TECTONO-SEDIMENTARY EVOLUTION OF THE EOCENE TRANSGRESSIVE DEPOSITS IN THE ACIGÖL, BURDUR AND ISPARTA AREAS (SW TURKEY)

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Abstract
The Eocene transgressive deposits of the Acıgöl, Burdur and Isparta basins are the best exposed of the SW Turkey and shed light on one of the outstanding problems of the tectono-sedimentary evolution during paleotectonic and neotectonic period. In the present paper we describe a tectonic model of the progressive foreland migration of the allochthonous units such as Lycian and Antalya nappes, initial emplacement onto stable carbonate platform in the Early Oligocene, carrying piggy-back basins and incorporating from alluvial fan to deep-marine deposits recognized in these terrigenous successions.
In general, the facies and structural observations on the overall Mid-Late Eocene clastic sequences, outcropping in behind the Lycian nappes, indicate: i) the alluvial fan to shallow marine settings of the Başçeşme Fm in Acıgöl, ii) the Varsakyayla Fm in Burdur and iii) proximal to distal flysch facies trend of the Kayıköy Fm in Isparta. The collected data allow us to hypothesize that the Mid-Late Eocene tectono-sedimentary history was characterized by a terrigenous clastics, probably lying on the constructing tectonic edifice and then deformed and covered by a piggy-back like sequence. The tectono-sedimentary evolution of the Eocene transgressive in SW Turkey has been probably developed through a progressive migration towards the foreland basin.

Keywords: Paleotectonic, neotectonic, Eocene transgressive deposits, Lycian nappes

1. Introduction

Southwestern Turkey is a place of the active continental extension and thus the most seismically active regions of the world (Jackson and McKenzie, 1984; Bozkurt, 2001). This region is affected in order of NW-SE, N-S and NE-SW extensional neotectonic regimes during the late Miocene and the result of this regime has been formed E-W, NE and NW-trending depression fields (Fig. 1).

According to Poisson et al., (2003), tectonic evolution stages of SW Turkey can be divided into four main periods (from latest Cretaceous to the late Miocene): i) closure of the Pamphylian basin and emplacement of Antalya nappes (during the latest Cretaceous and the Paleocene), ii) emplacement of Lycian nappes (end of Eocene-Early Oligocene), iii) evolution of the Oligocene molasse basins, iv) opening of the Baklan and Acıgöl grabens (late Miocene) under the NW-SE and

N-S extensional regimes of which has developed simultaneously (Poisson et al., 2003). The Acıgöl, Burdur and Isparta basin are known to have controlled the tectono-stratigraphic evolution of parts of the SW Turkey since the Upper Miocene.

In this paper, we document the depositional (sediment distribution, facies interpretation, sediment transport) and tectonic (compressional and extentional events) processes that operated on these three basins (Acıgöl, Burdur and Isparta) from Eocene to recent. In particular, we focus on Başçeşme, Varsakyayla and Kayıköy Formations of these basins respectively and assess the role of late Eocene-Miocene tectonics (paleotectonic and neotectonic). We also consider possible tectonic-sedimentary models for the evolution of these Eocene transgressive basins.

