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CONTENTS

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STRATIGRAPHIC AND STRUCTURAL FEATURES OF THE YEŞİLBARAK NAPPE IN WESTERN TAURUS RANGE AND ITS COMPARISON WITH THE SIMILAR UNITS IN SE ANATOLIA AND NORTH CYPRUS

Mustafa ŞENEL*

ABSTRACT.- The Yeşilbarak nappe is situated in between the Lycian nappes and Beydağları autochthon in southeast Turkey; it is a continuous unit for long distance and has an intermediate zone character. It is generally made up of turbiditic elastics of Upper Lutetian-Lower Miocene age and comprises of more or less different structural units such as Gömbe and Yavuz units. The latter is observed as overlying the former unit and in many places it is overturned. At the base of the Gömbe unit, the Gebeler formation which is made up of Upper Cretaceous neritic carbonates takes place. The Gömbe unit is represented by two formations: a) Upper Lutetian-Lower Miocene Elmalı formation which comprises sandstone with limestone intercalations, siltstone and claystone, and b) Upper Burdigalian-Lower Langhian Ucarsu formation which is made up of sandstone with limestone bands and lenses, and conglomerates. The second structural unit of the Yeşilbarak nappe, the Yavuz unit is represented by Yavuz formation which comprises limestone-interbedded sandstone, siltstone and claystone of Upper Lutetian-Priabonian age. The Gebeler and Uçarsu formations of Gömbe unit are observed only in limited locations. The Yeşilbarak nappe has undergone intensive deformation related to the southward movement of the Lycian nappes at the end of the Lower Miocene that resulted in a structure of folded, fractured and overthrusted. The unit has been thrusted along a distance of tens of kilometers southward together with the Lycian nappes on the Beydağları autochthone. In southeast Anatolia, in between the Bitlis-Pötürge-Malatya nappes and Southeast Anatolian autochthone, Eocene-Lower Miocene Çüngüş-Hakkari nappe, bearing the features of turbiditic character, is observed in a long distance continuously, with an intermediate zone character. This nappe, as well as in the case of the Yeşilbarak nappe in Western Taurus range comprises of two structural units, the Çüngüş formation and the Hakkari complex. The Eocene-Lower Miocene Çüngüş formation is the lower unit which is made up of sandstone with occasional blocks, siltstone and claystone and has similarities with the Elmalı formation of the Gömbe unit in the west. The Hakkari complex, on the other hand, is the upper structural unit and is composed of two more or less different structural units; the Urşe formation of Eocene-Oligocene age made up of sandstone, claystone, limestone, and the Durankaya formation of Lower-Middle Eocene age made up of sandstone with occasional blocks, shale and conglomerate. These formations that belong to the Hakkari complex may, even if partially, be correlated with the Yavuz formation in the west. These above-mentioned formations of the Çüngüş-Hakkari nappe have undergone intensive deformation related to the southward movement of the Bitlis-Pötürge-Malatya nappes in Miocene and have been thrusted on the Southeast Anatolian autochthone for tens of kilometers. Similar formations with that of the Yeşilbarak nappe and the Middle Eocene-Lower Miocene clastic rocks of the Çüngüş-Hakkari nappe can be observed widespreadly in northern Cyprus. Allochthonous masses have been emplaced on these clastic rocks in Cyprus during Miocene. The Middle Eocene-Lower Miocene elastics have been thrusted by the Ovgos fault southward in the region, however, no large-scale thrusting as observed in Anatolia has not occurred here, in Cyprus. All these data indicate that the results of large-scale nappe tectonics in southern Turkey reveal the occurrence of more or less similar structural styles.

Key words: Yesilbarak Nappe, Stratigraphy, Correlation, Western Taurides, SE Anatolia

INTRODUCTION

In southern Turkey (western Taurus ranges) the tectonic units known as Mende res massif, Beydağları autochthone and Antalya nappes are situated from northwest to southeast (Fig 1). To the northwest of the region, rocks of Precambrian to Eocene age that have undergone low to medium and high metamorphism, Menderes massif, is situated. Between the Menderes massif

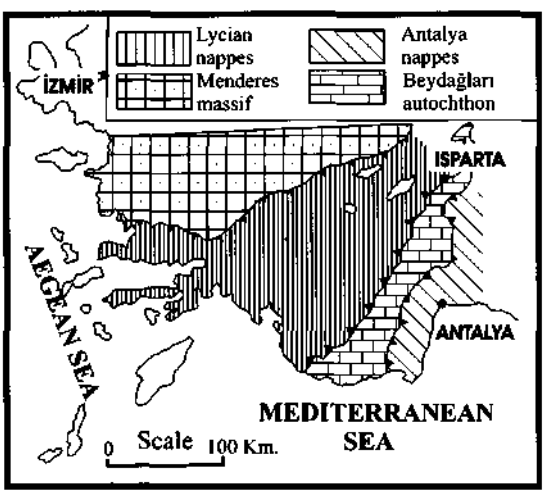

Fig. 1 – Tectonic units of SW Anatolia (West Taurides).

and the Beydağları autochthone, the Lycian nappes made up of rocks of platform, slope, basin and oceanic crust origin are observed. Southwest and west of the area, Antalya nappes, which are made up of rocks of platform, slope, basin and oceanic crust origin crop out. Beneath the Antalya and the Lycian nappes the Beydağları autochthone is observed, as a southwest-northeast trending uplifted dome comprising platform type sediments. In southwest Turkey, except for the above mentioned tectonic units, allochthonous Yeşilbarak nappe which is represented by Upper Lutetian-Lower Miocene rock units lies between the Beydağları autochthone and the Lycian nappes as an intermediate zone along long distances (Fig. 2).

The Yeşilbarak nappe, the subject of this paper, has been studied by many researchers in various locations in Southwest Turkey. While Colin (1955; 1962), Yılmaz (1966), Bassaget (1967), Richard (1967), Maitre (1967), Graciansky (1968; 1972), Akbulut (1977; 1980), Selçuk et al. (1985), Yalçınkaya et al. (1986), Yalçınkaya (1989), Altunsoy (1999) describe the unit as autochthone, some other researchers have proposed that it is allochthone (Gutnic, 1971), Poisson (1977), Gutnic et al. (1979), Erakman et al. (1982), Şenel et al. (1986; 1987; 1989; 1994), Ersoy (1989; 1992), Özkaya (1990; 1991), Collins and Robertson (1997; 1998), Bilgin et al. (1997), Şenel (1997a, *b, c, d, e, f, g, h, i, j, k).* The researchers have proposed different age ranges for the unit, too.

In this paper the stratigraphic and structural features of the Yeşilbarak nappe which is observed under the Miocene nappes in southwestern Turkey (western Taurus ranges) will be discussed, also, they will be compared with the rock units comprised by the allochthonous masses under the Miocene nappes (Bitlis-Poturge-Malatya nappes) in southeast Anatolia.

DESCRIPTION OF THE YEŞİLBARAK NAPPE AND THE PREVIOUS STUDIES

The Yeşilbarak nappe lying in between the Beydağları autochthone and the Lycian nappes in southeast Turkey (western Taurus ranges) was first named by Önalan (1979). The unit was interpreted to be

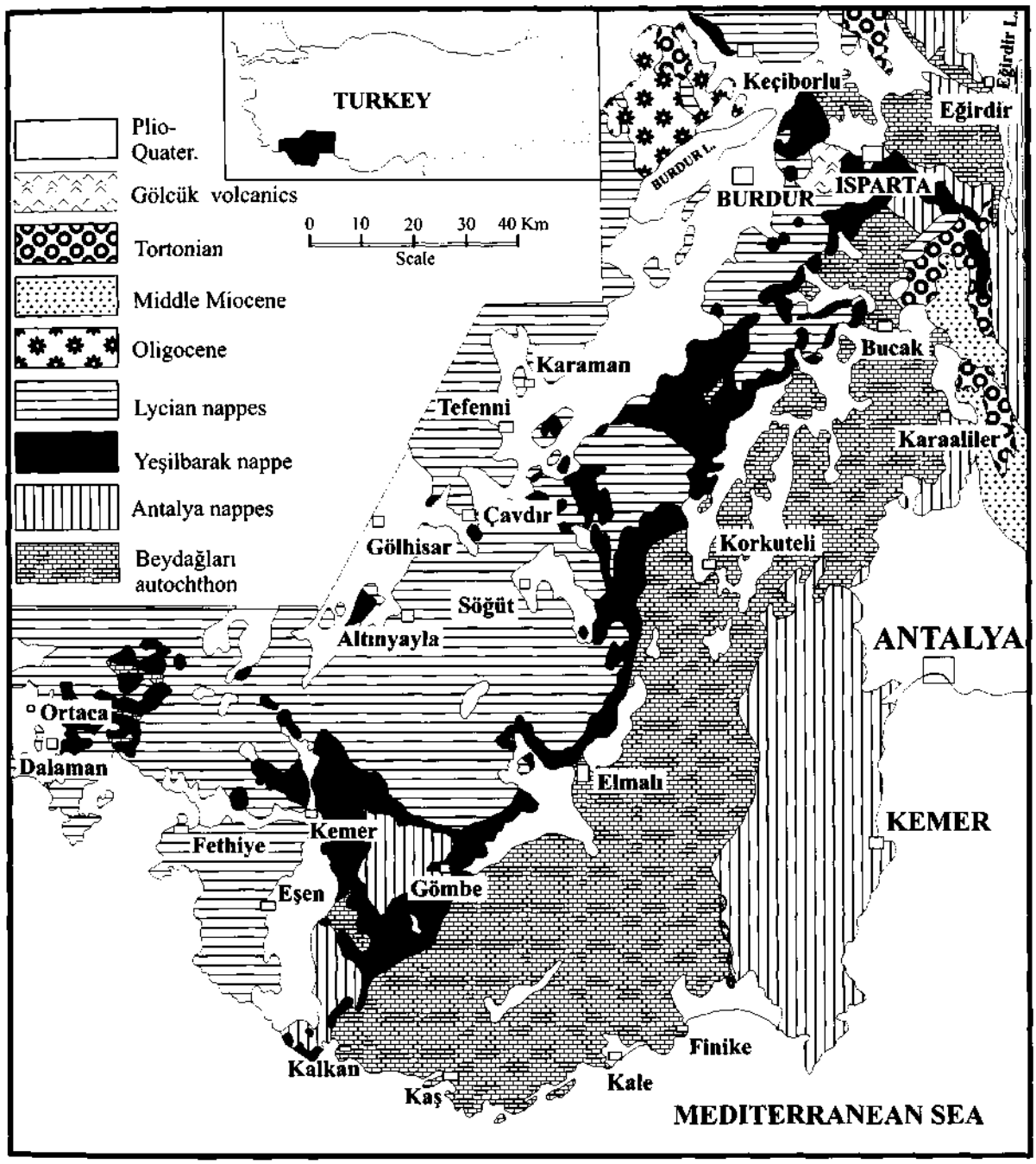

Fig. 2 – The map showing distribution of Yeşilbarak nappe in West Taurides.

