green-grey colored mudstone deposited in between the 340 and 455 m (DFT). This mudstone level is cut by restricted conglomeratic bodies. The log ends with red colored thin bedded wackestone-grainstone then mudstone. The red limestone thrusting on clastic rocks include the Campanian-Maastrichtian fauna: Planktic foraminifera: *Contusotruncana fornicata* (PLUMMER), *Globotruncanita stuartiformis* (DALBIEZ); Benthic foraminifera: Rotaliidae; red algae, pelecypod shell fragments. The whole section is overlain by the andesites.

After the volcanic and clastics alternations, andesites and pillow lava from the submarine volcanism ceased the sedimentation. Then depend on a lowering of energy level and relatively deep-quiet environment planktic foraminifera bearing 80 m thick mudstone deposited. The mudstones were characterized the lower energetic environment that permit the deposition from suspension in pelagic and hemipelagic environment evaluated as distal turbiditic environment (Mutti and Ricci, 1972; Mutti, 1992; Prothero and Schwab, 1996; Shanmugam, 2002). After this, restricted coarse-grained clastics evolved inside fine-grained clastic depend on a sediment input and proximity of source area. These coarser clastics are the products of sediment gravity flow in higher energetic shallow marine environment or reworked conglomerates in deep sea environment (Boggs, 1987; Cronin and Kidd, 1998). Fine-grained clastics that found in the lateral extension of the coarse clastics point out the deep sea environment. The high energy of environment cause to erosive base, depend on lowering of energy level, normally graded beds were deposited in middle fan turbiditic environment (Mutti and Ricci, 1972; Mutti, 1992; Shanmugam, 2002). Increasing of energy level and excess sediment input cause to reverse graded clastic deposition in proximal fan environment (Mutti and Ricci, 1972; Mutti, 1992; Shanmugam, 2002). The clastics indicate the excess sediment input and high energetic environment than the Imrahor section. Upper Paleocene (Thanetian) reef limestone fragments of clastics probably derived from the patch reefs seen in the northern part of the log area. Then again quiet environment product laminated mudstones were observed. These younger deposits were thrusted by the red colored planktic foraminifera bearing Campanian-Maastrichtian limestone and mudstones. Narrow region in front of the southern margin of the Ulukışla Basin (the Alihoca and Kırkgeçit Logs) were filled by the coarser sediments, while asymmetrically vast areas in the northern part were filled by the finer-grained clastics (in the Imrahor Log) with a different age.

Northern part of Central: Ardıçlı Log

Description: The lowermost part of this log comprises an alternation of agglomerate, andesite products of submarine volcanoes and planktic foraminifera bearing laminated mudstone, marl and limestone (VS; Fig. 8). The