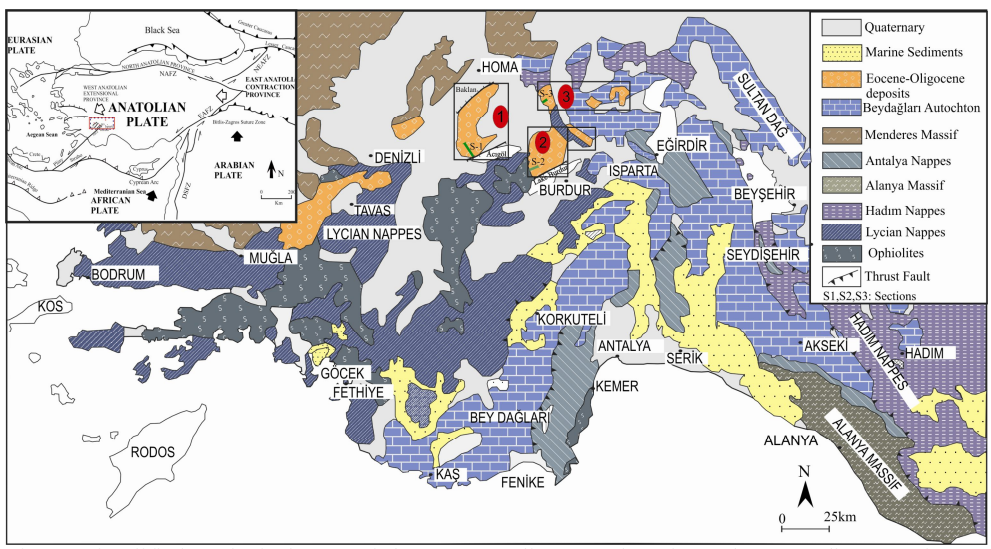

Fig. 1. Simplified geological map of the Eocene-Oligocene deposits and surrounding area in SW Turkey. (1) Acıgöl, (2) Burdur and (3) Isparta regions.

2. Methods and Terminology

The Eocene deposits have been studied in three sections cropping out around Acıgöl, Burdur and Isparta regions. The term facies is used to average grain size, grain textural parameters including type of framework support, orientation fabric, grading, roundness, sorting and type of stratification, as well as sometimes the internal structures and geometry of clastic bodies.

3. Geological setting

In this study, the geological framework of this study area has been focused on three mid-late Eocene localities: Acıgöl, Burdur and Isparta basins, respectively. One of the study localities is the north side of Acıgöl graben and named as the Başçeşme Formation (Göktaş et al., 1996). The Acıgöl graben is located 60 km northeast of Denizli and known as a NE- trending graben in the southwest of Turkey. The basin bounding faults of the Acıgöl graben are typically oblique-slip faults with an almost straight outcrop pattern (Bozkurt, 2003). The Başçeşme Formation, deposited in alluvial fan to shallow marine environment without any stratigraphical break (Toker, 2009). The Burdur basin is located in the north of Lake Burdur and named as the Varsakyayla Formation. The Varsakyayla Formation (Upper Lutetian-Pribonian) rests transgressively on the Lycian nappes and crops out in a restricted area at the north of Lake Burdur. This formation generally consists of sandstone and mudstone alternations at the lower part. The coal lenses and seams are present in the mudstones. Upper parts of the Varsakyayla Formation mainly consist of foraminifera-bearing cream-coloured limestones (Akkiraz, 2008 Toker, 2009). The Middle-Late Eocene Kayıköy Formation crops out between Isparta and Burdur cities. It consists mainly of flysch like turbiditic sediments such as sandstone and mudstone alternation and is unconformably overlain by the Oligocene deposits.

The study areas are affected by various tectonic regimes of different ages. During these periods there was the development many important geological events and structural deformation. The paleotectonic period has been prevailed in western Anatolia and is mostly characterized by compressive tectonic regime, ophiolitic melange nappes setting, NNW trending mega-folds and great reverse faults. The neotectonic period is dominated by an extentional regime and is characterized by block faulting, NNE trending dip-slip normal faulting, horsts-grabens and Mio-Pliocene aged maar type volcanism (Karaman and Hançer, 1993; Koçyiğit, 2005; Platevoet et al., 2008; Elitok et al., 2010). Lycian nappes and overlying supra–allochthonous sediments occupy a large area between Menderes Massif in the north and Bey Dağları in the east. The Lycian nappe zone in the SW-Anatolia consists dominantly of serpantinized peridotite, gabbro, diabase, chert, and giant limestone olistolithes. Furthermore, the Mesozoic carbonate sediments belonging to Bey Dağları autochthon are also observed around the area surrounding Isparta. Jurassic–Cenomanian carbonates of the Bey Dağları masif occupy a large part of the region and consist dominantly of neritic and pelagic limestones, dolomitic limestones and dolomites.

The Burdur - Isparta region is a transitional zone between two distinct neotectonic domains in Turkey: The Burdur graben system as the northeastern part of the Fethiye-Burdur fault zone and the Kovada graben at the apex of the Isparta angle.

