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Evidence for the Triassic rifting and opening of the Neotethyan Izmir-Ankara Ocean and discussion on the presence of Cimmerian events at the northern edge of the Tauride-Anatolide Platform, Turkey

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ABSTRACT

The Kütahya-Bolkardag Belt (KBB) in northern Central Anatolia is made up of numerous tectonic slivers that represent the passive margin of the Tauride-Anatolide Platform together with oceanic lithologies derived from the Izmir-Ankara branch of the Neotethys. Along the belt the Early Triassic continental clastics overlay the pre-Triassic basement with a very distinct angular unconformity. In the southern part the basement comprises a «Variscan» back-arc basin complex, unconformably overlain by Late Permian shallow-marine carbonates. In the north the Paleozoic rocks are totally eroded and the Early Triassic rocks rest on the Precambrian basement.

The basal part of the Lower Triassic succession is interpreted as proximal alluvial fans followed by meandering river deposits, which interfinger with flood- and coastal-plain sediments. The upper part is characterized by oscillating coastline sediments followed by shelf-type inter-tidal deposition. The minor carbonate lenses in this part contain late Lower Triassic marine fauna. The deposition of the overlying platform-type carbonates lasted from Anisian until the Late Jurassic with an extensional collapse during Carnian. The overlying Early to Late Cretaceous slope-type sediments are followed by a peripheral foreland basin complex of Maastrichtian- Early Paleocene age with olistoliths derived from the Neotethyan Izmir-Ankara oceanic crust.

Within-plate, transitional MORB and MORB-type pillow basalts associated with radiolarian cherts and pelagic limestones were found in the Triassic successions of Tauride-Anatolide Platform and as olistoliths in the Izmir-Ankara mélange complexes. They yielded radiolarians and conodonts of middle and early Late Carnian age, being so far the oldest ages obtained from the KBB.

It is inferred that during the Early Triassic time there was a period of extension, rapid uplifting and continental deposition within the northern margin of the Tauride-Anatolide Platform, which is ascribed to a period of initial rifting. This event is followed by the formation of the Neotethyan Izmir-Ankara oceanic crust during the Carnian between the Tauride-Anatolide Platform and the Sakarya Terrane.

KEY WORDS: *Rifting, Early Triassic, Neotethys, Tauride-Anatolide Platform, Turkey.*

RIASSUNTO

Evidenze del rifting triassico e dell'apertura dell'Oceano Neotetideo Izmir-Ankara e discussioni sulla presenza di eventi Cimmerici nel margine settentrionale della Piattaforma Tauride-Anatolide, Turchia.

La fascia orogenica Kütahya-Bolkardag nell'Anatolia centrale è caratterizzata da numerose scaglie tettoniche che rappresentano il margine passivo della Piattaforma Taurico-Anatolica insieme alle litologie oceaniche derivate dal braccio Izmir-Ankara della Neotetide. Lungo la fascia orogenica, i depositi terrigeni continentali del Triassico inferiore sono sovrapposti al basamento pre-Triassico tramite una ben distinta discordanza angolare. Nella parte meridionale il basamento comprende un complesso bacino di retroarco varisico, sormontato in discordanza da carbonati di mare basso del Permiano superiore. Nel Nord, le rocce paleozoiche sono totalmente erose e le rocce del Triassico inferiore giacciono sul basamento Precambriano.

La parte basale della successione del Triassico inferiore è interpretata come una conoide alluvionale prossimale seguita da depositi fluviali meandriformi, che si interdigitano con sedimenti di piana alluvionale e di piana costiera. La parte superiore è caratterizzata da sedimenti costieri oscillanti seguiti da una deposizione di tipo piattaforma intertidale. Le piccole lenti carbonatiche in questa parte contengono una fauna marina del Triassico inferiore. La deposizione dei carbonati sovrastanti di piattaforma si è sviluppata dall'Anisico fino al Giurassico superiore con un colasso estensionale durante il Carnico. I sovrastanti sedimenti di scarpata del Cretacico inferiore-superiore sono seguiti da un complesso di un bacino periferico di avampaese di età Maastrichtiano-Paleocene inferiore con olistoliti derivati dalla crosta oceanica neotetidea Izmir-Ankara.

Basalti a pillow di intraplacca, transizionali MORB e di tipo MORB, associati a radiolariti e calcari pelagici sono stati rinvenuti nella successione triassica nella Piattaforma Taurico-Anatolica e come olistoliti nei complessi a mélanges Izmir-Ankara. Essi contengono radiolari e conodonti di età Carnico medio e superiore che rappresenta in tal modo l'età più antica ottenuta dalla fascia orogenica KBB.

Si deduce che durante il triassico inferiore c'era un periodo di estensione, di sollevamento rapido e di deposizione continentale nel margine settentrionale della Piattaforma Taurico-Anatolica, che è attribuito ad un periodo iniziale di rifting. A questo evento ha fatto seguito la formazione della crosta oceanica della Neotetide Izmir-Ankara fra la Piattaforma Taurico-Anatolica ed il Terrane Sakarya durante il Carnico.