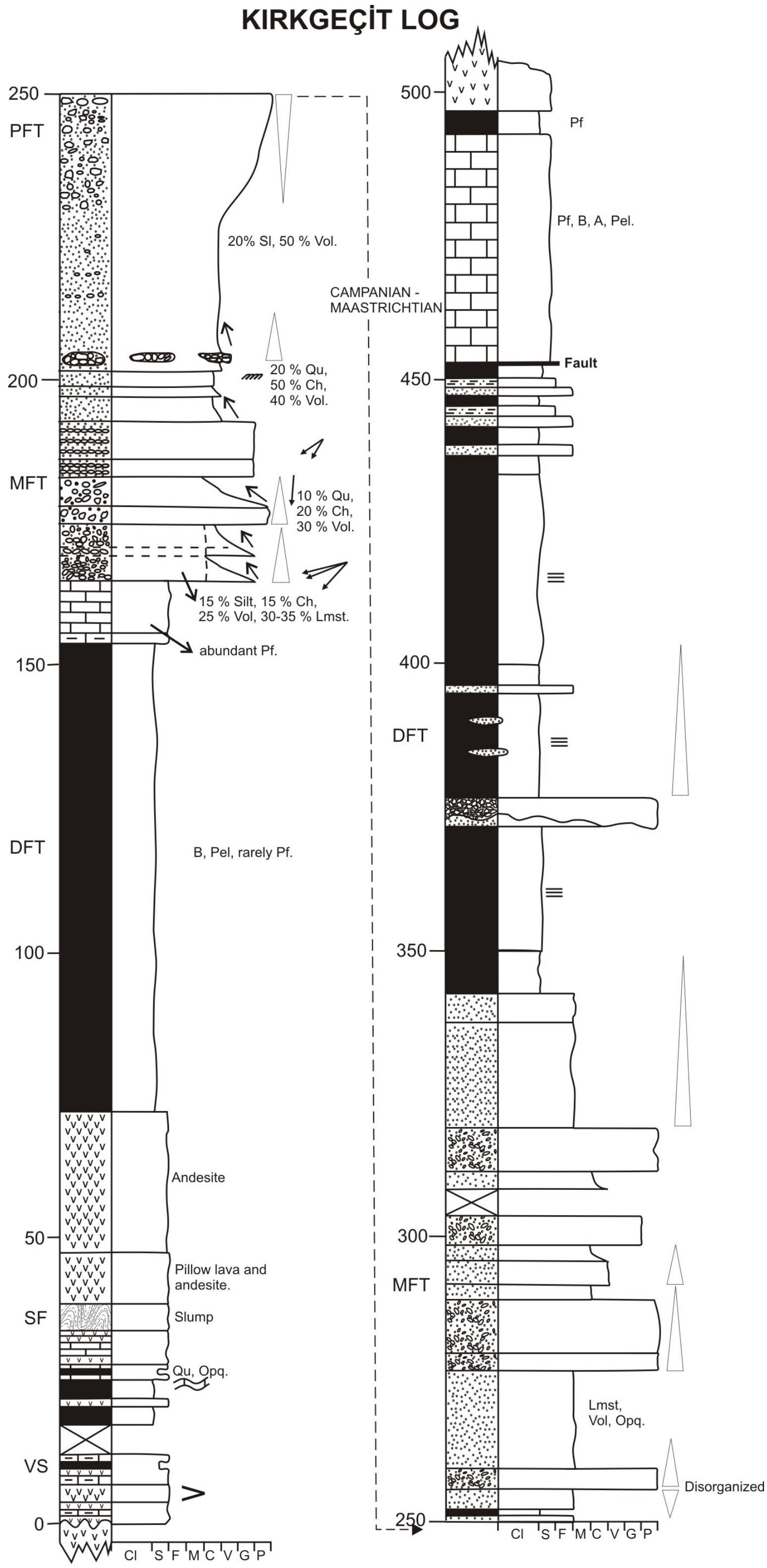

Figure 7. Kırkgeçit Log measured in the south of the central part of the Ulukışla Basin.
Şekil 7. Ulukışla Havzası'nın orta kesiminin güneyinden ölçülmüş Kırkgeçit kesiti.

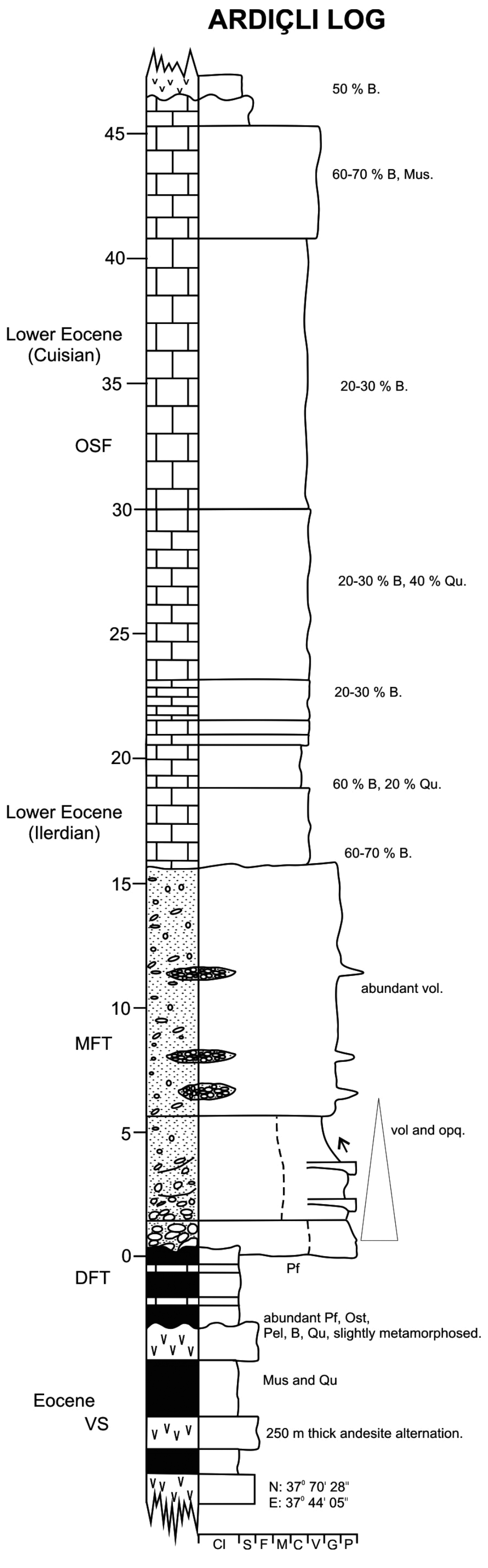

Figure 8. Ardıçlı Log measured in the north of the central part of the Ulukışla Basin.
Şekil 8. Ulukışla Havzası'nın orta kesimin kuzeyinden ölçülmüş Ardıçlı kesiti.