Each field represents a particular stress regime. These basins continue to settle progressively getting deeper from southwestern (Acıgöl, Burdur) toward the eastern (Isparta) direction.

4. Sedimentary features of the Eocene sequences

Middle-Upper Eocene sedimentary sequences in Başçeşme, Varsakyayla and Kayıköy Formations (SW Turkey) are characterized mainly by the transgressive sequence. The Başçeşme Formation consists of four members (from bottom to top), the Dazlak, Beşparmak reef, Maden and Asar members (Göktaş et al. 1989). The Dazlak member, which is barren of microfossils, generally comprises a reddish conglomerate and sandstone alternation of transgressive character. The conglomerates are coarse–grained and poorly sorted (Fig.2). Channel fills occur at some levels in the sandstone sequence. The Dazlak member was interpreted as alluvial-fan deposits by Şahbaz and Görmüş (1992). The Maden member, transitional with the underlying Dazlak member, generally consists of yellowish sandstone and mudstone alternations and includes conglomerate and reefal limestone lenses. The Maden member, deposited in a fan-delta environment, also contains coal seams and carbonaceous mudstone lenses (Einsele, 2000). Moreover, shallow marine macrofossils–such as gastropods and bivalves–are abundant in the sandstones. The last member of the Eocene transgressive sequence is the Asar member, which generally comprises cream–colored reefal limestones. In some places, the member includes conglomerate, sandstone, sandy limestone and mudstone. It has abundant macrofossils and microfossils, such as coral, benthic foraminifers, gastropods and bivalves. Further up the foraminiferal limestones rich in larger foraminifera (in particular, such as *Nummulites fabiani, Discocyclina* sp., *Halkyardia*) and coralline algae were deposited. It was deposited in an intertidal environment, including an ecologic reef complex (Göktaş et al. 1989; Akkiraz et al. 2006). The precise age of the Başçeşme Formation has been found Bartonian-Priabonian by palynological and foraminiferal data (Akkiraz, 2008). The Eocene Başçeşme Formation overlies unconformably the allochthonous Lycian nappes and in turn overlain unconformably by Oligocene molasse deposits which are called the Acıgöl group (Fig.5). The Pliocene sediments rest unconformably over the Acıgöl group (Göktaş et al. 1989; Sözbilir, 2002; Akkiraz et al. 2006; Sözbilir, 2007).