autochthonous by Colin (1955, 1962) west of Elmalı as a thrusted, folded, chaotic flysch of Eocene-Miocene age. Graciansky (1968, 1972) proposed that the unit is an olistostrome of Langhian age that belongs to the Beydağları autochthonous west and northwest of Fethiye. Poisson (1977), in Korkuteli area, named the rocks as Yavuz unit as an allochthone of Upper Lutetian-Priabonian age in this region but of Oligo-

cene age in Kemer region. Önalan (1979) who named the unit, stated that the unit is made up of the Elmalı formation (Lutetian), the Deliktaş shale (Oligocene), the Sinekçi formation (Burdigalian) and the Kasaba formation (Helvetian-Tortonian) west of Elmalı. Studying around Dinar-Akdağ, Gutnic (1971) proposed that the unit is an allochtonous flysch of Eocene age. These clastic rocks, on the other hand were defined as Oligocene-Lower Miocene Güneyce formation by Akbulut (1977; 1980) and were included in the Lower Miocene rocks of Beydağları autochthonous. In the western section of the western Taurus ranges Erakman et al. (1982) named the unit as Kemer flysch of Oligocene age. Bölükbaşı (1987*a,b)* differentiated these clastic rocks as two units: the Upper Eocene-Lower Miocene Kemer tectonic unit and the Upper Paleocene-Oligocene Sülekler formation. Around Isparta-Burdur region, Yalçınkaya et al. (1986) and Yalçın kaya (1989) proposed that these clastic rocks were included in the autochthone and named as Ağlasun formation (Lower Miocene) and as Yavuzlar formation (Eocene) in different locations. Altunsoy (1999), similarly proposed that this unit is to be considered in Lower Miocene rocks of the Beydağları autochthone and named it as Ağlasun formation. The Yeşilbarak nappe was defined as Elmalı thrust fault slice of Upper Paleocene-Oligocene age by Özkaya (1990, 1991). Colins and Robertson (1997. 1998) named the unit as Yavuz unit and Yavuz thrust sheet, while Bilgin et al. (1997) proposed the age of the unit was Upper Lutetian-Lower Miocene and they named it as Elmalı formation.

Şenel et al. (1986, 1987, 1989, 1994) defined the unit as an intermediate zone, but later on (Şenel, 1997a, *b, c, d, e, f, h)* they accepted the earlier definition of Önalan (1979) and used the term Yeşilba rak nappe and its definition for the whole western Taurus ranges. Şenel et al. (1986, 1987, 1989, 1994) and Şenel (1997a, *b, c, d, e, f, h)* studied many rock sections sampled from these clastic rocks all around the western Taurus ranges and concluded that the unit comprises two structural units; 1) the lower Gömbe unit of Upper Lutetian-Lower Miocene age and 2) the upper Yavuz formation of Upper Lutetian-Priabonian age. The researchers state that at the bottom of the Gömbe unit 60 m thick neritic carbonates of Upper Cretaceous age is situated.

THE STRATIGRAPHIC FEATURES OF YEŞİLBARAK NAPPE

The Yeşilbarak nappe is observed as tectonic windows in the front borders of the Lycian nappes and beneath the Lycian nappes in the western Taurus ranges (Fig. 2). These allochthonous masses were made up of clastic rocks in general and having intermediate zone character were divided into two structural (tectono-stratigraphic) units as Gömbe and Yavuz (Şenel et al., 1986, 1987, 1989, 1994). The generalized stratigraphic features of these structural units were given in figure 3.

The Gömbe unit

The Gömbe unit (Fig. 3) is the lower structural unit of the Yeşilbarak nappe and is represented by the Cenomanian-Santonian Gebeler formation made up of neritic carbonates, the Upper Lutetian-

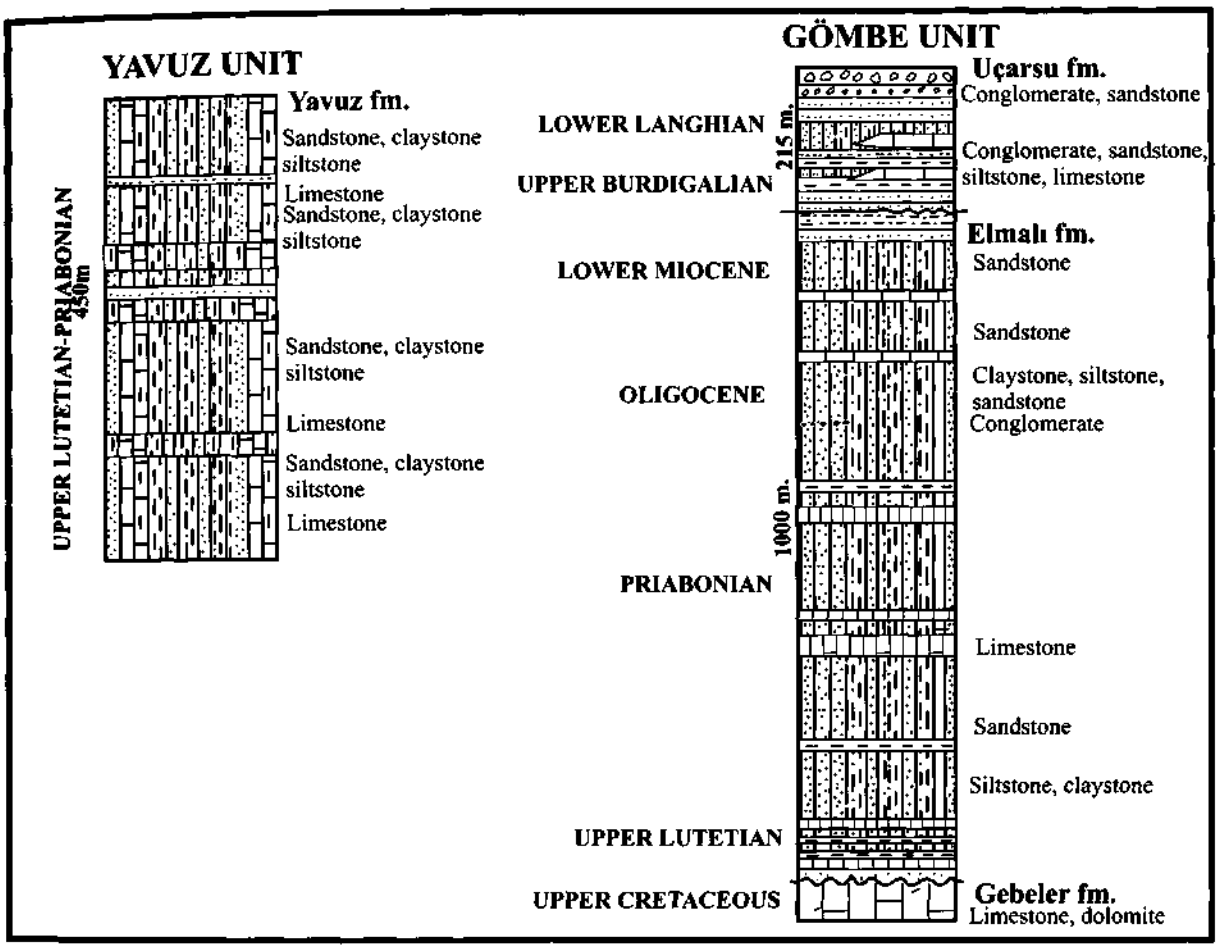

Fig. 3 – Generalized columnar section of structural units of Yeşilbarak nappe.

Lower Miocene Elmalı formation which is made up of sandstone and shale and the Upper Burdigalian-Lower Langhian Uçarsu formation bearing sandstone and conglomerate (Şenel et al., 1989). Of these, the Elmalı formation is widespreadly observed along the belt. On the other hand, the Gebeler formation can only be observed in the Gebeler district east of Fethiye (Fig. 4). Similarly, the Uçarsu formation crops out on the eastern slope of the Akdağ (Fig. 5), situated in between Fethiye-Elmalı.

The Gebeler formation. - This formation which is situated at the base of the Gömbe unit is named by Şenel et al. (1989). All along the western Taurus range it only crops out near a hot spring (Fig. 4) in the Gebeler district, approximately 25 km east of Fethiye. It is made up of massive, medium to thick bedded, dark gray, blackish gray, black and dark brown colored, stinky, hard, highly fractured and jointed karstic limestone, dolomite and dolomitic limestone. The limestones bear milliolides in places and are of biomicrite, biosparite and intrabiosparite character.

The lower contact of the Gebeler formation can not be observed but it is overlain by the Elmalı formation with angular unconformity. It is almost 60 m thick

and poor in fossils. Depending on the fossils such as *Thaumatoporella parvoesessiculifera* Rannier, *Raadoshouuenia?* sp., *Biblanata* Sp., *Sgrossoella* sp., *Cuneolina* sp. its age is accepted as Cenomanian-Santonian The rocks similar to these carbonates which were deposited in shallow carbonate shelf environment can be observed in the synchronous units of Beydağları autochthonous and Dumanlıdağ nappe (Şenel, 1994).