limestone levels are classified as a wackestone/packstone. The following fauna has been fixed from mudstones and limestones: Planktik foraminifera: *Globigerina* cf. *linaperta* FINLEY, *Acarinina* sp., *Globigerinatheka* sp., *Morozovella* sp.; radiolarian, pelecypoda, ostracoda, rare echinoids and benthic foraminifer's fragments. Paleontological data points out the Eocene age. The basal part of the detail log contains fifteen meter thick; fining upward channelized sequence including abundant volcanic rock fragments and opaque minerals derived from surrounding volcanic rocks. The sandier section of these bottom levels classified as lithicwacke that locally cuts by granule and pebble bearing channel conglomerates (MFT). The upper thirty meter of the log contains limestone (OSF). Initially medium-thick bedded, white colored, packstone with abundant benthic foraminifera (60-70 %) and lesser extent quartz (0-20 %) are found. Then thin to medium bedded wackestone, thickly bedded grainstone and medium-thick bedded wackestone with abundant quartz (0-40 %) and lesser extent benthic foraminifera (20-30 %) are observed. At the top of section, medium-thick bedded packstone with abundant benthic foraminifera (50-60 %) and lesser extent muscovite (0-20 %) were observed. These microfacies contain following fauna; Benthic foraminifera: *Alveolina* cf. *corbarica* HOTTINGER, *Alveolina ellipsoidalis* SCHWAGER, *Assilina* cf. *prisca* SCHAUB, *Asterigerina* cf. *rotula* KAUFMANN, *Asterocyclina stella taramellii* MUNIER CHALMAS, *Discocyclina archiaci bartholomei* (SCHLUMBERGER), *Discocyclina scalaris* (SCHLUMBERGER), *Gyroidinella magna* LE CALVEZ, *Lockhartia haimei* (DAVIES), *Nummulites* cf. *minervensis* SCHAUB, *Nummulites* cf. *atacicus* LEYMERIE, *Orbitocylpeus ramaraoi crimensis* LESS, *Orbitocylpeus ramaraoi ramaraoi* (SAMANTA), *Ronicothalia* cf. *couisensis* (d'ARCHIAC), *Rotalia trochidiformis* LAMARCK, *Alveolina* sp., *Assilina* sp., *Asterocyclina* sp., *Chrysalidina* sp., *Opthalmidium* sp., *Orbitoclypeus* sp., and *Orbitolites* sp. This fossil assemblage indicates the early to late Lower Eocene (the Ilerdian-Cuisian; Fig. 8). The section is nonconformably overlain by the andesites.

Interpretation: Intense submarine volcanic activity with an excess volcanic rock fragments gave way to deposition of andesites pebbles bearing agglomerates, during the subsequent quiet period mudstone and limestone developed depend on low sediment input and relatively deeper marine environmental condition (Strasser and Strohmenger, 1997; Fournier et al., 2004; Gül, 2007). High sediment input caused the lithic wacke and channelized coarser conglomerate evolutions. Normally graded clastics indicate the excess sediment input and high energy level in the middle fan turbiditic environment (Mutti and Ricci, 1972; Shanmugam, 2002). Then, sediment input was decreasing, and carbonates started to deposition. The types, abundance and size of the benthic foraminifera indicate suitable open shelf conditions. However, the high quantity extraclast (quartz + muscovite) and grainstone in the middle level of limestone indicates the higher energy environment (Fig. 8).

Some small reefal mounds surrounded by relatively deeper marine mudstone crop out between the Ardıçlı and İmrahor logs. Bioclasts bearing wackestone and packstone around the bindstone bearing patch reef core reflect sedimentation in quieter water (Strasser and Strohmenger, 1997). These reefs include: Benthic foraminifera: *Cuvillerina sireli* İNAN, *Gypsina linearis* (HANZAWA), *Miscellanea primitiva RAHAGHI*, *Rotalia trochidiformis* LAMARCK, *Discocyclina* sp. Algae: *Distichoplax biserialis* (DIETRICH), *Corallina* cf. *abundans* LEMOINE, *Amphiroa* cf. *propria* (LEMOINE). This fossil assemblage indicates the Upper Paleocene (Thanetian). These reefs show the existence of a shallow marine environment before the Eocene. The limestone in the Başmakçı Hill located in this area has been termed as the Başmakçı Limestone (Çevikbaş and Öztunalı, 1992) or the Başmakçı Member (Demirtaşlı et al., 1984; Clark and Robertson, 2002, 2005). Çevikbaş and Öztunalı (1992) suggested the Upper Paleocene age for this limestone, while Demirtaşlı et al., (1984) and Clark and Robertson (2002, 2005) consider it to be the Early Eocene.

LATE CRETACEOUS-EOCENE GEOLOGIC EVOLUTION OF THE ULUKIŞLA BASIN

The lateral and vertical stratigraphy changings, facies distribution and asymmetrical depositional characteristics demonstrate the two-phased tectono-sedimentary evolution in the Ulukışla Basin; the Late Cretaceous-Late Paleocene Extensional phase and the Late Paleocene-Eocene Compressional phase.

Interpretation of the Late Cretaceous- Late Paleocene (Thanetian) Extensional Phase

Firstly, the Upper Cretaceous shallow marine environment limestone (unconformable resting on older rocks) was deposited in the narrow region in front of the southern margin of the basin (the Campanian-Maastrichtian limestone of Kırkgeçit Log). The narrow southern margin was tectonically more active than northern margin because of the earlier subduction of northern branch of the Neotethyan Ocean and related ophiolite emplacement. In addition to the agglomerates (VS), limestones, turbiditic clastic rocks (DFT) and slumped (SF) submarine slope deposits were deposited in this margin. The alkaline volcanism in form of pillow lavas and massive lava flows reflect post collision extension within the sedimentary sequence during this stage (Alpaslan et al., 2004).