TERMINI CHIAVE: *Rifting, Triassico inferiore, Neotetide, Piattaforma Taurico-Anatolica, Turchia.*

INTRODUCTION

Within the Eastern Mediterranean realm, the Neotethys is believed to have several branches, which are represented by a complex suture network, separating a large number of continental micro-plates (Sengör *et alii*, 1984; Ricou *et alii*, 1984; Robertson & Dixon, 1984; Okay & Tüysüz, 2000; Stampfli, 2000). The northern branch, located in N Anatolia, had separated the Tauride-Anatolide Platform (TAP) from the Sakarya Microcontinent or the Sakarya Composite Terrane (Göncüoglu *et alii*, 1997) during the Mesozoic. The «Vardar-Izmir-Ankara-Erzincan Ocean» and the «Izmir-Ankara Ocean (IAO, Okay, 1984)» are names proposed for different portions of this main branch. The Kütahya-Bolkardag Belt (KBB) including the «Bolkardag Unit» of Özgül (1976) and the Tavsanli and Afyon zones of Okay (1984) is made up of numerous high pressure/low temperature (HP/LT) metamorphic tectonic slivers that were derived from the northern passive margin of the northwards facing TAP as

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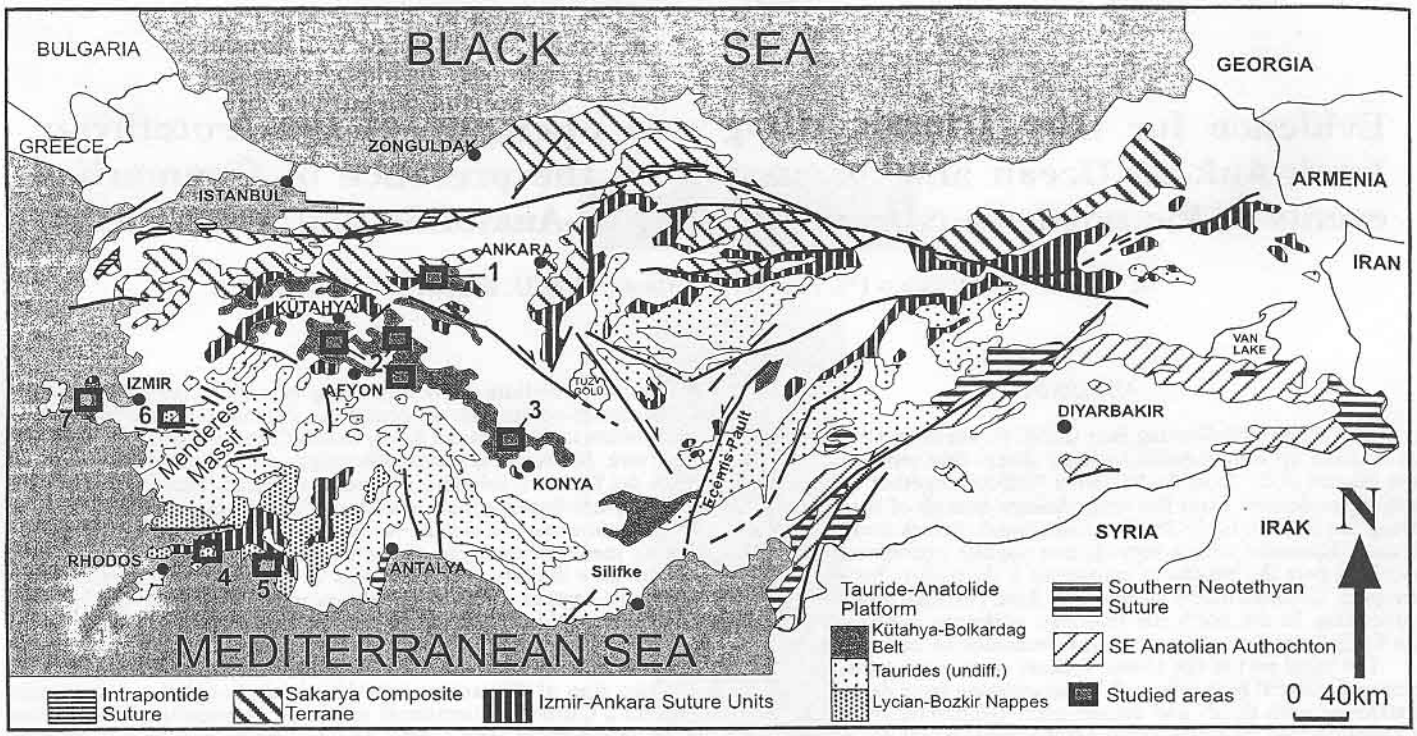

Fig. 1 - Tectonic map of Turkey showing the distribution of the Alpine suture belts, Tauride-Anatolide Platform and the location of the areas referred in the text on the Kütahya-Bolkardag Unit and the Lycian Nappes (simplified after GÖNCÜOGLU *et alii*, 1997). 1) Central Sakarya Area, 2) Kütahya-Afyon Area, 3) Konya Area, 4) Turunc area, 5) Fethiye area, 6) Selcuk area, 7) Karaburun area.
– Carta strutturale della Turchia nella quale sono indicati: la distribuzione della sutura alpina; la Piattaforma Taurico-Anatolica; la posizione geografica delle aree citate nel testo sull'Unità Kütahya-Bolkardag e sulle falde della Lycia (semplificate da GÖNCÜOGLU et alii, 1997). 1) Area Centrale Sakarya; 2) Area Kütahya-Afyon; 3) Area Konya; 4) Area Turunc; 5) Area Fethiye; 6) Area Selcuk; 7) Area Karaburun.

well as ophiolites and ophiolitic mélanges of the IAO, formed during its subduction in Late Cretaceous (GÖNCÜOGLU *et alii*, 2000a). Nappe packages characterizing the northern edge of this platform (e.g. COLLINS & ROBERTSON, 1999) and parts of the oceanic lithosphere are tectonically transported even some 500 km southwards (Lycian nappes) onto the TAP during the Early Tertiary.