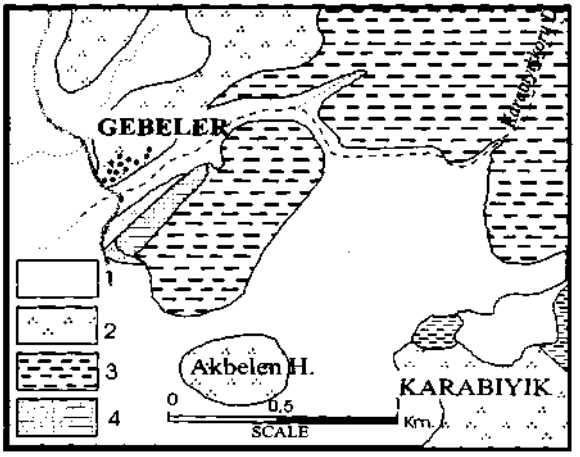

Fig. 4– The map showing exposure of Gebeler formation at Gebeler province southeast of Fethiye; 1-Quaternary, 2-Pliocene, 3-Elmalı formation, 4-Gebeler formation.

The Elmalı formation. - This formation, formed by sandstone, siltstone and claystone in general, has first been named by Önalan (1979). It is the most widespreadly outcropping unit of the Yeşilbarak nappe all along the belt and is highly folded and thrusted.

The Elmalı formation is represented by thin to medium, thick bedded gray, green, dark gray, light brown colored sandstones, siltstone and claystones with limestone intercalations. The dominant lithology of the unit is sandstone which grain size vary between coarse to fine and composed of various lithologic origins. They display turbiditic character and in places pillow structure and the grading may vary in between well to poor. The basal structures were well developed in these sandstones. The siltstones and claystones which are relatively less abundant than the sandstones are darker in color, foliated and have gained the appearance of shale. Sometimes these are thick enough to differentiate as layers. The limestones which are observed as interbeddings and lenses are as sandy limestone, calcarenite, micrite and clayey micrite and generally situated in the lower levels (in Upper Lutetian-Priabonian levels), and rarely in the uppermost levels (in Lower Miocene levels) with thicknesses varying in between 7-8 m. They contain nummulites and planctonic foraminifera in places, and have blocky appearances due to intensive deformation. In the Elmalı formation, rare multi-component conglomerates and debris flows can be seen.

The Elmalı formation is generally situated on the Lower Miocene elastics of Beydağları autochthone with tectonic contact. The only exception is that, in the Gebeler district, east of Fethiye, it rests on the Gebeler formation with angular unconformity (Fig. 4). The unit is technically overlain by the Yavuz unit, the upper structural unit of the Yeşilbarak nappe or the Lycian nappes. On the eastern flanks of the Akdağ, between Fethiye and Elmalı, the Elmalı formation is overlain by the Uçarsu formation of Upper Burdigalian-Lower Langhian age, conformably and unconformably, in places. It is difficult to measure the thickness of the formation since it is highly thrusted and fractured, but in places it was measured to be exceeding 1000 m. However, it is thought to be more thicker (Şenel etal., 1989).

The clastic rocks of the formation are poor in fossil content contrary to the limestone interbeddinqs. In the lower sections of the. formation *Nummulites millecaput* Boubee, *Naturicus* (Joly-Lrymerie), *N, holveticus* (Kaufman), *N.* cf. *fabianii* (Prever), *N.* cf. *munieri* Ficheur, *Chapmanina gassiensis* Silvestri, *Fabianina cassis* (Oppenheim), *Eorupertia magna* Le Calvez, *Linderina brugesi* Schlumberger, *Sphaerogypsina globus* Reuss, *Halkyardia minima* ' Liebus, *Globorotalia centralis* Cushman-Bermudez, *Globigerosistf. kugleri* Loeblich-Topp, *Assilina* sp., *Alveolina* sp., *Globigerina* sp., *Discocyclina* sp., and in the upper levels *Lepidocyclina* sp. *(Nephrolopidin* type), *Miogyssinoides complanatus* (Schlumberger), *Amphistegina* cf. *lessoni* D'Orbigny, *Globoquadrina* cf. *dehicens* (Ch:-Parr.-Col.), *Catapsydrax* cf. *dissimilis* (Cushman-Bermudez), *Globigerinoides* cf. *trilobus* Reuss, G. cf. *bisphericus* Todd, G. cf. *diminitus* Bolli, *Globigerina* sp., *Globigerinata* sp., *Globigerinatella* sp., *Operculina* sp. forms were determined. The fossils in the lower levels indicate Upper Lutetian-Priabonian, whereas the fossils in the upper levels indicate Lower Miocene age. The fossils collected from the central sections are nannoplanktons such as *Spherolithus distendus* (Martini), S. *Predistendus* Bramlette-Wilcoxon, *Cyclicargolithus abisenctus* (Muller), *C. Floridanus* (Roth.-Hay), *Helicopontosphaera intermedia* (Martini), *H. Recta* (Hao), *H. Seminilum* (Bramlette-Sullivan) which indicate Oligocene age. These data show that the Elmalı formation is of Upper Lutetian - Lower Miocene age. No unconformity in the formation has been observed. However, in the-Western Taurus ranges, and moreover in the Central Taurus ranges a continuous sequence between Upper Lutetian and Lower Miocene has not been identified. Therefore, the presence of an unconformity at post-Upper Lutetian-Priabonian and pre-Lower Miocene is possible and it may not have been observed due to intensive deformation and also the similarity of the elastics in the lower and upper levels.

The Elmalı formation displays transgressive features at the base, it has been deposited on shelf slope-basin medium.

The Elmalı formation has -at least partial- similarities with the Varsakyayla formation of Upper Lutetian-Priabonian age (Poisson, 1977; Şenel et al., 1989) and the Yavuz formation which constitutes the upper structural unit of the Yeşilbarak nappe of the same age and the Küçükköy formation (Poisson, 1977; Şenel, 1997h,j) that is observed on the upper levels of the Beydağları autochthonous. In the above-mentioned formations, the carbonate interbeddings are much more compared to the Elmalı formation. In the Western and Central Taurus ranges there are no elastics that are similar to the Oligocene-Lower Miocene elastics of the unit.

The Uçarsu formation - This formation is comprised of sandstone with abundant macro fossils and conglomerate and first named by Şenel et al. (1989). It can only be observed in the Western Taurus ranges, on the eastern flank of the Akdağ in between Fethiye and Elmalı (Fig. 5) and on the northeast of the Deliklitaş Hill east of the Döğüş district.

The Uçarsu formation can easily be differentiated from the Elmalı formation by its abundant content of macro fossils and high content of coarse elastics. The unit is

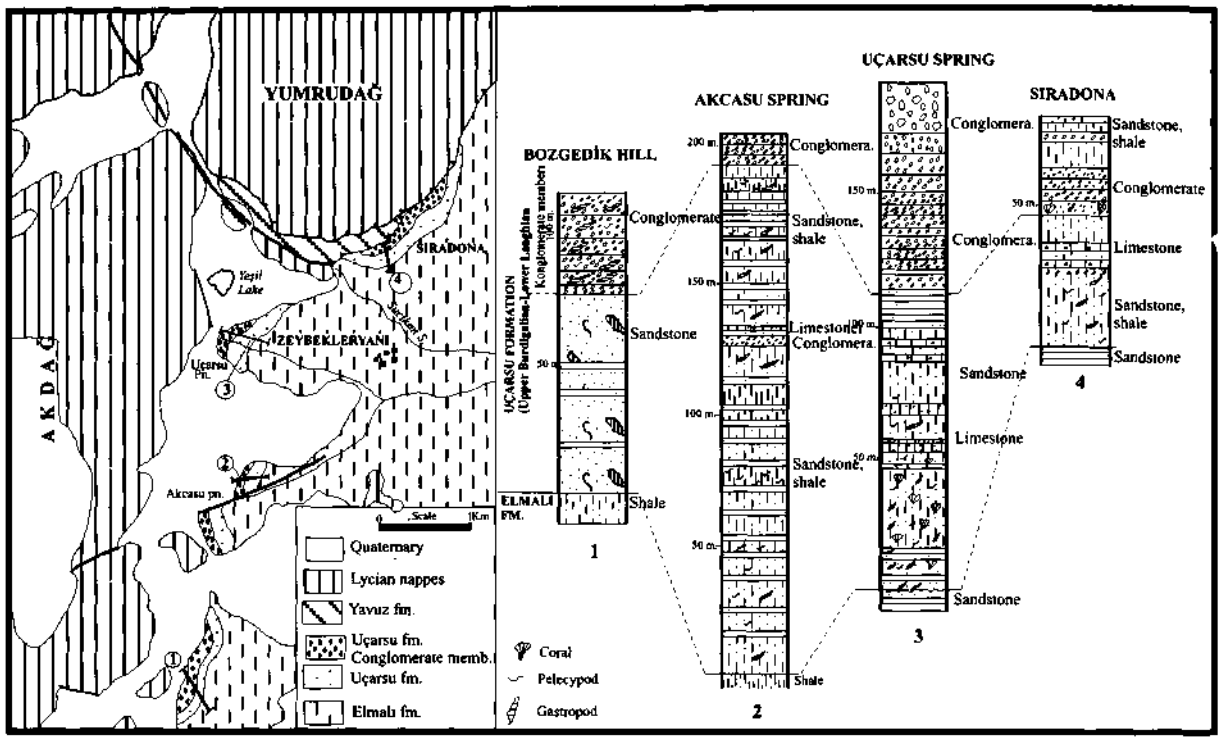

Fig. 5 – Geological map and columnar section of Uçarsu formation

composed of thin-medium-thick bedded, green, greenish gray sandstone, claystone and siltstone, and multi-component conglomerates (Fig. 5.b1). The formation rests on the shales of the Elmalı formation conformably as thick bedded, light gray to green colored, poorly sorted coarse sandstones including gastropods, corals, echi nides. This sandstone is overlain by thick bedded, well sorted, conglomerates with rounded gravels with abundant macro fossils. The elastics that may appear as shales due to foliation may be differentiated from the Elmalı formation by their abundant macro fossil content. The elastics contain 30 cm- thick sandy limestone level including benthic foraminifera and macro fossils. There is a very thin grained conglomerate level below this unit. In the Uçarsu section (Fig. 5.b3) the unit comprises thin-medium-thick bedded, green, greenish gray colored sandstone including gastropoda, lamelli branch, corals and macro fossils, claystone, siltstone, and thick overlying conglomerates. In the lower levels where the sandstone is dominant, limestone intercalations of bioherm nature including abundant ben thic foraminifera and macro fossils can be observed. These limestone intercalations that may contain sand in places, pinch out in elastics. The overlying conglomerates are thick bedded, but in the upper levels they are not bedded. They may contain sand lenses and pebble fills. The gravels which are small in size and angular in the lower levels grow in size in the upper levels (up to 70 cm) and they have sharp corners; the sorting is well in the lower levels but poor in the upper levels. There are no macro fossils in these coarse elastics but instead relicts of

plants can be seen. In the measured Sıradona section (Fig. 5.b4) the Uçarsu formation comprises, in the lower levels, massive, thick bedded, green in color sandstone, claystone and siltstone with macro fossils. Above these elastics there are conglomerates and an intercalation of conglomerate, sandstone and claystone. Another outcrop of the Uçarsu formation can be seen in the Döğüş district, in the east but here the formation is represented with poligenic conglomerates.