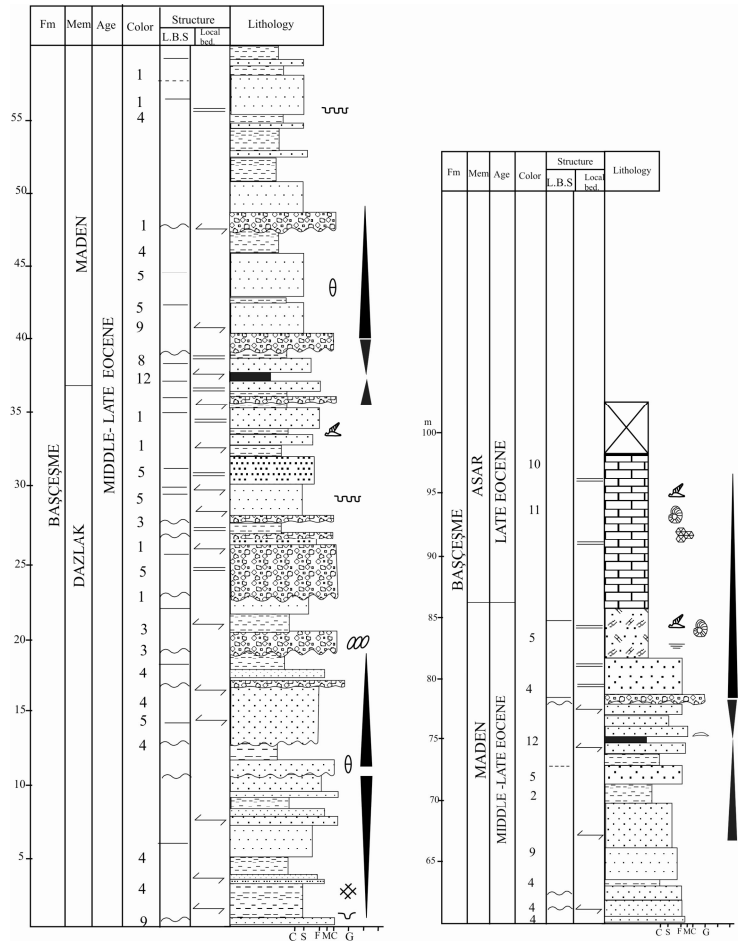

Fig. 2. Measured section of Başçeşme Formation in the northern part of Acıgöl. It can be shown in figure 1, S-1 section.

The Varsakyayla Formation is made up mainly of conglomerate, sandstone, mudstone and reefal limestone (Fig. 3). The lower part of the sequence consists of sandstone and mudstone alternation. Sandstones are generally greyish and comprise channel-fills, cross–beddings, hematite concretions, plant debris and bioclast at some part. The conglomerates poorly sorted, derived from ophiolites occur through the upper part of the sequences. Additionally, bivalves and gastropod –bearing limestone are also present in the sequence. The limestone including bivalves, gastropods, algae and benthic foraminifers are dominant through the upper part of the sequence. Generally, Varsakyayla Formation has been deposited in a shallow beach environment under terrestrial influence (Fig 5). The age of the Varsakyayla Formation has been found Bartonian-Priabonian by palynological data (Akkiraz et al., 2006; Akkiraz, 2008). The Varsakyayla Formation is unconformably overlain by Oligocene sediments.

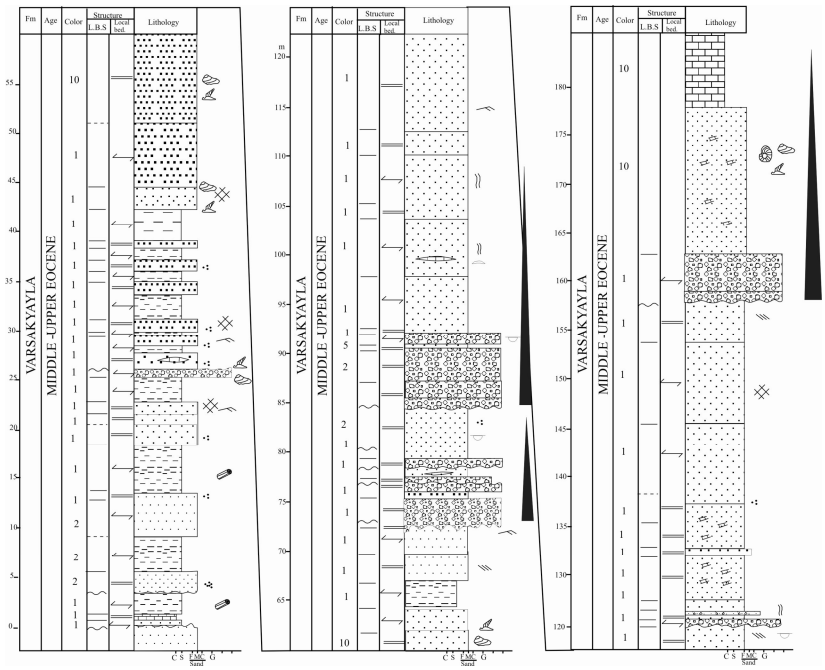

Fig. 3. Measured section of Varsakyayla Formation in the northern part of Burdur Lake. It can be shown in figure 1, S-2 section.