Some of the evolutionary models concerning the opening of the IAO are mainly based on sedimentological data, obtained from Liassic sequences of the Pontide Belt as well as from the central part of the TAP, and suggest an Early Jurassic rifting (e.g. GÖRÜR *et alii*, 1983; YILMAZ *et alii*, 1997; STAMPFLI, 2000). A recent unorthodox geodynamic scenario (STAMPFLI, 2000), on the other hand, puts forward that the Late Triassic time span in the TAP is dominated by an important orogenic event (the Eocimmerian event) caused by the closure of a Paleotethyan oceanic branch.

Our detailed fieldwork in different parts of western Anatolia (fig. 1) along the KBB (ÖZCAN *et alii*, 1988, 1989, 1990; GÖNCÜOGLU *et alii*, 1992, 1997, 2000a, 2001) and on the Lycian nappes in SW Anatolia (TEKIN & GÖNCÜOGLU, 2002) was mainly concentrated on the stratigraphy and ages of the Late Paleozoic-Mesozoic successions of different nappes/slices in Central Sakarya, Kütahya-Afyon (figs. 2 and 3) and Konya areas and have revealed a new insight on the geological evolution of the TAP passive margin as well as the opening of the Izmir-Ankara-Erzincan Ocean.

In this paper our largely unpublished stratigraphic and structural data from the KBB, one of the northernmost tectonic units of the TAP, facing to the Neotethys, will be presented. We then interpret the timing of the rifting and opening events of IAO in NW-Anatolia with the aid of new data and correlate these events in neighboring areas. Finally, we will discuss the different geodynamic scenarios regarding the Early Mesozoic evolution of the TAP within the framework of the Cimmerian and Alpine orogenic cycles.

STRATIGRAPHY OF THE KBB

The KBB consists of nappe-package of variably metamorphosed rocks that include a low to medium grade poly-metamorphic basement overlain by a thick sequence of Lower Triassic-Upper Cretaceous, rift, platform and slope-type sediments, respectively. The latest Cretaceous-?Early Paleocene peripheral foreland basin complex overlying them is overthrust by ophiolites derived from the Izmir-Ankara Ocean. The Mesozoic-Lower Tertiary sequence is characterized by alpine low grade HP/LT metamorphism.

Post-tectonic (in regard to the ophiolite emplacement) Paleocene (Selandian-Thanetian)-Lower Eocene clastic rocks and carbonates unconformably overlie the whole sequence.

PRE-TRIASSIC BASEMENT

The pre-Triassic basement of the KBB comprises different pre-alpine low-grade metamorphic units (ÖZCAN *et*

alii, 1990) and their Permian cover. In Central Sakarya area (fig. 1, location 1) the basement consists of garnet-biotite schists, greenschists, graphite-rich phyllites, quartzites with rare marble bands and meta-granites (GÖNCÜOGLU *et alii*, 2000a). The oldest rock-units in Afyon region (fig. 1, location 2; fig. 2) consist of meta-rhyolites, garnet-bearing micaschists, ortho-amphibolites and ortho-gneisses that belong to the Precambrian «Sandıklı Basement Complex» (GÜRSU & GÖNCÜOGLU, 2001). In Konya area (fig. 1, location 3) the Lower Triassic rocks rest with an angular unconformity on different pre-Triassic rocks including the Devonian Bozdag Limestones and the Halici Complex of late Early Carboniferous age (ÖZCAN *et alii*, 1990). The Halici Complex comprises an almost 4000m thick low-grade metamorphic mélange containing olistoliths of platform-type limestones and lydites of Silurian to Viséan age (GÖNCÜOGLU *et alii*, 2000b) and a great variety of arc and within-plate type felsic to intermediate meta-volcanic rocks (e.g. KURT, 1996). Locally, the Halıcı Complex is overlain paraconformably by Serpukhovian-Bashkirian shallow-water carbonates. Upper Carboniferous and Lower Permian rocks are totally missing in Konya area.

The youngest lithologies beneath the Lower Triassic rocks are represented by Permian shallow-marine limestones, interlayered with meta-quartzites that unconformably overly older rock-units. The basal part of the Permian is made up of discontinuous conglomerates with well-rounded quartz, mica-schist, quartzite and marble pebbles, followed by massive quartzites with bands and lenses of recrystallized limestones. In Afyon area, the basal metaclastic rocks include muscovite and kyanite. The overlying limestones are highly recrystallized and only yielded ghosts of Upper Permian algae and foraminifers. In Konya area the recrystallized limestones contain badly preserved *Tetrataxis* sp., *Staffella* sp., *Hemigordius* sp., *Nankinella* sp., *Globivalvulina* sp., *Verbeekina* sp., *Neoschwagerina* sp., *Kahlerina* sp. and algae (*Pseudovermiporella* sp.). From these fossils the three foraminifers *Verbeekina* sp. *Neoschwagerina* sp., and *Kahlerina* sp. are indicative for Wordian-Capitanian (Guadalupian) and hence suggests a late Middle Permian depositional age. Moreover, the Verbeekinid and Neoschwagerinid population is typical for the outer northern platform margin of the Tauride-Anatolide Platform and has been attributed to the «Northern Biofacies Belt» of the platform (ALTINER *et alii*, 2000).