The Uçarsu formation is in turn overlain by the Lycian nappes and the Yavuz formation with tectonic contact. The maximum thickness of the formation is 215 m. It frequently changes lithology in lateral direction.

The formation is rich in macro and micro fossils. Micro fossils such as *Miogypsina irregularis* (Micheloss), *M.* cf. *intermedia* Droger, *Miogypsinoides dehaartii* (Van Der Klerk, *M.* cf. *bantamensis* Tan, *Amphistegina lessoni* D'Orbigny, *Operculina complanata* Defrance, *Spiroplectammina carinata* D'Orbigny, Nonion *pompilioides* D'Orbigny, *Globigerinoides* cf. *trilobus* Reuss, *Globigerina* sp., *Ditrupa* sp., *Acervolina* sp., *Gypsina* sp., *Victoriella* sp., *Lithohammium* sp., *Cibicides* sp., *Robulus* sp., corals such as *Thegiostraea crassi coslata* (Michelotti), *Heliastraea oligophyllia* Reuss, *Aquitanastraea quetterdi* (Michelin), *Siderastraea miocenica* Osasca, *Stylophera* cf. *reussiana* Montanara-Galitelli, *Acanthocyathus trasiluencus* Reuss, *Balanophyllia conconna* Reuss, *Leptomussa? Faloti* Chevaier, gastropoda such as *Turitella* (Turitella) cf. *terebralis* Lamarck, *T. terebralis terebralis* Lamarck, *Ancilla* (Baryspira) *glandiformis* (Lamarck), *Conus* cf. *betulinoides* Lamarck, *Strombus* sp., *Natica* sp. and pelecypods such as *Pecten* cf. *josslingi* Smith, *Pecten fushsi styriacus* Hilbe'r, *Glycymeris* (Glycymeris) *inflatus* Brocchi, *Venus* cf. *multilamella* Lamarck, the age of the formation is determined as Upper Burdigalian-Lower Langhian.

The Uçarsu formation was deposited on the Elmalı formation in shelf environment with slow regression. However, since the terrestrial input to this high-energy medium is too intense, in general, the formation of a wide reef is hindered but instead small reefs in patches were formed. Related to the emplacement of the Lycian nappes the basin has become shallower and finally has closed, giving way to accumulation of coarse material and hence the fans. Moreover, as in the case of the Uçarsu section, alluvial fans in the upper levels have developed.

The Uçarsu formation can be correlated with the Kasaba formation of the Beydağları autochthonous (Şenel et al., 1989, 1994) and with the transgressive rock units (Becker-Platen, 1970; Hakyemez and 6rgen, 1982; Şenel et al., 1989) observed as small outcrops over the Lycian nappes.

The Yavuz unit

The Yavuz unit, which is the upper structural unit of the Yeşilbarak nappe, is represented by the sandstone, claystone and limestones of Upper Lutetian-Priabonian age. It tectonically overlies the Lower Miocene elastics of the Beydağları autochthonous and the Gömbe unit, which is the lower structural unit of the Yeşilbarak nappe and is overlain by the Lycian nappes. In the fore front of the Lycian nappes it is generally observed as overturned.

The Yavuz formation.- This formation comprises of limestone, claystone and sandstones and is named by Poisson (1977). It is difficult to differentiate this formation with the Elmalı formation due to the similarity of the lithology. The formation is quite widespread around Korkuteli area and is made up of an intercalation of claystone with dominant limestone, limestone, siltstone and sandstone in the lower levels and that of sandstone, claystone and siltstone in the upper levels. The limestone has micritic texture and is thin to medium bedded, beige and light gray in color with planktonic foraminifera. It sometimes contains chert nodules. These are as interbeddings reaching up to 20 m. The micrites pass into the clayey limestone and marls in the upper levels. There are thin to medium and rarely thick, beige and light gray, light brown in color, calcarenites and clayey limestones in the formation. These are below or in between the micrites, sandstones and claystones. There are small nummulites in calcarenites and limestones. Flow structures can be seen at the base of the calciturbidites. The sandstones, siltstones and claystones, which are thin-medium-thick bedded with gray, light gray, green, greenish gray in color are of turbidite nature. The claystones and siltstones are sometimes foliated and appears as shale. The formation sometimes observed to comprise conglomerates as thin layers, some limestone layers appear as apart blocks due to intensive deformation. In the lower levels of the Yavuz formation red clayey limestone and claystones as marker beds are present and they extend laterally.

The Yavuz formation technically overlies the Lower Miocene elastics of the Beydağları autochthonous and the lower structural unit of the Yeşilbarak nappe, the Gömbe group and is overlain by the Lycian nappes technically. The thickness of the unit is measured as 450 m, however, Poisson (1977) proposes that its thickness may exceed 750 m. The unit does not display lateral change in lithology.

The biostratigraphic features of the unit was discussed in detail by Poisson (1977). According to its fossil content, such as *Nummulites* cf. *millecaput* Boubee, *Sphaerogypsina globulus* Reuss, *Globorotalia* cf. *bulbrooki* Bolli, *Eorrupertia magna* Le Calvez, *Nummulites* sp., *Discocyclina* sp., *Alveolina* sp., *Globorotalia* sp., *Globigerina* sp., *Truncorotaloides* sp., etc., the age of the formation is Upper Lutetian-Priabonian (Poisson, 1977; Şenel, 1989).

The unit comprises similar lithology with the Varsakyayla (Poisson, 1977; Şenel et al., 1989) formation which is transgressive over the Lycian nappes.

THE OCCURRENCE OF THE YEŞİLBARAK NAPPE AND ITS STRUCTURAL SETTING

The Yeşilbarak nappe which is observed below the Miocene nappes in southwest Turkey and occurring as an intermediate zone between the Lycian nappes and the Beydağları autochthonous, can continuously be observed in the fore front of the Lycian nappes and as tectonic windows at the back of the fore front of the Lycian nappes. The drillings made by TPAO shows that the Yeşilbarak nappe taking place between the Lycian nappes and the Beydağları autochthonous display various thickness in the area.

The Yeşilbarak nappe can be observed in between Dalaman (east of Köyceğiz) and southeast of Isparta and is represented by the Elmalı formation that belongs to its lower structural unit (Gömbe) west of the area Fethiye-Akdağ. The westernmost outcrops of the unit can be observed in Karadere (Fig. 6), Kargın and Günlük (Fig. 7) tectonic windows, 5 km southeast, 4 km east and 10 km north of Dalaman, respectively. The Yeşilbarak nappe, which is represented only by the Elmalı formation in these tectonic windows, is overlain by the Marmaris ophiolitic nappe and the Tavas nappe. In Günlük and Kargın tectonic windows, the nappe can not be observed. In Karadere tectonic window, the Yeşilbarak nappe overlies the Burdigalian claystones (Sinekçi formation-Çayboğazı member) of the Beydağları autochthonous. The area where the Yeşilbarak nappe crops out widely Is the Göcek-Aygırdağı tectonic window. (Fig. 8). In this area where the Beydağları autochthonous is uplifted by normal faults, only the Elmalı formation of the nappe can be observed. The Yeşilbarak nappe which tectonically overlies the Burdigalian claystones (Sinekçi formation-Qaybogazi member) of the Beydağları autochthonous, is tectonically overlain by the Tavas nappe, the Marmaris ophiolitic nappe and partly by the Bodrum nappe. In Eldirek tectonic window (Fig. 9), 11 km east of Fethiye,. the lower contact of the Yeşilbarak nappe can not be observed. The unit is overlain by the Marmaris ophiolitic nappe, the Bodrum nappe and the Gülbahar nappe-Middle-Upper Triassic Çövenliyayla volcanics of the Ağla unit. The Yeşilbarak nappe which lower contact can not be

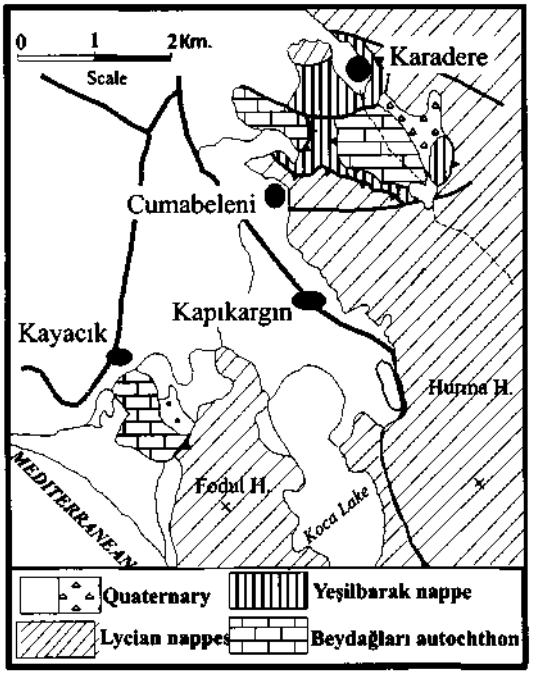

Fig. 6 – Geological map of Karadere tectonic window and surrounding area.