Allochthonous Eocene flysch deposits were reported as a tectonic slice at the apex of the Isparta Angle: beneath the Antalya Complex and Lycian nappes (Poisson et al., 2003). The Middle Eocene Kayıköy Formation which is generally composed of conglomerate, sandstone, mudstone alternation in flysch like facies (Fig.4). Fining and coarsening upward sequences also occur. Blockstones are poorly sorted and include hematite concretions. Shallow marine fossils occur in the fine grained sediments consisted of sandstone, mudstone. Sandstones comprise hematite concretions, bioturbations, bioclasts, coalified plant detritus and also conglomerate lenses. Conglomerates, which are generally moderately to poorly sorted, derived from the basement rocks of serpentine, diabase and limestone. Thick bedded sand–mud couplets with well developed normal grading and commonly T-abc division of Bouma sequence are represented to deposit from turbidity currents, ranging from high concentration to low concentration (Stanley and Kelling 1978; Stow and Piper, 1984). The Eocene turbiditic sediments around Isparta area can be termed as flysch sediments (Fig.5). The Mid-late Eocene Kayıköy Formation is unconformably overlain by the İncesu Formation.

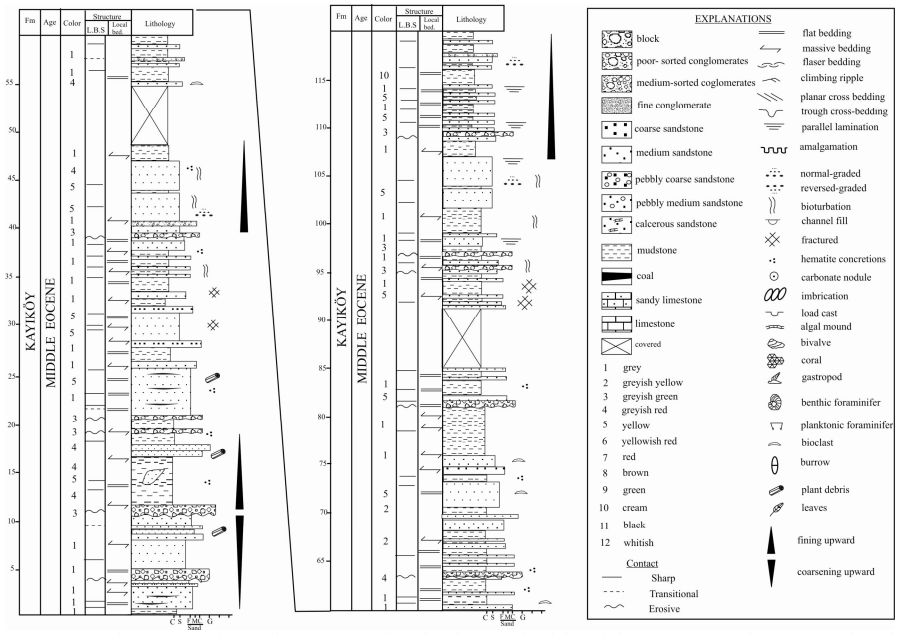

Fig. 4**.** Measured section of Kayıköy Formation in the north side of the Isparta region. It can be shown in figure 1, S-3 section.