MESOZOIC SEQUENCE

Lower Triassic-Lower Cretaceous units in western Anatolia extend along the KBB for about 600km from Kütahya region to the east of Ecemis Fault (fig. 1). All along the KBB, the Mesozoic sequence starts with Lower Triassic continental clastics and continues as a thick, platform-type carbonate unit without any important depositional brake or angular unconformity up to Late Jurassic and grades upward into basin-slope toe deposits of Early Cretaceous age. In contrast to the pre-Triassic garnet and biotite-bearing low to medium grade metamorphic basement rocks, the Mesozoic units are characterized by the presence of only HP/LT metamorphic minerals such as Fe-Mg carpholite in the Lower Triassic metapelites (CANDAN *et alii*, 2002) and aragonite in the Lower Cretaceous recrystallized limestones. In the NW and SW of the Menderes Massif, analogous metamorphic successions are described in the Mesozoic cover units (KONAK *et alii*, 1987), indicating the continuation of the KBB-type successions in the circum-Menderes nappes. Correlative Mesozoic successions are found within the Lycian nappes in southwest Anatolia (e.g. GRACIANSKY, 1972; COLLINS & ROBERTSON, 1999).

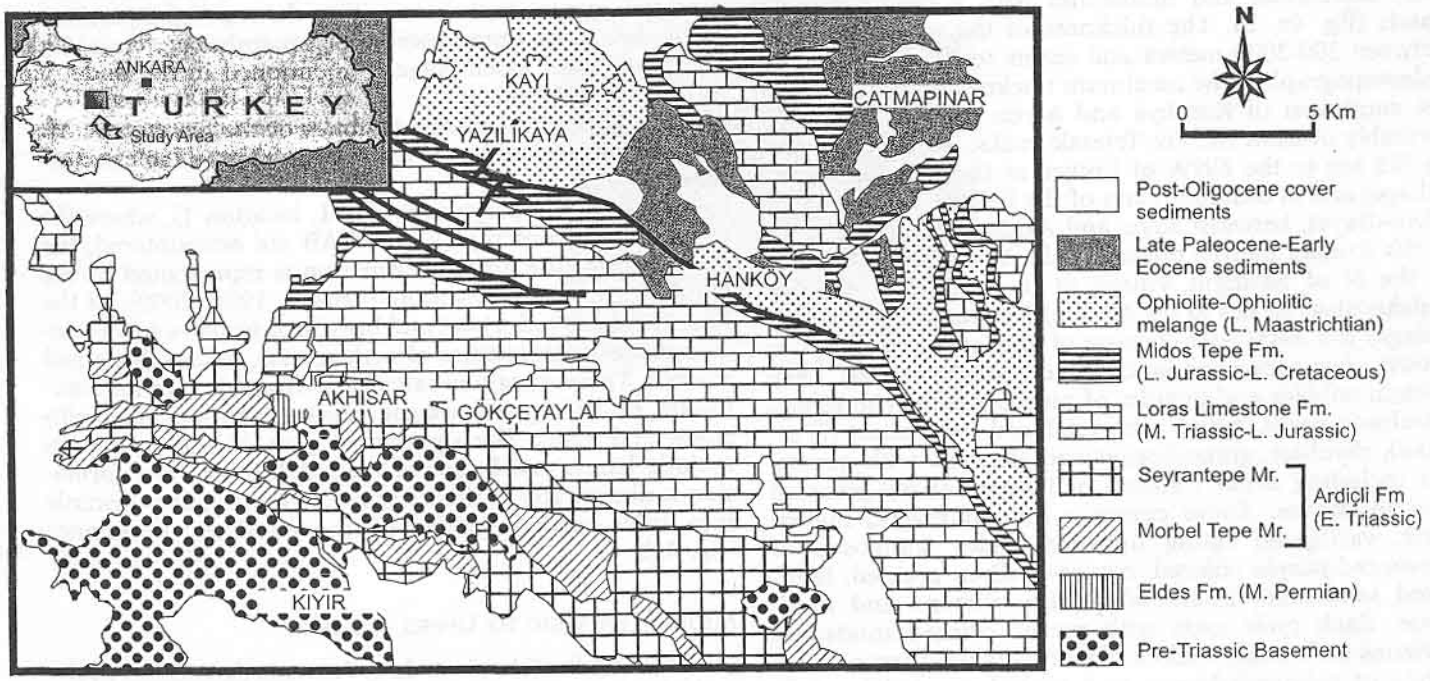

Fig. 2 - Geological map of the northwestern part (N of Afyon) of the Kütahya-Bolkardag Unit.
– *Carta geolgica della parte nordoccidentale (a Nord di Afyon) dell'Unità Kütahya-Bolkardag.*