The northern-northwestern margin, during the tectonic quiescence, was covered by large and relatively deeper water until the Late Paleocene (Thanetian). The fine grained sandstone and laminated mudstone (DFT) deposited during this time interval. The sandstones of the northern region (observed in the bottom part of İmrahor log) were initially fed from the Niğde-Kırşehir Metamorphic Massif, then from the younger volcanic rocks. Later, the red algae bearing patch reefs (RC; surrounded by fine-grained clastics and marl, BR) evolved in this area. The examples of the Paleocene patch reefs also occur in the area between the Başmakçı Village and the Ardıçlı Log. Such reefs need clear, well oxygenated, warm and high nutrient environment (Strasser and Strohmenger, 1997; Gül and Eren, 2003; Gül, 2007). Topographically higher areas (formed

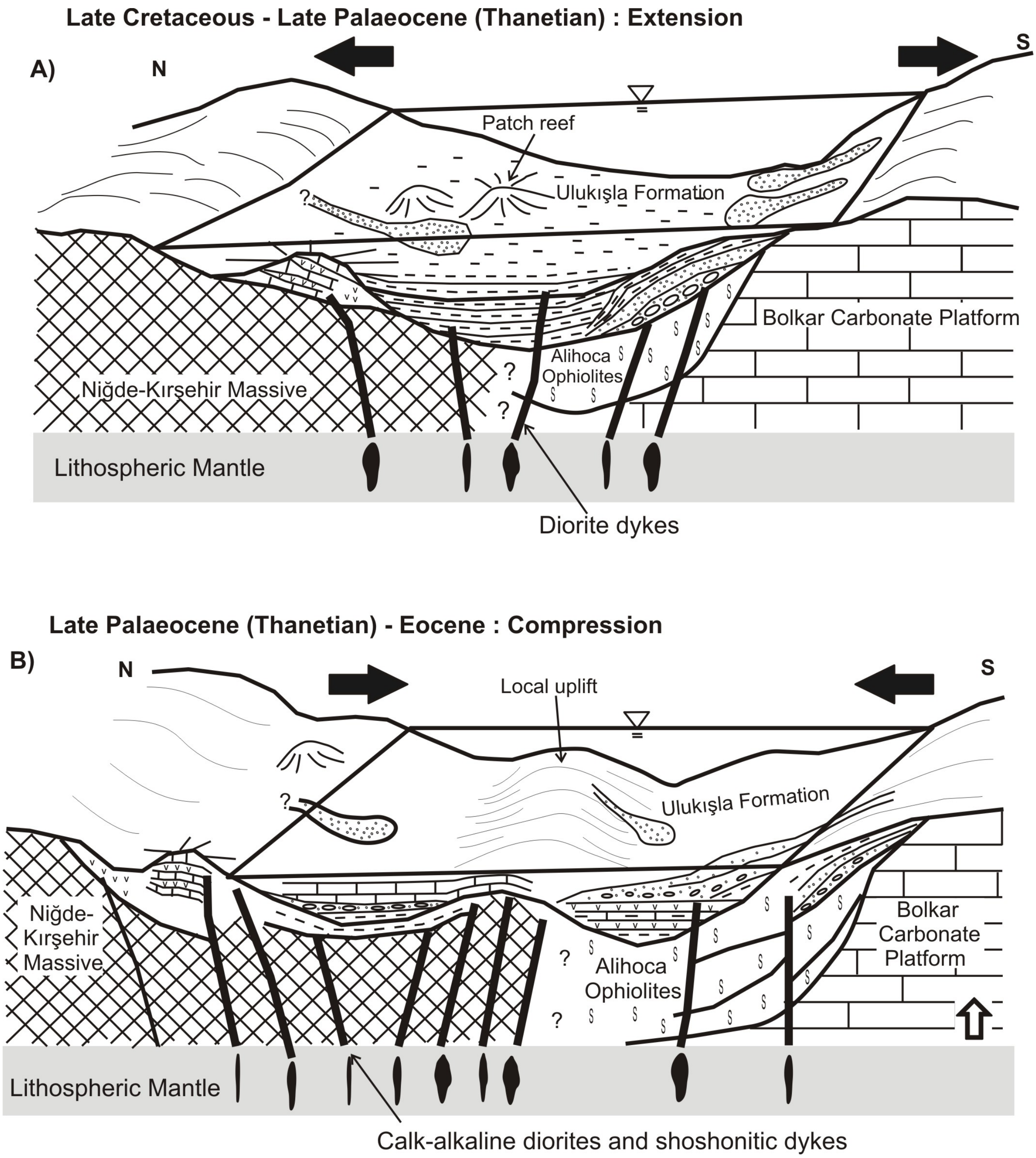

Figure 9. A) Schematic diagram showing the geologic evolution of the Ulukışla Basin during the Late Cretaceous – Late Paleocene (Thanetian). B) Schematic diagram showing the geologic evolution of the Ulukışla Basin during the Late Paleocene (Thanetian) – Eocene. (not to scale)