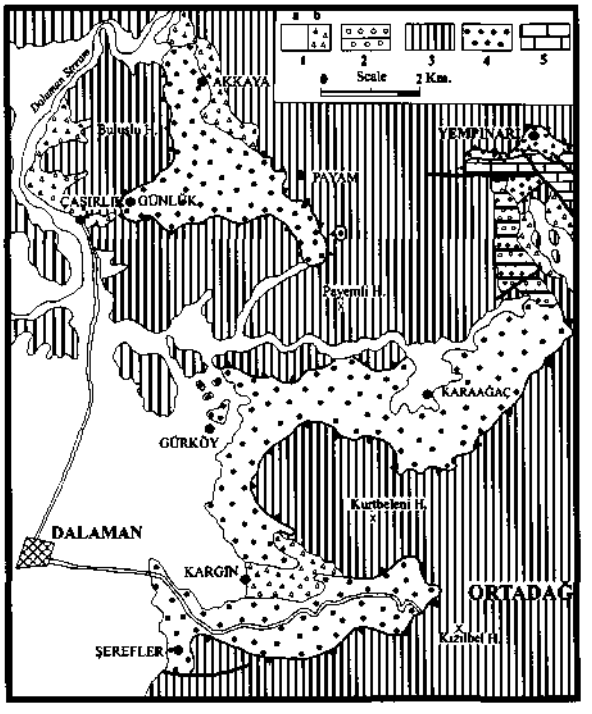

Fig. 7 – Geological map of Kargın and Günlük tectonic windows and surrounding areas; 1- Quaternary- a) Alluvium,- b) Slopesorce deposits, 2- Pliocene, 3- Lycian nappes, 4- Yeşilbarak nappe, 5- Beydağları autochthone.

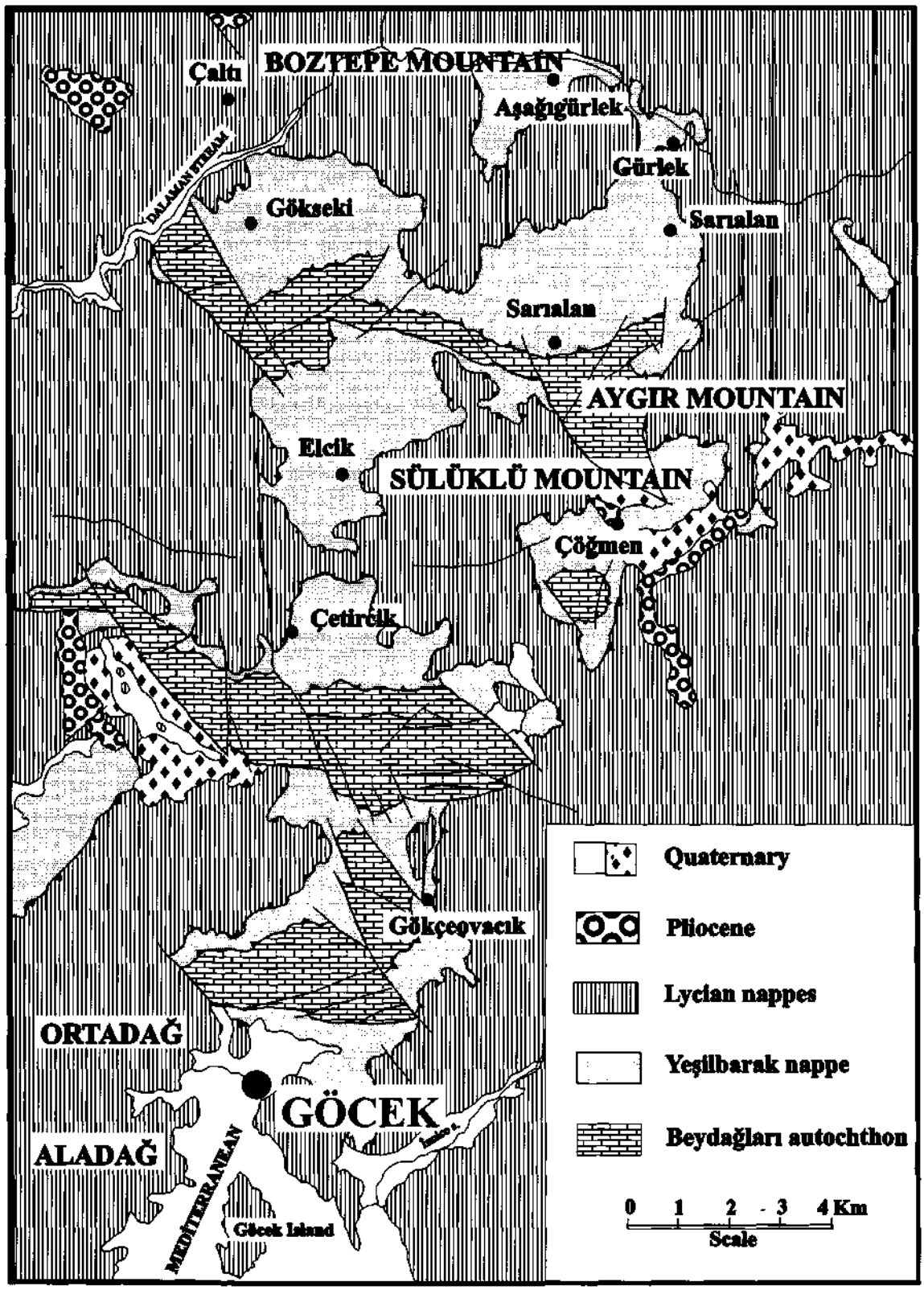

Fig. 8 – Geological map of Göcek-Aygır dağı tectonic Windows and surrounding areas.

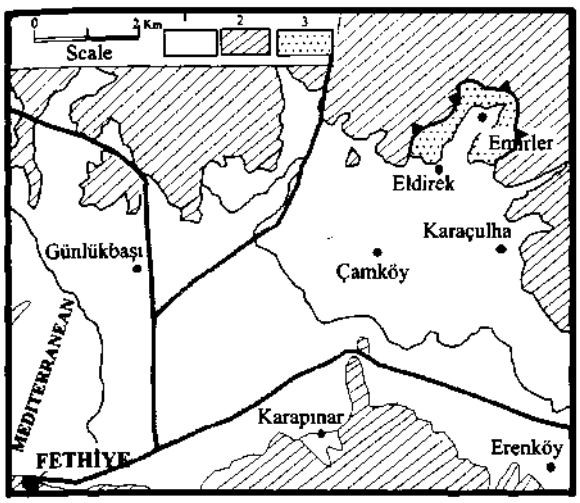

Fig. 9 - Geological map of Eldirek tectonic window and surrounding area; 1- Quaternary, 2- Lycian nappes (Marmaris ophiolite nappe), 3. Yeşilbarak nappe (Elmalı fm.).

observed in Söğütlüdere and Karantili tectonic windows (Fig. 10), is only represented by the Elmalı formation and is overlain by the Tavas nappe, the Gülbahar nappe and the Marmaris ophiolitic nappe. In Minare tectonic window (Fig. 11), 4.5 km north of Eşen (Kestep), between Fethiye and Kalkan, the Yeşilbarak nappe can be observed in a very narrow area and its lower contact can not be observed. It, here, is represented by the Elmalı formation and is overlain by the Tavas nappe, technically. In Yalıburnu tectonic window (Fig. 12), 7 km southwest of Kalkan, the Yeşilbarak nappe is represented only by the Elmalı formation again, and its lower contact can not be observed. In this area the nappe is overlain by the Dumanlıdağı nappe. In Keller tectonic window (Fig. 13), west of Burdur-Antalya (Dirmil), the Elmalı formation has a wide outcrop. However, the lower contact can not be observed in this area, too. In this tectonic window, generally the Lower Miocene rocks of the Elmalı formation are well displayed (Selçuk et al., 1985) as well

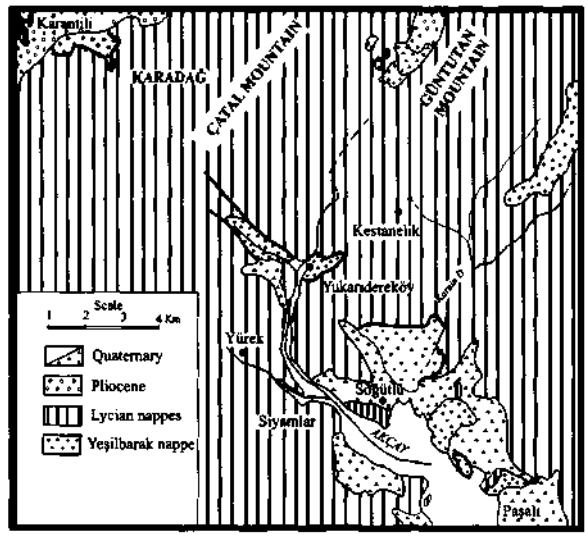

Fig. 10 – Geological map of Söğütlüdere, Karantili tectonic windows and surrounding areas.

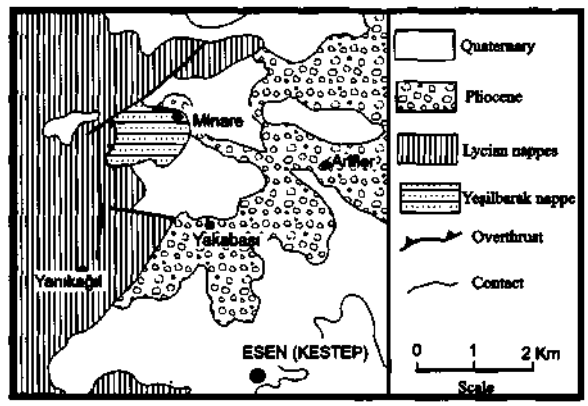

Fig. 11 – Geological map of Minare tectonic window and surrounding area.

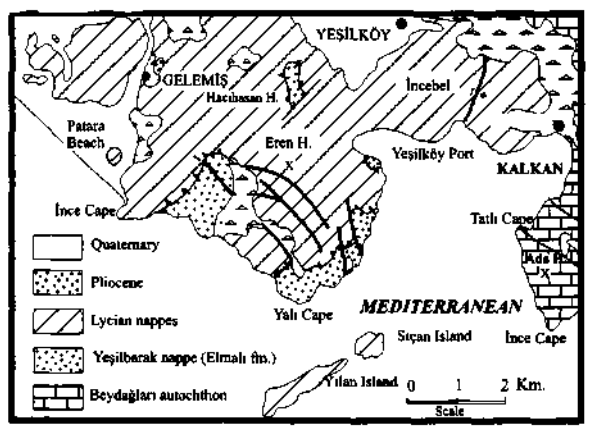

Fig. 12 – Geological map of Yalıburnu tectonic window and surrounding area.