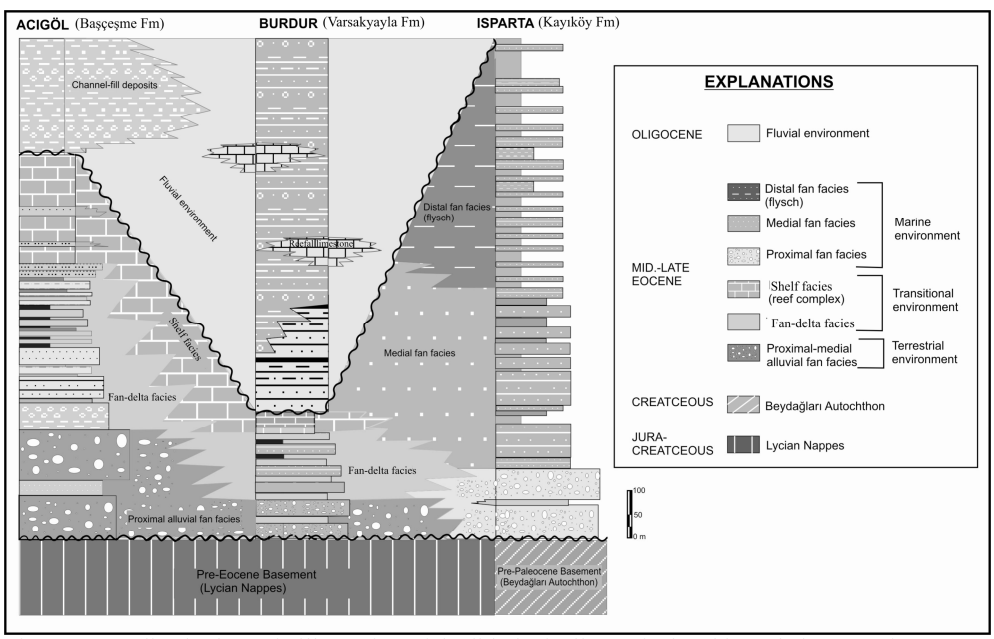

Fig. 5. Generalized schematic illustration of the lithologically vertical and lateral changes of Eocene – Oligocene outcrops in the study areas.

5. Tectono-sedimentary constraints

The collected data, concerning the preliminary facies analysis of the Mid-Late Eocene transgressive deposits of the Başçeşme, Varsakyayla and Kayıköy Formations, and the Lycian ophiolithic mélange which has progressively affected these deposits, place some constraints on the tectono-sedimentary evolution of the SW Turkey

In SW-Anatolia, two sets of nappes thrust over the Bey Dağları carbonate platform: the Lycian Nappes to the northwest, and the Antalya Nappes to the east (Poisson, 1977; Gutnic et al., 1979; Robertson, 2000). The Lycian Nappes, issued from the Northern branch of the Neotethys were initially thrust southwards upon the margin of the Anatolian micro-continent during the Late Cretaceous. Subsequent southwards thrusting across the Anatolian micro-continent brought the Lycian Nappes to their present position during the Langhian (Poisson, 1977).

The Palaeocene– Upper Eocene supra–allochthonous sediments which are observed around the southwestern Turkey rest unconformably on different tectonostratigraphic units, such as the Lycian and Beyşehir-Hoyran-Hadım nappes (Poisson, 1976; Özkaya, 1991; Şenel, 1991; Collins and Robertson, 1997, 1998, 1999, and 2003), the Menderes Massif (Poisson, 1976; Özkaya, 1991; Özer et al., 2001) and the Bey Dağları carbonate platform (Özkaya, 1991; Collins and Robertson, 1998). The non– metamorphosed Palaeocene–Eocene supra–allochthonous sediments generally consist of turbiditic sandstone–mudstone alternations, coal-bearing sandstones and mudstones, bioclastic and reefal limestone lenses, blocks of limestone (Fig. 6). The supra–allochthonous sediments are separated from the basement rocks by a regional unconformity (Sözbilir, 2002).

According to Collins and Robertson (2003), The Lycian Thrust Sheets and the Lycian Peridotite Thrust Sheet were initially emplaced on the Menderes Massif by latest Cretaceous time, due to closure of the northern Neotethyan oceanic basin, probably northward-dipping subduction zone. Also, Collins and Robertson (2003), interpreted that the unstable deeper water Eocene turbiditic sediments and related debris-flow deposits indicate that to record reactivation of the underlying thrust pile related to renewed southeastward thrusting on the Beydağları carbonate platform after Middle Eocene time.

Fig. 6. Field photos of the Eocene outcrops and relationship with Oligocene sediments in Acıgöl (Başçeşme Fm.), Burdur (Varsakyayla Fm.) and Isparta (Kayıköy Fm.). (a-b) Başçeşme Formation in Acıgöl area; (c) Varsakyayla Formation in Burdur area; (d-e) thin-bedded sandstone-mudstone alternations of the Kayıköy Formation and contact with debris flow of the Oligocene sediments in Isparta area.

The tectono-sedimentary evolutions and geological settings of the supra-allochthonous basins show on figure 7. According to this figure, during the Middle Eocene period the Lycian Peridotite thrust sheets and the Lycian ophiolithic nappes emplaced due to southeastward thrusting on the Beydağları carbonate platform. During the Late Eocene-Early Miocene period the supra – allochthonous basins and their sedimentary sequences formed on the allochthonous ophiolithic basement under the NW-SE extensional tectonic conditions within the SW-Anatolia.