Şekil 9. A) Ulukışla Havzası'nın Geç Kretase – Geç Paleosen (Tanesiyen) dönemindeki jeolojik evrimini gösteren şematik blok diyagram. B) Ulukışla Havzası'nın Geç Paleosen (Tanesiyen) – Eosen dönemindeki jeolojik evrimini gösteren şematik blok diyagram.(ölçeksiz)

as a result of the volcanic activities or uplifting) created the suitable environmental condition for the reef development. The reef limestone deposition interrupted time to time by syn-sedimentary volcanism (Fig. 9A). Because the materials erupted from the volcanoes deteriorated the environmental conditions.

Interpretation of the Late Paleocene-Eocene Compressional Phase

The regional uplifting caused breaking of northwest and southern margin of the basin and sea regressed asymmetrically towards the central part of the basin. On southern flank of the basin, shallow marine deposition represented with limestone-marlstone alternation (the Kırkgeçit log) changes into clastic dominated deposition as a result of the subsidence of basin with continuous regression. Despite the basal units composing of channelized coarse clastics (MFT, PFT), younger units contains sediments derived from the Paleocene reef limestone. Furthermore, the continuous basin margin uplifting and basin subsidence caused the deepening of environment and sandy/muddy turbidites deposition (DFT). These facies and/or environmental changings can be attributed to strong tectonic effect in the Ulukışla Basin. Intense tectonic activities caused to coarser clastics evolution (MFT, PFT).

Sedimentation on northern central margin of the basin started with the deep sea mudstone, limestone and submarine andesitic rock alternations (VS) synchronously with thrusting. The fossil content listed in the Ardıçlı Log section point out the relatively deeper marine environment. Possible sea level fallings and tectonic activities caused to deposition of coarser channelized deposits. Then open shelf environment (OSF) evolved presumably due to shallowing of the area, and extraclast-rich and abundant benthic foraminifera-bearing limestone (fossil contents listed in the Ardıçlı Log section) deposited. Thus the northern and southern flanks of this intracontinental basin reveal significantly different depositional features appear to have been separated by the local uplift may evolved due to tectonic and/or magmatic activity (Fig. 9B).

Final closure of the Ulukışla Basin was achieved by compressional deformation at the end of Eocene, orientated perpendicular to the E–W axis of the basin. The subsequent uplift and erosion resulted in the sub-Oligocene unconformity, as observed around the Ulukışla Basin (Clark and Robertson, 2005). The compressional regime has been characterized by the southward thrusting and E-W trending folds (Fig. 2). In the southern part of basin, the main E-W trending thrust zone allowed the emplacement of the calk-alkaline diorites (Kurt, 2004). The ongoing compression has also resulted with emplacement of the shoshonitic dykes (Kurt, 2004).

DISCUSSION AND CONCLUSIONS

Turner and Williams (2004) indicated that the sedimentary basin inversion is compressing of formerly extensional basins. The basin inversion caused that the basin exhumation and significant sedimentary deposits changes. Several inversion basins evolution reported by different researcher in different areas during the Late Cretaceous and the Early Tertiary time coeval with the Ulukışla Basin. The Ulukışla Basin evolved under the effect of Alpine Orogeny. The compressional region from Spain to Turkey was closely attributed to northern movement ratio of the Arabian and African Plates depend on the Alpine Orogeny (Boccaletti et al.,1988; Binks and Fairhead, 1992; Bosworth, 1992; Guriaud et al., 1992; Guriaud and Bosworth, 1997). Moreover, the sedimentary basin inversion in the some African Basin, for example SW and central part of the Somalia (from the Triassic to the Early Cretaceous extension, then continue with the compressive phase with folding and faulting), was attributed with changes of the Indian Ocean spreading (Boccaletti et al.,1988). The extensions of East and Central Africa during the Late Cretaceous, wrench faulting and basin inversion of it during the Early Tertiary time was evolved under the effects of both the Indian and Atlantic Ocean spreading ratios changes (Bosworth, 1992; Guriaud et al., 1992). Guiraud and Bosworth, (1997) emphasized that several basins along the Tethyan margin from the Morocco to the Syrian Arc were folded and inverted during the Early Tertiary time. Similar inversion basin evolution was also reported in front of the NW European Alpine Foreland basin (Ziegler, 1987a, 1987b). Ziegler et al. (1995) reported Cenozoic inversion effected basins some 1600 km from the Alpine front. Golonka (2004) schematically shows inversion affects over the southern margins of the Eurasian Plates; in and around the Turkey and the Central Europe.