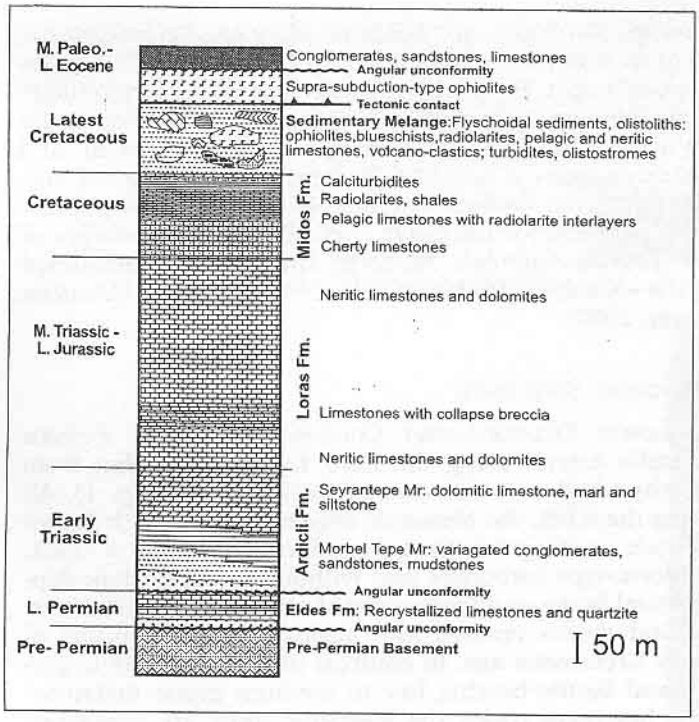

Fig. 3 - Generalized columnar section of the Kütahya-Bolkardag Unit (simplified from GÖNCÜOGLU *et alii*, 1992).
- Colonna dei rapporti stratigrafico-strutturali dell'Unità Kütahya-Bolkardag (semplificata da GÖNCÜOGLU et alii, 1992).

LOWER TRIASSIC ROCKS

In central western Anatolia, Lower Triassic rocks are known as the Ardıçlı Formation (ÖZCAN *et alii*, 1989, 1990; GÖNCÜOGLU *et alii*, 1992). In Kütahya and Konya areas (fig. 1, locations 2 and 3) this formation consists of two members; the lower member (Morbel Tepe Member, ÖZCAN *et alii*, 1990) is made up of variegated conglomerates, sandstones and mudstones with a few carbonate bands (fig. 4a, b). The thickness of the member varies between 300-2000 meters and seems to be controlled by paleotopography. The maximum thickness measured is to the southwest of Kütahya and Afyon (fig. 2). It unconformably overlies the Pre-Triassic rocks. At its type locality (15 km to the NNW of Konya, at the Ardıçlı (Malas) Village) and at different parts of the KBB (e.g. to the N of Afyon-Bayat, between Kıyır and Akhisar villages (fig. 2); at the Roman marble quarry to the W of Afyon-Altıntas; to the N of Sevdigin Village at the southern slope of Kulaksızdag; 32 km to the NNE of Konya, at the Meydan Village) the basal part consists of almost massive, red to brown, clast-supported breccias and conglomerates. They contain cobbles and pebbles of muscovite-chlorite schist, metabasic rocks, lydites, recrystallized limestones (?Permian), rhyolites, granodiorites and alternate with quartzites including small volumes of interstitial red-greenish gray mudstone. Above comes a unit of several meters thick, variegated fining upwards cycles composed of brown-red-purple colored, coarse-medium grained, laminated sandstones interbedded with siltstone and mudstone. Each cycle ends with purple colored mudstone horizons with mud-cracks and worm-tracks. Discontinues bands of yellowish-brown and pinkish gray dolomites, dolomitic limestones and oolitic limestones occur at the upper part of the member. The limestones are oosparitic-oomicritic and contain undetermined bivalves.

The depositional features and the complete absence of marine fossils in the lower and middle levels of the member point to a sub-aerial deposition. The conglomerate dominated basal levels are interpreted as proximal alluvial fans, grading into sandstone-siltstone-mudstone rich meandering river deposits that are interlayered with flood-plane and coastal plane sediments. The upper part of the sequence is interpreted as oscillating coastline environment giving rise to subtidal to intertidal deposits. In the Afyon area (between Incebel Tepe and Obruk Tepe, 5 km to the N of Afyon-Altıntas) the first limestone bands above the variegated sandstones include *Glomospira sinensis* HO and *Glomospirella shengi* HO. In the Konya area (between Tepecik Sırtı and Sızma Village 15 km to the NNE of Konya and, at Gökceyayla village 13 km to the SW of Konya-Ilgın) the earliest limestone beds and lenses contain the following fossils: *Glomospira sinensis* HO, *Glomospirella shengi* HO, *Glomospira* sp., *Meandrospira pusilla* HO, *Nodosinella* sp., *Earlandia* sp., algae and gastropods. These fossil findings indicate an Induan to Olenekian deposition age of the Morbel Tepe Member.

The upper member of the Ardıclı Formation is named as the Seyrantepe Member in Konya area (ÖZCAN *et alii*, 1990). This unit is composed of yellowish brown, medium to thick-bedded, recrystallized dolomitic limestones and oolitic dolomites with some marl, sandstone and siltstone interlayers. In Afyon area, discontinuous bands and lenses with dark green volcaniclastic rocks alternate with these slightly metamorphosed siltstones and sandstones. The thickness of the member varies between 10 and 200 meters. It shows lateral and vertical transitions to the underlying Morbel Tepe Member. Petrographically, the limestones are determined as bioclastic grainstones, packstones and oolitic grainstones, indicative for shelf margin and tidal bar (WILSON, 1975) depositional environment. The microfossil bearing bioturbated bioclastic wackestones of the uppermost part of the carbonate succession suggests deposition within the restricted platform facies belt. The limestones of the member have yielded the same fossil assemblage mentioned in the underlying Morbel Tepe Member.

The uppermost wackestones of the Seyrantepe Member are transitional to the overlying Loras Limestone Formation.