On the other hand, the Oligocene –Late Miocene sediments, which unconformably overlies the supra–allochthonous sediments which the latter have been regarded as the sediments of piggy–back basins (Akgün et al., 2000; Gürer and Yılmaz, 2002; Sözbilir, 2002) or molasses basins (Koçyiğit, 1984; Göktaş et al., 1989; Yağmurlu, 1994; Sözbilir, 2005). These basins are accepted as sequences of continental and shallow marine sediments of transition between palaeotectonic and neotectonic periods in western Turkey (Koçyiğit, 1984). In these basins, sedimentary sequences are described by interdependence between tectonism and sedimentation, the latter of which involves fining–and coarsening–upward sedimentary cycles. In some places, the sequences include reefal limestones. The Oligocene-Late Miocene

sediments, which are generally composed of coarse-grained conglomerates, have unconformable boundary with underlying Eocene flysch sediments.

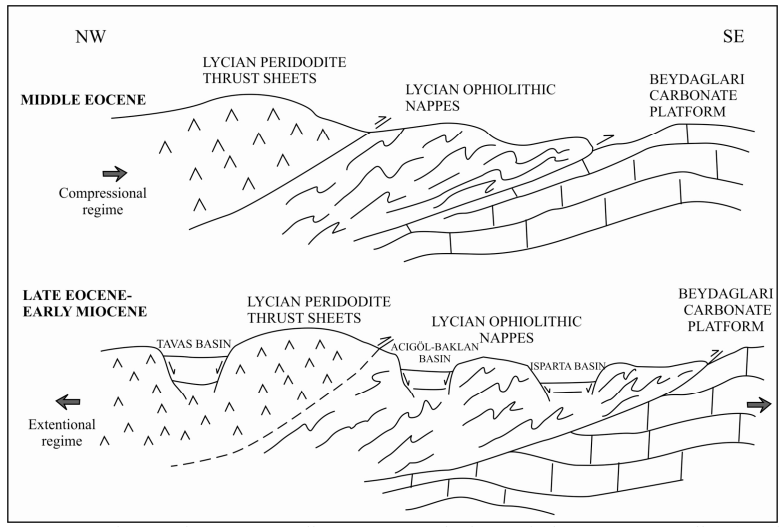

Fig.7. The cross-sections of tectono-sedimentary evolution of the SW Anatolia (modified from Collins and Robertson, 2003).

The thick bedded and coarse grained clastic sediments cover the metamorfic units of the Menderes Massif in the northern regions of Acıgöl and Oligocene coarse conglomerates cover the ophiolithic melange and Mesozoic carbonate units in the NE regions of Isparta. Acıgöl and Burdur grabens began to form during neotectonic period of Turkey and extension in the region commenced in the Late Miocene, and still active at present (Kaymakcı, 2006).

6. Conclusions

Our goal has been to gain insight into the Eocene transgressive deposits and particularly the tectono-sedimentary developing of Acıgöl-Burdur-Isparta basins and for this reason it has been focused on three Mid-late Eocene formations. These are Başçeşme, Varsakyayla and Kayıköy Formations, respectively.

After the emplacement of the Lycian nappes in the SW-Anatolia, presumably the Paleocene-Upper Eocene supra-allochthon basin formed on the ophiolithic basement. The sedimentary sequence of the supra-allochthon basin consists dominantly of alluvial –fan, fluvial, tidal and shallow marine sedimentary constituents.

The collected data allow us to hypothesize that the Paleocene-Upper Eocene tectono-sedimentary history was characterized by pre-transgressive conglomerates-sandstone, transgressive shallow marine-marine deposits (reefal limestone and flysch like fine grained sediments). The tectono-sedimentary evolution of the Eocene outcrops in SW Anatolia has been probably developed through progressive different depositional environments (such as shallow to basinal marine) towards to the eastern part of Turkey.

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