Guiraud and Bosworth, (1997) shows the magnetic anomalies, tectonic events in Africa-Arabian Plates and related motion of the Africa against the Eurasian. The northern movement of African Plate during the Campanian depend on the Atlantic Ocean spreading caused closing of the Neotethyan Ocean and ophiolite emplacement. Rifting of the northern margin of the African and Arabian Plates during the Campanian-Maastrichtian time referred to an extensional regime in the Ulukışla Basin. Clark and Robertson (2002, 2005) consider the Ulukışla Basin to have formed in response to extensional, or transtensional processes in the Early Tertiary time. The extensional phase in the Ulukışla Basin is characterized by the finer-grained clastics deposition in wide, relatively deeper marine environment in northern margin, while coarser-clastics are observed in narrow southern margin, which is tectonically more active. Subsequent northern movement of the African and Arabian Plates were not tolerated with the Neotethyan Ocean Crust due to subduction. Thus, the compressional regime developed in the study area. Depend on compressional phase; initially deeper marine environments, then shallow marine environment (host the Paleocene reefs) were observed. Those reefs are locally intercalated with the volcanic materials. The sedimentation shifting through the basin interior were evolved depends on regional uplifting, the Eocene sedimentation including reef limestone and clastics deposited. It is accompanied with calk-alkaline diorites and shoshonitic dykes (Kurt, 2004).

ACKNOWLEDGEMENTS

The authors thank to Kemal TASLI (Mersin University/Turkey) who determined the planktonic foraminifers. The authors warmly thank to Prof. Dr. Uğur İnci (Dokuz Eylül University/Turkey) and Prof. Dr. Haluk Temiz (Cumhuriyet University/Turkey) for their constructive criticism of the paper.

REFERENCES

Akgünlü, F., 2003. Benthic Foraminifera Association of the Tertiary Sequence in Çamardı (Niğde-Turkey) Region. Çukurova University Institute of Basic and Applied Science, MSc Thesis, 76 p. (unpublished, in Turkish with English abstract).

Alpaslan, M., Frei, R., Boztuğ, D., Kurt, M. A. and Temel, A., 2004. Geochemical and Pb-Sr-Nd Isotopic Constrains Indicating Enriched-Mantle Sources for Late Cretaceous to Early Tertiary Volcanism, Central Anatolia, Turkey. International Geology Review 46 (11), 1022-1041.

Alpaslan, M., Boztuğ, D., Frei, R., Temel, A. and Kurt, M.A., 2006. Geochemical and Pb-Sr-Nd isotopic composition of the ultrapotassic volcanics from the extension-related Çamardı-Ulukışla Basin, Niğde Province, Central Anatolia, Turkey, Journal of Asian Earth Sciences 27 (5), 613-627.

Baş, H., Ayhan, A. and Atabey, E., 1986. Petrological and Geochemical Properties of the Ulukışla-Çamardı (Niğde) Volcanics. Geological Engineering Journal of Turkey 26, 27-34.

Binks, R.M. and Fairhead, J.D., 1992. A plate tectonic framework for the evolution of the Cretaceous rift basins in West and Central Africa. In: Geodynamics of Rifting, Case History studies on Rifts: North and South America, Africa-Arabia. (ed. P.A. Ziegler), Tectonophysics, 213 (2), 141–151.

Boccaletti, M., Dainelli, P., Angelucci, A., Arush, M.A., Cabdulqaadir, M.M., Nafissi, P., Piccoli, G. and Robba, E., 1988. Folding of the Mesozoic cover in SW Somalia: a compressional episode related to the early stages of Indian Ocean evolution. J. Pet. Geol. 11, 157–168.

Boggs, S., 1987. Principles of Sedimentology and Stratigraphy. Macmillan Publ. Co., New York, 784 p.

Bosworth, W., 1992. Mesozoic and early Tertiary rift tectonics in East Africa. Tectonophysics 209, 115-137.

Bouma, A.H., 1962. Sedimentology of some flysch deposits. A graphic approach to facies interpretation: Elsevier, Amsterdam.

Cater, J. M. L., Hanna, S. S., Ries, A. C. and Turner, P., 1991. Tertiary Evolution of the Sivas Basin, Central Turkey. Tectonophysics 195, 29-46.

Clark, M. and Robertson, A., 2002. The role of the Early Tertiary Ulukışla Basin, Southern Turkey, in Suturing of the Mesozoic Tethys Ocean. Journal of the Geological Society, London 159, 673–690.

Clark, M. and Robertson, A., 2005. Uppermost Cretaceous–Lower Tertiary Ulukışla Basin, south-central Turkey: sedimentary evolution of part of a unified basin complex within an evolving Neotethyan suture zone. Sedimentary Geology 173, 15–51.

Cronin, B.T. and Kidd, R.B., 1998. Heterogeneity and lithotype distribution in ancient deep-sea canyons: Point Lobos deep-sea canyon as a reservoir analogue. Sedimentary Geology 115, 315–349.

Çevikbaş, A. and Öztunalı, Ö., 1992. Geology of the Ulukışla-Çamardı (Niğde) Depositional Basin after Maastrichtian, Bulletin of Mineral Research and Exploration Institute of Turkey (MTA) 114, 155-172 (in Turkish, with English abstract).

Demirtaşlı, E., Turhan, N., Bilgin, A. Z. and Selim, M., 1984. Geology of the Bolkar Mountains. In: Tekeli, O. and Göncüoğlu, M.C. (Eds.), Geology of the Taurus Belt, Proceedings of the International Symposium on the Geology of the Taurus Belt, pp. 125-141.