In Central Sakarya area (fig. 1, location 1), where the northernmost outcrops of the TAB are encountered, the equivalent of the Ardıçlı Formation is represented by the Otluk Formation (GÖNCÜOGLU *et alii*, 1996; 2000). At the base there are red, violet and brownish massive meta-conglomerates with pebbles of orthogneiss, mica-schists and marble. These conglomerates pass upwards into an alternation of variagated arkosic meta-sandstone, meta-siltstone and slate. The uppermost part of the formation include bands and lenses of meta-dolomites. The formation is almost 160 m thick in this area and grade upwards into thick-bedded Loras-type recrystallized limestones (fig. 4c).

MIDDLE TRIASSIC TO UPPER JURASSIC

The Middle Triassic to Late Jurassic deposition in the KBB includes a continuous succession of medium-thick bedded, recrystallized limestones and dolomites of the

Loras Limestone Formation (ÖZCAN *et alii*, 1990; KAYA *et alii*, 1995). At its lowermost part in Loras Dagı (10 km to the S of Konya-Kadındanı), the formation starts with dark gray, medium-thick bedded biohermal limestones with dolomitic interlayers and yielded Anisian foraminifers (e.g. *Glomospirella triphonensis*, *G. semiplana* in its lower layers and *Trochammina alptalensis* KOEHN-ZANN, in the upper part). The following black, medium-thick bedded cherty limestones and black dolomites are more than 200m thick and include foraminifers and conodonts of Ladinian to Norian age. The pink micritic limestone sequence with intra-formational conglomerates of mass-flow origin in this part of the succession has yielded Late Ladinian-Early Carnian conodonts (KAYA *et alii*, 1995). Upwards follows an alternation of dark gray, medium-bedded breccoidal algal limestones and dolomites that grade into a very thick sequence of black to dark gray thin to medium-bedded limestones and gray dolomite. The fossil content of this part of the succession indicates to a depositional age from Norian to Middle Liassic (Sinemurian) as shown by ÖZCAN *et alii* (1989, 1990) and KAYA *et alii* (1995). The upper part of the Loras Limestone Formation includes light colored, medium to thick bedded limestones and dolomitic limestones with foraminifers and algae and reaches up to the pink to beige colored, thin bedded micritic limestones of Late Malm-Berriasian age. The detailed litho-stratigraphy and the fossil content of the Triassic and Jurassic parts of the Loras Limestone Formation are given in GÖNCÜOGLU *et alii* (1992) and ÖZCAN *et alii* (1989; 1990). The thickness of the unit reaches up to 350 m in the Kütahya area. Except the level with the intra-formational conglomerates, the lower part of the succession is made up of lagoon and tidal plane deposits of restricted shelf facies belt whereas the upper part is ascribed to the open shelf facies belt (WILSON, 1975). The field observations and the paleontological data based on foraminifers and conodonts (ÖZCAN *et alii*, 1989, 1990) indicate that there are no angular unconformities or any significant depositional breaks within the succession.

UPPER JURASSIC TO UPPER CRETACEOUS

Along the KBB, the Late Jurassic to Late Cretaceous time interval is characterized by the deposition of pelagic limestones and mudstones with radiolarian chert interlayers (Midos Tepe Formation of ÖZCAN *et alii*, 1990). The petrographic work on the carbonates of the Midos Tepe Formation suggest that it is deposited within the continental slope facies belt of WILSON (1975) the upper part being characteristic for the lower continental slope-type.

With an increase of calcareous turbidites and turbiditic sandstones with ophiolitic detritus the Midos Tepe Formation grades into an ophiolite-bearing sedimentary mélange (Cögürler and Hatip mélanges in Kütahya and Konya areas, respectively; ÖZCAN *et alii*, 1989, 1990; GÖNCÜOGLU *et alii*, 1992). The sedimentary mélange overlying the Midos Tepe Formation is more than 3000m thick and includes huge olistoliths of blueschists, mafic and ultramafic rocks, spilites-basalts with radiolarites and pelagic limestones of Late Triassic to Late Cretaceous age.

In the Central Sakarya area (fig. 1, location 1), a mega-olistolith with basaltic pillow lavas interlayered with radiolarian cherts and mudstones included abundant *Xiphotheca* especially *Xiphotheca rugosa* BRAGIN and *Capnuchosphaera* revealing that the age of the volcanic

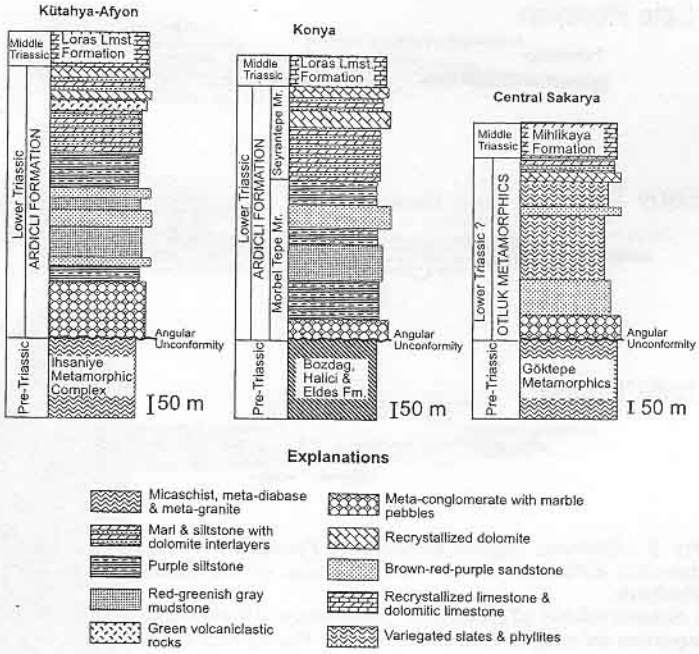

Fig. 4 - Schematic stratigraphic logs of the Ardiçli Formation in different parts of the Kütahya-Bolkardag Unit. a) Kütahya-Afyon area, b) Konya area, c) Central Sakarya area.
– Log stratigrafico schematico della Formazione di Ardiçli in differenti parti dell'Unità di Kütahya-Bolkardag: a) area di Kütahya-Afyon; b) area di Konya; c) area di Sakarya Centrale.