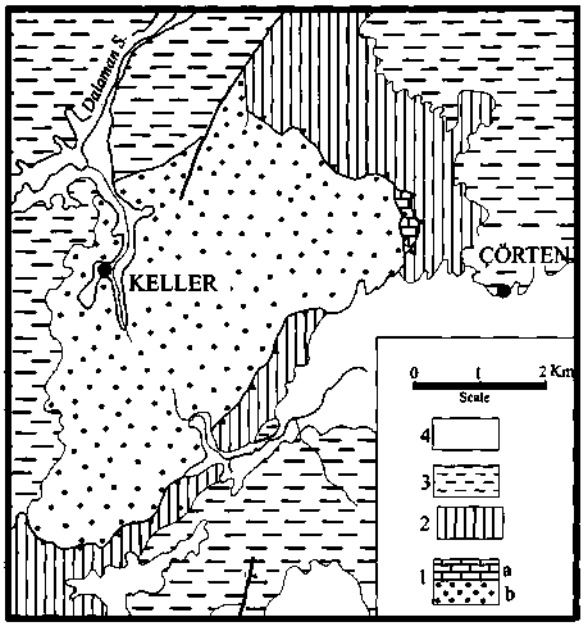

Fig. 13 - Geological map of Keller tectonic window and surrounding area; 1. Yeşilbarak nappe- a)Elmalı formation, b)Yavuz formation,. 2- Lycian nappes, 3- Pliocene, 4- Quaternary.

as a small slice of the Yavuz formation of the Yavuz unit. The Yeşilbarak nappe is overlain by the Marmaris ophiolitic nappe and by the Pliocene terrestrial elastics. In İsak tectonic window (Fig. 14), northwest of Burdur-Çavdır, both of the structural units (the Gömbe and Yavuz units) of the Yeşilbarak nappe can be observed. They are covered by alluviums and terrestrial Pliocene. North of the İsak village, the nappe is technically overlain again by the Marmaris ophiolitic nappe. In this area subophiolitic meta-morphics (amphibolite schist, etc.) can be seen as a thin tectonic slice (Şenel et al., 1989). In Çavdır tectonic window (Fig. 15), 3 km southeast of the Çavdır, only the Elmalı formation can be observed and its lower contact is not visible. The unit is technically overlain by the Marmaris ophiolitic nappe.

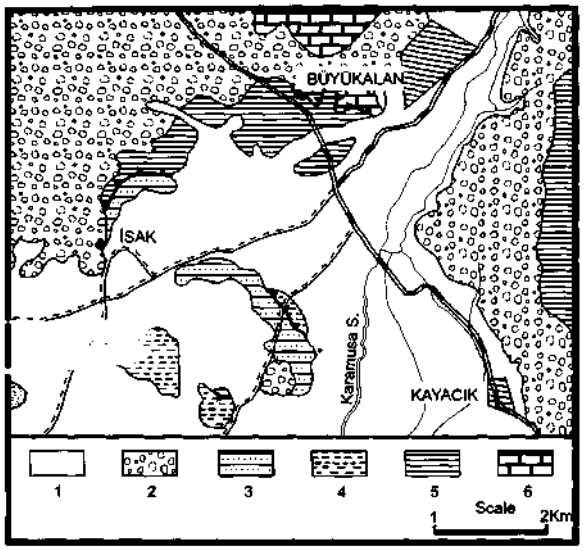

Fig. 14 - Geological map of İsak tectonic window and surrounding area; 1-Quaternary, 2-Pliocene, 3-Elmalı formation, 4-Yavuz formation, 5-Marmaris ophiolite nappe, 6-Gülbahar nappe.

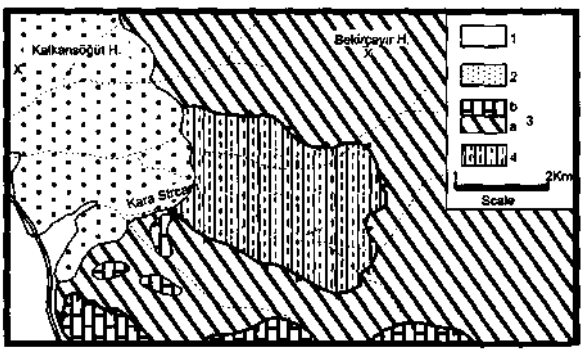

Fig. 15 - Geological map of Çavdır tectonic window and surrounding area; 1-Quaternary, 2-Pliocene, 3-Lycian nappes-a)Marmaris ophiolite nappe, b)Domuzdağ nappe, 4-Yeşilbarak nappe (Elmalı formation).

The units of the Yeşilbarak nappe which widespeadly crop out in between the Lycian nappes and the Beydağları autochthonous in vicinity of Isparta and Bucak (Fig. 16) has not yet been investigated sufficiently. In the area, the rock units of the Yeşilbarak nappe have been studied with the formations of the Beydağları autoch-

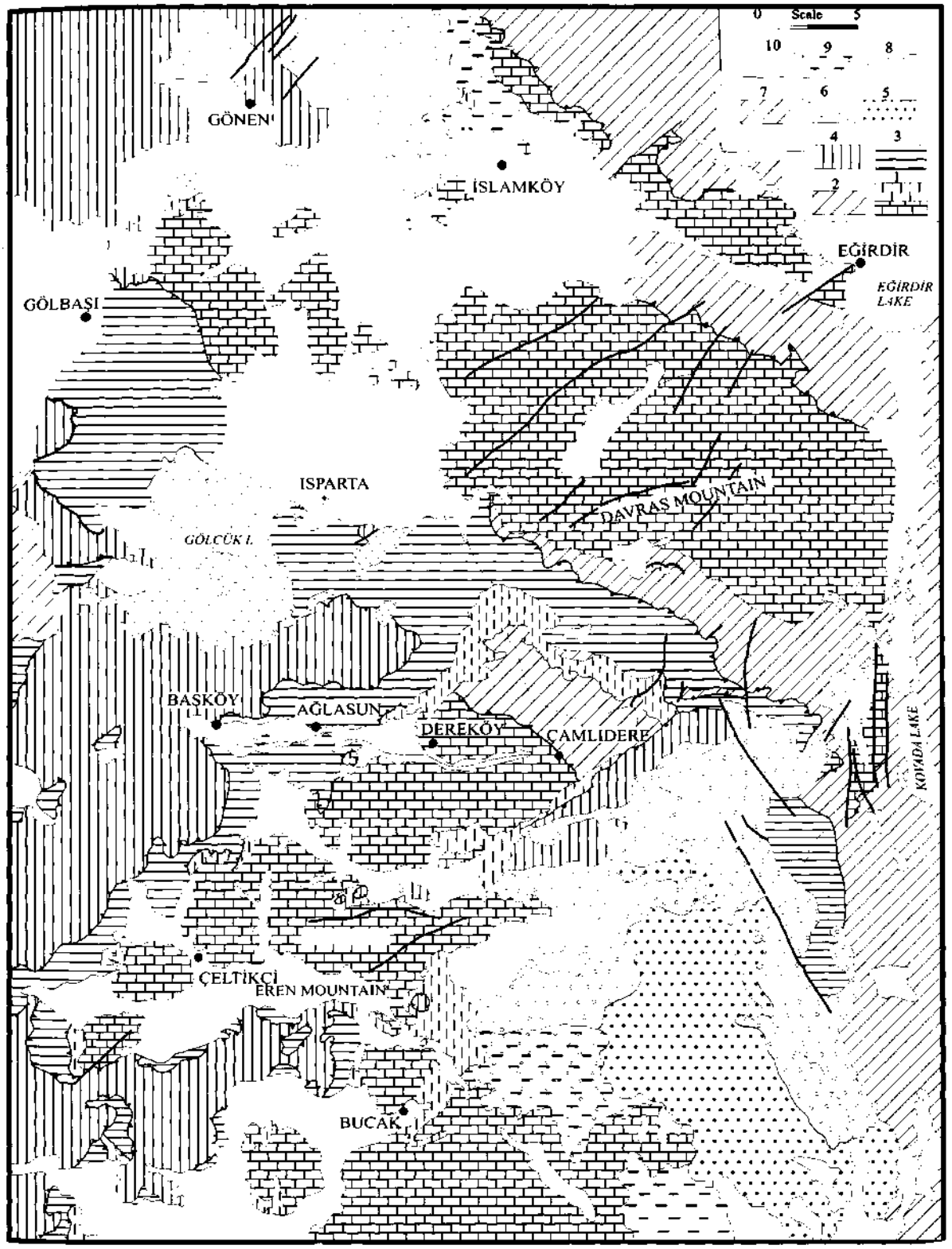

Fig. 16 - Map of structural units of Isparta and surrounding; 1- Beydağları autochthone-a)Pre-Miocene, b)Miocene, 2-Antalya nappes, 3-Yeşilbarak nappe, 4-Lycian nappes, 5- Middle Miocene, 6-Upper Miocene, 7-Pliocene, 8-Gölcük volcanics, 9-Pleistocene, 10-Quaternary.

thonous by researchers such as Gutnic (1971), Poisson (1977), Akbulut (1977), Yalçınkaya et al. (1986), Yalçınkaya (1989) and Altunsoy (1999). The structural features in the area where the Elmalı formation of the lower structural unit of the Yeşilbarak nappe (the Gömbe unit) crops out have not been differentiated. Akay and Uysal (1985), Akay et al. (1985) report the presence of similar units southeast of Lake Kovada-northwest of Bucak (Fig. 2). They are really similar to the Elmalı formation and must be belonging to the Yeşilbarak nappe. Gutnic (1971) reports the presence of allochthonous Eocene flysch in vicinity of Dinar-Kegiborlu area (Fig.2). This flysch also must be belonging to the Yeşilbarak nappe.