Dunham, R. J., 1962. Classification of carbonate rocks according to depositional texture. In: W. E. Ham (Ed.), Classification of carbonate rocks, Amer. Assoc. Petroleum Geologists Mem. pp. 108-121.

Embry, A.F. and Klovan, J. E., 1971. A Late Devonian ReefTract on Northeastern Banks Island. Bulletin of Canadian Petroleum Geology, v. 19, p. 730-781.

Fournier, F., Montaggioni, L., Borgomano, J., 2004. Paleoenvironments and high-frequency cyclicity from Cenozoic South-East Asian shallow water carbonates: a case study from the Oligo-Miocene buildups of Malampaya (Offshore Palawan, Philippines). Marine and Petroleum Geology 21, 1–21.

Golonka, J., 2004. Plate tectonic evolution of the southern margin of Eurasia in the Mesozoic and Cenozoic. Tectonophysics 381, 235– 273.

Göncüoğlu, M. C., 1986. Geochronological data from the Southern Part (Niğde Area) of the Central Anatolian Massif: Bulletin of Mineral Research and Exploration Institute of Turkey (MTA) 105/106, 111-124.

Göncüoğlu, M. C., Toprak, G. M. V., Kuşçu, İ., Erler, A. and Olgun, E., 1991. Geology of the Western Part of the Central Anatolian Massif, Part I: Southern Part Ankara, Turkey, METU-TPAO Project Report, 140 pp (in Turkish, unpublished).

Görür, N., Oktay, F. Y., Seymen, I., and Şengör, A. M. C., 1984. Palaeotectonic Evolution of the Tuzgölü Basin Complex, Central Turkey: Sedimentary Record of a Neotethyan Closure. In: Dixon, J. E. and Robertson, A. H. F. (Eds.), The Geological Evolution of the Eastern Mediterranean, Geological Society of London, Special publication 17, pp. 467-482,

Görür, N., Tüysüz, O., and Şengör, A. M. C., 1998. Tectonic Evolution of the Central Anatolian Basins. International Geology Review 40, 831-850.

Görür, N. and Tüysüz, O., 2001. Cretaceous to Miocene Palaeogeographic Evolution of Turkey: Implications for Hydrocarbon Potential. Journal of Petroleum Geology 24, 119-146.

Guezou, J. C., Temiz, H., Poisson, A. and Gürsoy, H., 1996. Tectonics of the Sivas Basin: The Neogene Records of the Anatolian Accretion along the Inner Tauride Suture. International Geology Review 88, 901-925.

Guiraud, R., Binks, R. M., Fairhead, J. D. and Wilson, M., 1992. Chronology and geodynamic setting of Cretaceous-Cenozoic rifting in West and Central Africa. Tectonophysics 213 (1-2), 227-234.

Guiraud, R. and Bosworth, W., 1997. Senonian basin inversion and rejuvenation of rifting in Africa and Arabia: synthesis and implications to plate-scale tectonics. Tectonophysics 282, 39-82.

Gül, M and Eren, M., 2003. The Sedimentary Characteristics of Dağpazarı Patch Reef (Middle Miocene, Mut-İçel/Turkey). Carbonates and Evaporites 18 (1), 51-62.

Gül, M., 2007. Effects of Antecedent Topography on Reefal Carbonate Deposition: Early-Middle Miocene of the Adana Basin, S Turkey. Journal of Asian Earth Science 31 (1), 18-34.

Gürer, Ö. F. and Aldanmaz, E., 2002. Origin of the Upper Cretaceous-Tertiary Sedimentary Basins within the Tauride-Anatolide Platform in Turkey. Geological Magazine 139 (2), 191-197.

Heckel, P.H., 1972. Recognition of ancient shallow marine environments. In: Rigby, J.K., Hamblin, W.K. (Eds.), Recognition of Ancient Sedimentary Environments. Society of Economic Palaeontologists and Mineralogists Spec. Publ. No.: 16, pp. 226–286.

İşler, F., 1988. Mineralogic-Petrographic and Geochemical Investigation of the Çiftehan (Niğde) Volcanics. Geological Bulletin of Turkey 31, 29-36,

Kalelioğlu, Özgür, Zorlu, K., Kurt, M.A., Gül, M. and Güler, C., 2009. Delineating compositionally different dykes in the Ulukla basin (Central Anatolia, Turkey) using computer-enhanced multi-spectral remote sensing data. International Journal of Remote Sensing 30 (11), 2997—3011.

Ketin, İ. and Akarsu, İ., 1965. Report about the Geology of Ulukışla Tertiary Basin TPAO Report No: 339 (in Turkish, unpublished).

Koçyiğit, A. and Beyhan, A., 1998. A new Intracontinental Transcurrent Structure: the Central Anatolian Fault Zone, Turkey. Tectonophysics 284, 317-336.

Kurt, M.A., 2004. Mineralogical, petrographical and geochemical investigations of the gabbroic and dioritic dykes cuts the Ulukışla (Niğde) volcano-sedimentary sequence. Mersin University, Physical and Applied Science Institute, MSc thesis. 71 pp. (in Turkish with English abstract, unpublished).