rocks is early Late Carnian (TEKIN *et alii*, 2002). This age determination is also confirmed by conodont data (*Gondolella polygnathiformis* BUDUROV & STEFANOV, written comm., Prof. Dr. Ismet GEDIK, Trabzon-Turkey). Our preliminary geochemical data on the pillow basalts (GÖNCÜOGLU *et alii*, in prep.) clearly display the characteristics of transitional mid ocean ridge basalts (MORB).

The oldest post-tectonic (in respect to sedimentary mélange formation) sedimentary cover in the KBB is represented by shallow-marine deposits of Late Paleocene-Early Eocene age.

TRIASSIC ROCKS OF THE LYCIAN NAPPES

It is unanimously accepted that the Lycian nappes represent the northern margin sequences of the TAP and the adjacent oceanic lithologies of the IAO. The overall assumption is that they were emplaced on the Menderes Massif of the TAP during the closure of the IAO and transported for several hundreds of kilometers during the late alpine movements (e.g. SENGÖR *et alii*, 1984). By this, their Lower Mesozoic successions may give a clue on the geological evolution of the northern margin of TAP.

The Turunc Unit in the Gülbahar Nappe of the Lycian nappes in SW Turkey (fig. 1, location 4) include in its lower part a well-developed succession with volcanic/volcaniclastic rocks associated with pelagic sediments (Cövenliyayla Volcanics). The Cövenliyayla Volcanics comprise MORB and within-plate-type basalts (COLLINS & ROBERTSON, 1999) with pink to red intra-pillow limestones and cherty limestones, alternating with volcaniclastic rocks and debris flow conglomerates. Along an intensively sliced section to the north of the Turunc Vil-

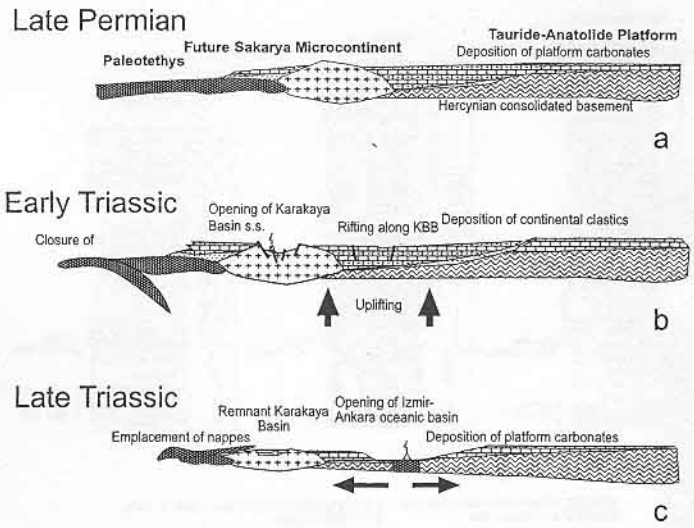

Fig. 5 - Cartoons suggesting the Late Permian to Late Triassic geodynamic evolution of the northern edge of the Tauride-Anatolide Platform.
– Schemi relativi all'evoluzione geodinamica dal Permiano al Triassico superiore del margine settentrionale della Piattaforma Taurico-Anatolica.

lage (Marmaris) the Cövenliyayla Volcanics include spilitic basalts with pink to red intra-pillow limestones and cherty limestones, alternating with volcaniclastic rocks and debris flow conglomerates. From the intra-pillow limestones on the main road to the N of Turunc Village (GPS locality: 10042/70480), following moderately preserved radiolarians were obtained (TEKIN & GÖNCÜOGLU, 2002); *Capnuchosphaera colemani* BLOME, *C. triassica* DE WEVER, *Vinassaspongus subsphaericus* KOZUR & MOSTLER, *Triassocrucella triassica* (KOZUR & MOSTLER), *Paronaella* sp. aff. *P. simoni* (KOZUR & MOSTLER), *Tetraporobrachia haeckeli* Kozur & Mostler, *Nabolella parvispinosa* (KOZUR & MOCK), *Ruesticyrtium goczani* KOZUR & MOSTLER, *Annulotriassocampe* sp., *Xiphotheca longa* KOZUR & MOCK. Radiolarians of this limestone clearly indicate *Tetraporobrachia haeckeli* Zone (middle Carnian) due to presence of index-species and associated fauna.

The Upper Triassic rocks in this unit are transitional to Jurassic carbonate successions (GRACIANSKY, 1972; COLLINS & ROBERTSON, 1999) and there is no evidence for an important unconformity between them, as it is the case in the KBB Mesozoic successions.