The widest outcrops are displayed by the Elmalı formation of the Yeşilbarak nappe can be divided into two structural units. The Elmalı formation has wide outcrops in between Elmalı and Dalaman (Fig. 2). Similar wide outcrops can be observed in between north of Korkuteli and Isparta (Fig. 2). The other formations of the Gömbe unit, the Gebeler and the Uçarsu formations are observed in very limited areas. The Yavuz unit which can only be represented by the Yavuz formation is observed in between northwest of Korkuteli and west of Elmalı. The Yavuz unit, on the other hand, can be observed in northeast of Fethiye-Kemer, to the north of Akdağ and Yumrudağ, in north and northwest of Akçay as thin, small overturned slices. Between Bucak and Isparta the unit can not be observed due to lack of detailed investigation, however, it can be observed in the east and north of Gökçebağ and northwest of Keçiborlu.

In the fore front of the Lycian nappes, the Yeşilbarak nappe can be observed on the Burdigalian Çayboğazı member (comprised of claystones) of the Sinekçi formation in between Dalaman and Elmalı, and the Lower Miocene Karakuştepe formation of (comprised of sandstone, siltstone and claystone) and rarely on the Upper Burdigalian-Lower Langhian Kasaba formation (comprised of conglomerate and sandstone). The nappe has emplaced on the Beydağları autochthonous in the end of Lower Miocene and in the beginning of Middle Miocene (in Lower Langhian) along the fore front of the Lycian nappes. In the same period, around Isparta-Çay (Fig. 16) the Yeşilbarak nappe and the Lycian nappes were emplaced on the Antalya nappes in Danian and as well as on the Karakuştepe formation overlying the Lower Miocene Karabayır formation, both with tectonic contact. Some researchers (Poisson, 1977; Yalçınkaya et al., 1986), however, include the Elmalı formation in the Lower Miocene Karakuştepe formation which is made up of elastics. The formations belonging to the Yeşilbarak nappe has been mapped, even if partially, by Bölükbaşı (1987b). The nappe, on the southern flanks of the Davras mountain, east of Isparta, has been technically overlain by the Tertiary elastics of the Beydağları autochthonous, the Kızılcadağ melange and the olisthostromes of the Lycian nappes and the structural units of the Antalya nappes. The Yeşilbarak nappe has been thrusted over the Tortonian Aksu formation south of Lake Kovada and related to this thrusting, the Antalya nappe has been thrusted over the Yeşilbarak nappe. This thrusting of rocks of the Beydağları autochthonus and the Antalya nappe over

the Elmalı formation of the Yeşilbarak nappe in the abovementioned areas must be related to the Aksu thrust (Aksu phase; Poisson, 1977) that took place north of the Gulf of Antalya (Şenel et al., 1996).

REGIONAL COMPARISON OF THE YEŞİLBARAK NAPPE

Southeast Anatolia (western Taurus ranges) has been exposed to emplacement of large scale allochthonous masses in the end of Lower Miocene and in the beginning of Middle Miocene (Lower Langhian). Almost at the same time, similar emplacements (the Bitlis-Pötürge-Malatya nappes) were observed in southeast of Turkey (Ricou, 1979; Şengör and Yılmaz, 1981; Aktaş and Robertson, 1984; Göncüoğlu and Turhan, 1984; Perinçek and Kozlu, 1984; Yılmaz and Yiğitbaş, 1990; Perinçek, 1990). These Miocene nappes in southeast Turkey have been differentiated and named as the Keban metamorphics, the Malatya metamorphics, the Pötürge metamorphics, the Bitlis metamorphics (Tolun, 1954), the Baskil magmatites, the Yüksekova complex (Özkaya, 1977), the Bitlis-Pötürge nappe (Aktaş, and Robertson, 1984), the Upper nappe and the Lower nappe (Yılmaz et al., 1991), the Bitlis-Pötürge-Malatya nappes (Şenel, 1999), the Mordağ metamorphics (Özkaya, 1977; Perinçek, 1990), the Hak kari complex (Maxson, 1937), the Maden complex (Ketin, 1948), and the Çüngüş formation (Sungurlu, 1974; from Yılmaz and Duran, 1997). Of these allochthonous masses that emplaced in Miocene, the Çüngüş formation and the Maden complex, both by their structural setting and by their stratigraphic features, are very similar to the Yeşilbarak nappe observed in southeastern Turkey. These masses that have been studied in detail by Özkaya (1977), Perinçek (1990), Yılmaz and Duran (1997) were observed as an intermediate zone in between the autochthonous rock units and the allochthonous rocks that emplaced in Miocene and were observed along a thrust zone (Bitlis thrust zone) as similar as that observed in west (Fig. 17). The Çüngüş formation observed in between the Miocene

Fig. 17 - The alignment of Eocene-Lower Miocene allochthonous clastic rocks (Yeşilbarak nappe, Çüngüş-Hakkari nappe etc.) as intermediate zone beneath Miocene nappes (Lycian nappes, Bitlis-Pötürge-Malatya nappes) at southern Turkey.

nappes in southeast Anatolia and southeatern Anatolian autochthonous, and the Hakkari complex will be discussed as the Çüngüş-Hakkari nappe in this paper. The Çüngüş formation, the lower structural unit of the Çüngüş-Hakkari nappe was first named by Sungurlu (1974; from Yılmaz and Duran, 1997). It can be accepted as the first allochthonous structural unit (below the Miocene nappes) on the southeast Anatolian autochthone represented by Eocene-Lower Miocene elastics. It is lithologically and structurally similar to the Upper Lutetian-Lower Miocene Elmalı formation of the lower structural unit (the Gömbe unit) of the Yeşilbarak nappe and is continuous along the Bitlis suture zone.

The Çüngüş formation (Fig. 18) cornrises thin-medium-thick bedded, green, gray, greenish gray, yellowish gray sandstones, siltstones and marl (Perinçek, 1990; Yılmaz and Duran, 1997). Local conglomerates and thin limestone intercalations may also be seen in the unit which has underone intensive deformation and hence appears as to be thrusted, folded and fractured. It may contain blocks, in places. The Çüngüş formation has turbiditic character ana debris flows may be seen on the formation. The lower and upper contact of the formation is tectonic. Its thickness varies in between 200-1500 m. The age of the formation is Eocene-Lower Miocene.

The Hakkari complex situated under the Miocene nappes (the Bitlis-Poturqe-Malatya nappes) in southeast Anatolia has first been named by Maxson (1937). It is the upper structural unit of the Çüngüş-Hakkari nappe and generally is of Eocene age but sometimes reaches up to Oligocene. The Hakkari complex (Fig. 18) comprises more or less different Urşe and Durankaya formations which have tectonic contacts in between (Perinçek, 1990; Yılmaz and Duran, 1997). The Urşe formation has first been named by Perinçek (1977; from Yılmaz and Duran, 1987). The age of the formation is Eocene-Oligocene and its lower and upper contacts are tectonic (Yılmaz and Duran, 1997). It comprises thin-medium-thick, gray, green, greenish gray, reddish sandstones, shale and limestones (Yılmaz and Duran, 1997). Its thickness may reach up to 2075 m. The Durankaya formation named by Perinçek (1978; from Yılmaz and Duran, 1997) is of Lower-Upper Eocene age and comprises of sand-stone with serpantinite, gabbro, basic volcanics, marble, limestone, amphibolite etc. blocks, shale and conglomerate. The blocks are in an olisthostromal fades. There are red pelagic limestone and gray limestone blocks and lenses in the unit. Many of the limestones were broken and in form of blocks due to intensive deformation. The red limestones bear planctic foraminifera and may reach up to thickness (150-200 m) to form hills. There are chert nodules in these limestones which do not have lateral continuity. The grav limestones have abundant amounts of reworked and broken nummulites. The Durankaya formation comprises of lithologies that have undergone low grade metamorphism. The Urşe and Durankaya formations may be correlated with the Yavuz formation with respect to their lithologies and structural setting. However, the Yavuz formation does not contain onsthostrome facies and blocks. Kozlu (1997) reports about the existence of Tertiary allochthonous elastics to the south of Engizek mountain, although