Mutti, E. and Ricci, L.F., 1972. Le türbiditi dell' Appenino settentrionale: introduzione del analizi di facies. Soc. Geol. Italiana, Mem. 11, 161–199.

Mutti, E., 1992. Turbidite Sandstones, AGIP S. P. A. pp. 275

Nazik, A. and Gökçen, N., 1989. Stratigraphical Interpretation of Ulukışla Tertiary Sequence according to Foraminifera and Ostracoda Fauna. Geological Bulletin of Turkey 32(1-2), 89-99.

Okay A.I., Tansel, İ. and Tüysüz, O., 2001. Obduction, subduction and collision as reflected in the Upper Cretaceous-Lower Eocene sedimentary record of western Turkey. Geological Magazine 138, 117-142.

Oktay, F. Y., 1982. Stratigraphy and Geological evolution of the Ulukışla and Surrounding Area. Geological Bulletin of Turkey 25 (1), 15-23,

Özgül, N., 1984. Stratigraphy and tectonic evolution of the Central Taurides. Geology of the Bolkar Mountains. In: Tekeli, O. and Göncüoğlu, M.C. (Eds.), Geology of the Taurus Belt, Proceedings of the International Symposium on the Geology of the Taurus Belt, pp. 77-90.

Pettijohn, F. J., Potter, P. E. and Siever, R., 1987. Sand and Sandstone. Springer Verlag, Berlin, pp. 553.

Poisson, A., Guezou, J. C., Öztürk, A., İnan, S., Temiz, H., Gürsoy, H., Kavak, K. S. and Özden, S., 1996. Tectonic Setting and Evolution of the Sivas Basin. International Geology Review 38, 833-853.

Polat, A. and Casey J.F., 1995. A structural record of the emplacement of the Pozanti-Karsanti ophiolite onto the Menderes-Taurus block in the late Cretaceous, eastern Taurides, Turkey. Journal of Structural Geology 17(12), 1673-1688.

Prothero, D.R. and Schwab, F., 1996. Sedimentary Geology. New York, W.H. Freeman, 575 p.

Robertson, A. H. F. and Dixon, J. E., 1984. Introduction: Aspects of the Geological Evolution of the Eastern Mediterranean. In: Dixon, J. E. and Robertson, A. H. F. (Eds.), The Geological Evolution of the Eastern Meditararnean, Geological Society of London, Special publication 14, pp. 1-74.

Shanmugam, G., 2002. Ten turbidite myths. Earth-Science Reviews 58, 313–343.

Strasser A. and Strohmenger C., 1997. Early Diagenesis in Pleistocene Coral Reefs, Southern Sinai, Egypt: Response to Tectonics, Sea-Level and Climate. Sedimentology 44(3), 537-558.

Şengör, A. M. C. and Yılmaz, Y., 1981. Tethyan Evolution of Turkey: A Plate Tectonic Approach. Tectonophysics 75, 181-241.

Turner, J. P. and Williams, G. A., 2004. Sedimentary basin inversion and intra-plate shortening. Earth Science Reviews 65, 277–304.

White J.D., Polat A., Casey J.F. and Kerrich R., 1996. Geochemical characteristics of accreted material beneath the Pozanti-Karsantı ophiolite, Turkey: Intra-oceanic detachment, assembly and obduction. Tectonophysics 263 (1), 249-276.

Whitney, D. L. and Hamilton, M. A., 2004. Timing of high-grade metamorphism in central Turkey and the assembly of Anatolia. Journal of the Geological Society 161 (5), 823-828.

Yetiş, C., 1984. New observations on the age of the Ecemis Fault. Geology of the Bolkar Mountains. In: Tekeli, O. and Göncüoğlu, M.C. (Eds.), Geology of the Taurus Belt, Proceedings of the International Symposium on the Geology of the Taurus Belt, pp. 159-164.

Yetiş, C. and Demirkol, C., 1984. Geotectonic Evolution of the Ecemiş Fault Belts, Bulletin of Earth Science of Hacettepe University 11, 1-12. (in Turkish with English abstract).

Yılmaz, Y., Tüysüz, O., Yigitbaş, E., Genç, Ş. C. and Şengör, A. M. C., 1997. Geology and Tectonic Evolution of the Pontides. In: A. G. Robinson (Ed.), Regional and Petroleum Geology of the Black Sea and Surrounding Region, American Association of Petroleum Geologists Memoir no: 68, pp.183-226.

Ziegler, P.A., 1987a. Compressional Intra-Plate Deformation in the Alpine Foreland-an introduction. Tectonophysics 137, 1-5.

Ziegler, P.A., 1987b. Late Cretaceous and Cenozoic intra-plate compressional deformations in the Alpine foreland—a geodynamic model. Tectonophysics 137, 389-420.

Ziegler, P.A., Cloetingh, S. and van Wees, J.-D., 1995. Dynamics of intra-plate compressional deformation: the Alpine foreland and other examples. Tectonophysics 252, 7–59.