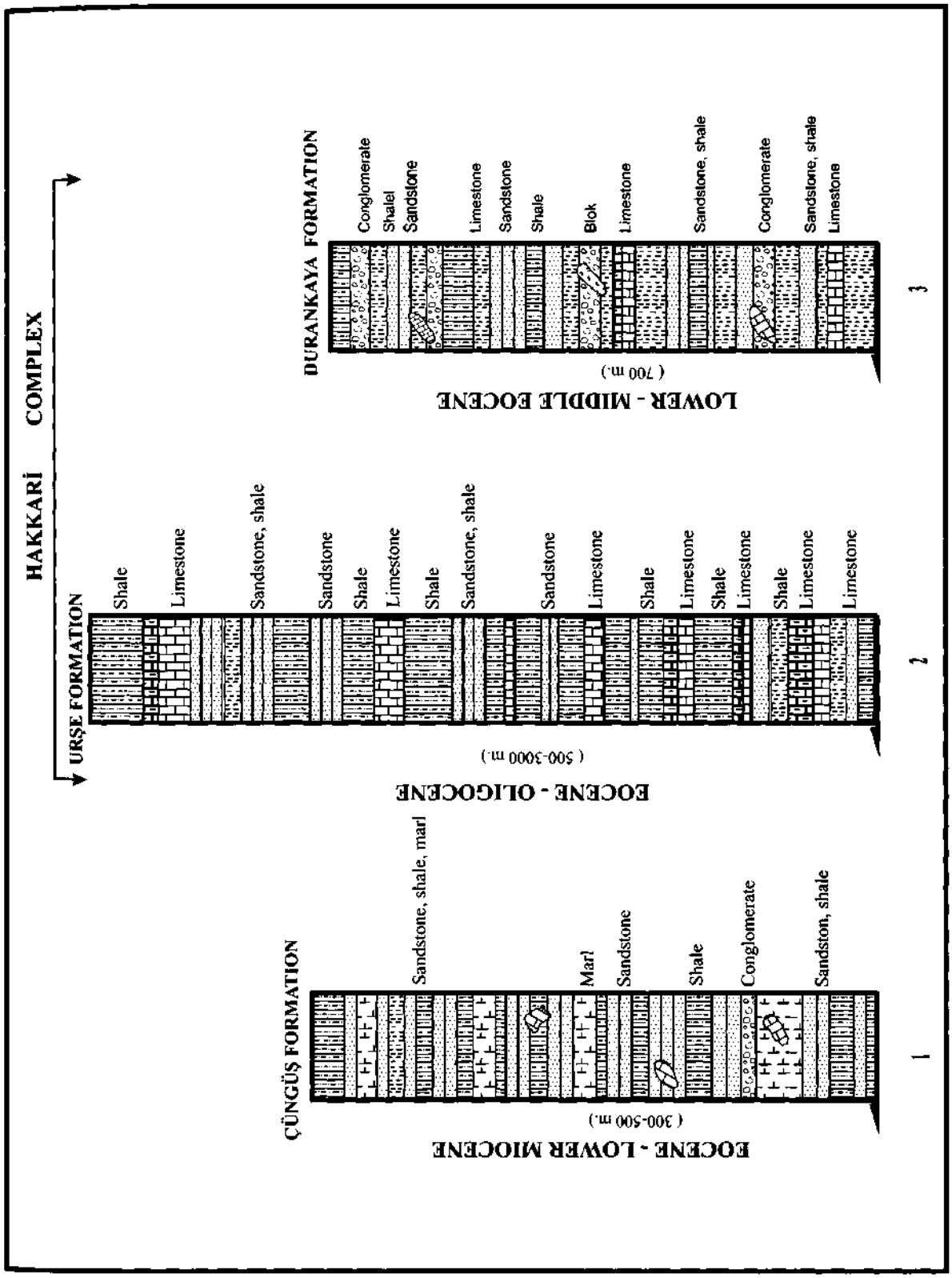

Fig. 18 Generalized columnar sections of the units of Çüngüş-Hakkari nappe

the features and the origin are not known well. In the area around Andırın similar rocks were observed (Kozlu, 1997). The elastics resembling the Çüngüş formation overlying the Lower Miocene around Adana-Andırın were observed during our studies but no detailed investigation was carried out.

The rock units similar to that forming the Yeşilbarak nappe and the Çüngüş-Hakkari nappe were observed in Cyprus, around the Beşparmak mountains (Fig. 17). The Middle-Upper Eocene turbiditic clastic rocks around the Beşparmak mountains that were named as the Kalograia-Ardana formation and the Mavri Skala flysch by Knup and Kluvyer (1969) and Baroz (1979) were re-defined by Hakyemez et al. (2000) as the Ardahan and Kantara formations. The Mavri skala flysch (Baroz, 1979) or the Ardahan formation (Hakyemez et al., 2000) is reported to unconformably overlie different formations and its age is reported as Upper Lutetian-Priabonian. It is made up of turbiditic elastics and has completely similar features with the Elmalı and Çüngüş formations. The Oligocene-Lower Miocene turbi ditic clastic rocks on which the Ardahan formation rests on (Hakyemez et al., 2000) are very similar to those equivalent units in the Elmalı and Çüngüş formations. The Kalogria-Ardana (Baroz, 1979) or the Kantara (Hakyemez et al., 2000) formation is of Upper Lutetian-Priabonian age and is made up of clastic rocks including various blocks. The Andırın formation, a member of the Misis group (Schmidt, 1961; Bilgin et al., 1981; Ayhan and Bilgin, 1986; Ayhan et al., 1988) observed around Adana, is of Upper Lutetian-Priabonian age and is represented by elastics bearing various blocks (Bilgin et al., 1981; Ayhan et al., 1988). With this feature, the formation is very similar to the Middle-Upper Eocene Kalograia-Ardana formation (Knup and Kluvyer, 1969; Baroz, 1979) in northern Cyprus. However, it is known that the Andırın formation includes Lower Miocene, too. The Kantara and Andırın formations may be correlated with the Durankaya formation, the upper structural unit of the Çüngüş-Hakkari nappe in southeast Anatolia. The micritic, clayey micritrc, calciturbiditic, marly and claystone lithologies of Upper Lutetian-Priabonian age that observed around Sangarbulakçeşme and Yenicerisırtı area (south of Sipahili, east of the Beşparmak mountains) have similar character with the lower levels of the Yavuz formation of the Yeşilbarak nappe.

RESULTS AND DISCUSSIONS

The Lycian nappes in the western Taurus ranges have emplaced on the Beydaglari autochthonous and the Yeşilbarak nappe in Lower Langhian (Graciansky, 1972; Poisson, 1977; Şenel et al., 1989; 1994). The lithological features of the Yeşilbarak nappe indicate the presence of a very wide basin (Fig. 19) in between the Beydağları autochthone and the Lycian nappes in which the deposition of turbiditic elastics from the Lycian nappes were dominant in Lutetian-Lower Miocene. When the para-allochthonous transgressif Varsakyayla formation of Upper Lutetian-Priabonian age (Poisson, 1977), the Küçükkoy formation (Poisson, 1977; Şenel et al., 1989) of the same age situated on the Beydağları autochthonous, the Susuzdağ formation (Önalan, 1979; Şenel et al., 1989; 1994) and the synchronous units in the Yeşilbarak nappe are studied, it is understood that the development of this basin started in the beginning of Upper Lutetian.

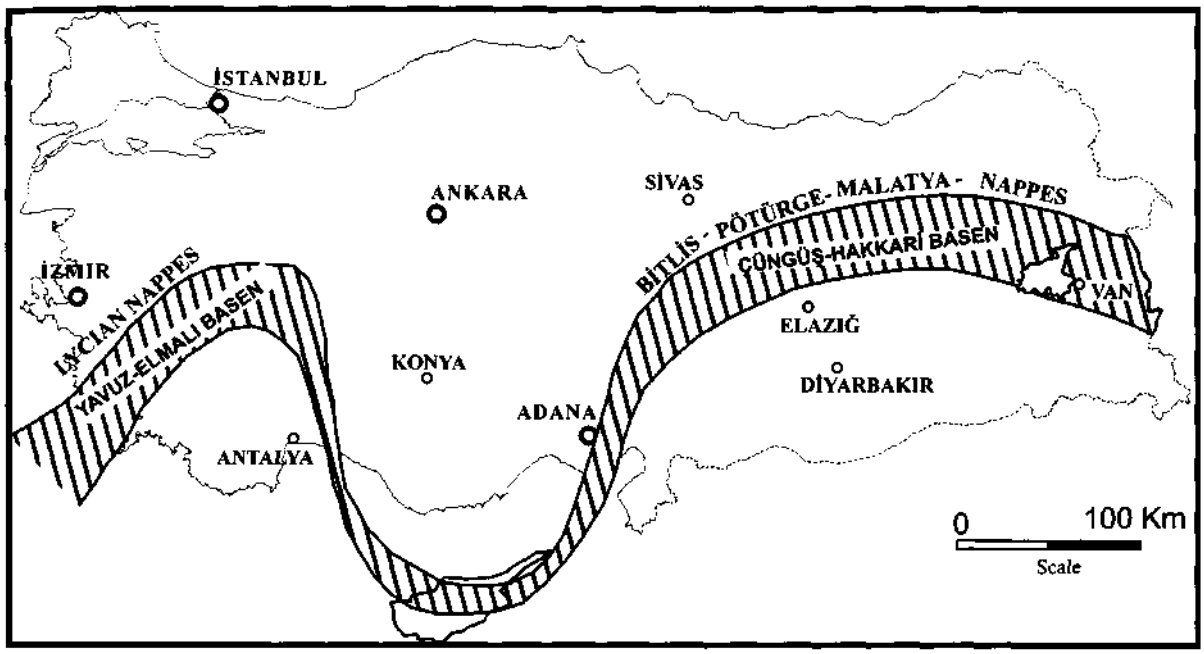

Fig. 19 - Schematic map indicating basins of Yeşilbarak and Çüngüş-Hakkari nappes observed between autochthonous masses and Miocene nappes in Tauride belt.

This basin, known as the Yavuz-Elmalı basin, is the source of the Yeşilbarak nappe which has been thrusted on the Beydağları autochthonous for kilometers-long distance along with the Lycian nappes. This basin was closed in the end of Lower Miocene, at the beginning of Middle Miocene (Lower Langhian).

Similar phenomena have been observed in southeast Anatolia. The lithological features of the Çüngüş formation forming the Çüngüş-Hakkari nappe and the Durankaya and Urse formations of the Hakkari complex (Perinçek, 1990; Yılmaz and Duran, 1997) indicate the presence of a basin where the deposition of the elastics were dominant in between the Bitlis-Poturge-Malatya nappes and the southeast Anatolian autochthonous during Eocene-Lower Miocene (Fig. 19). While the deposition of shelf-type carbonates were prevailing during Eocene-Miocene in the southeast Anatolian autochthone, in the north, in the same period, we can talk about the presence of a deeper basin that was fed by the Bitlis-Poturge-Malatya nappes. These elastics comprising blocks locally imply that the basin is instable. This basin which can be defined as Çüngüş-Hakkari basin (Fig. 19), has been thrusted for tens of kilometers during Eocene-Lower Miocene on the Southeast Anatolian autochthonous, related to the southward transfer of Bitlis-Poturge-Malatya nappes. As related to this thrusting, The Çüngüş-Hakkari basin was closed in the east, in the area reaching down to iskenderun Bay, most possibly in the end of the Lower Miocene.

In northern Cyprus, the existence of the rocks similar to and synchronous with the Yeşilbarak nappe and the Qungus-Hakkari nappe (Baroz, 1979; Robertson and Woodcock, 1986; Hakyemez et al., 2000), and the emplacement of the nappes in the

Beşparmak mountains in Miocene implies the connection of the basins located in the western Taurus ranges and in the southeast Anatolia, and also their similar geodynamic evolution.

In the southern Aegean, the Hellenide nappes overlie the Upper Eocene-Oligocene flysch (Hall et al., 1984; Bonneau, 1984). The Ida zone (Bonneau, 1984) or the Plattenkalk series as defined by Hall et al. (1984) which is considered as autochthonous relative to the Hellenide nappe and shows similarities with the Lycian nappes and the Tripolitza nappe that (Bonneau. 1984, Hall et al., 1984) end up with Eocene-Oligocene flysch. It is not well known, however, if these flysch covers Lower Miocene or not. They show, at least partial, similarities with the rocks forming the Yeşilbarak nappe. During or after the deposition of these flysch, large scale emplacement (in Lower Miocene, Bonneau, 1984) of the Hellenide nappes in the south Aegean was observed as seen in the western Taurus ranges.

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