The Lycian nappes in the western part of the Menderes Massif (fig. 1, location 6) also include Triassic and Jurassic successions (KONAK *et alii*, 1987). In a recent study GÜNGÖR & ERDOGAN (2002) report the presence of within-plate type metabasalts within the Caltası Formation in the Selcuk area. This formation unconformably covers Permo-Carboniferous recrystallized limestones and start with violet basal conglomerates, followed by mica-schists with rare limestone interlayers. The volcanic succession studied is located in the upper part of the formation and is tentatively dated as Late Triassic by GÜNGÖR & ERDOGAN (2002). The overlying carbonate unit that yielded Upper Triassic to Early Cretaceous fossils is several hundred meters thick. Again, there are neither conglomerates nor any indication for an angular unconformity between the Triassic and Jurassic successions in this locality.

DISCUSSION

Even if there are still some disagreements about the names, life-spans of the Tethyan oceans as well as the subduction polarities of their lithospheres, a consensus exists regarding the presence of a Paleozoic oceanic branch (Paleotethys) to the north of Gondwana (for a brief discussion see STAMPFLI, 2000). It is also frequently accepted that some continental fragments were rifted off from the Gondwana-margin during the closure of this oceanic seaway. In the scenario we suggest, the Tauride-Anatolide Platform and the Sakarya Terrane at its northern periphery were during the Late Paleozoic still located at the southern margin of Paleotethys (fig. 5a). The configuration of the Carboniferous arc-back-arc pair in the Sakarya Terrane and KBB, respectively (GÖNCÜOGLU *et alii*, 2000a), and the lateral continuity of the «Northern Biofacies Belt» of KBB (typified by benthic foraminifers; ALTINER *et alii*, 2000) in the Sakarya Terrane during Late Permian support this interpretation. The southward subduction of the Paleotethyan oceanic lithosphere (e.g. SENGÖR *et alii*, 1984; OKAY *et alii*, 1996) has very probably resulted in the formation of a series of basin and range-type extensional basins on the Tauride-Anatolide Platform. The representative of this marginal basin development within the Sakarya Terrane in the north is the disputed Triassic «Karakaya Basin», that was originally considered as a rift basin (BINGÖL *et alii*, 1975). We consider the Karakaya Basin as the main extensional basin in the upper plate (GÖNCÜOGLU *et alii*, 2000a). The basin-fill here starts with conglomerates and arkosic sandstones on a metamorphic basement (intruded by Carboniferous granitoids) and its Permian carbonate cover. The oldest age (conodont data) obtained yet from the Karakaya basin-fill is Olenekian-Early Anisian (GENC, 1992).

In further south the KBB part of the Tauride-Anatolide Platform, the Latest Permian-Earliest Triassic time interval is characterized by a rapid uplifting (fig. 5b), evidenced by the complete erosion of the Paleozoic rocks, prior to the deposition of the proximal alluvial fan, meandering river, flood-plane and coastal plane sediments during the Induan. The initiation of this event is ascribed to the initial rifting of the Tauride-Anatolide Platform during the extensional phase. The massive breccias and conglomerates of the alluvial fan deposits at the lower part Morbel Tepe Member of the Ardıçlı Formation are very probably formed along the boundary-faults on the footwall. The lithospheric break-up is accompanied by a local thermal uplift due to the intrusion of mantle material at depth. The Triassic intrusion ages obtained from some of the gneissic granitoids in the E and NE Menderes Massif (single zircon Pb/Pb evaporation ages; DANNAT & REISCHMANN, 1998) may be related to this thermal event. Ongoing subsidence in the rift basin is marked by a transition of continental sediments into the shelf margin and tidal bar-type sediments of the Seyrantepe Member of the Ardıçlı Formation, followed by lagoon and tidal plane deposits of the lower part of the Loras Formation during the Anisian-Ladinian time. The formation of mass-flow-type intra-formational conglomerates within the Loras Formation during Late Ladinian-Early Carnian time in the KBB very probably suggests the final break-up stage and sea floor spreading further north giving way to the formation of the oceanic crust of the Izmir-Ankara Ocean (fig. 5c). The products of this event are the MORB-type

basaltic rocks, associated with early Late Carnian radiolarian cherts we discovered in the Late Cretaceous mélange complex of Izmir-Ankara Suture Belt in Central Sakarya region (GÖNCÜOGLU *et alii*, 2001; TEKIN *et alii*, 2002). The within-plate to transitional-MORB type basaltic volcanism of middle Carnian age in the Gülbahar Nappe of the Lycian nappes (GÖNCÜOGLU *et alii*, 2002) is another evidence for the initial stages of the oceanic crust formation within the Izmir-Ankara Ocean.

During the tensional phase, the extensional processes have very probably carried on within the southern part of the Tauride-Anatolide Platform along detachment faults, along which small extensional rim-basins with continental-shallow marine sediments were formed. This is the case in most of the outcrops in western Taurides, where upper Late Triassic or Liassic red clastics that unconformably rest on older sequences (e.g. MONOD & AKAY, 1984). The KBB part of the Tauride-Anatolide Platform must have remained as an Atlantic-type passive margin with open shelf and slope-type deposition during Jurassic and Cretaceous, respectively. The Latest Cretaceous sedimentary mélanges with ophiolite and blueschist knockers in the KBB were formed in peripheral foreland basins in front of the nappes derived from the subduction-accretion complex of the Izmir-Ankara Ocean.

This tectonic scenario involving the Early Triassic rifting on the TAP and the opening of the Neotethyan Izmir-Ankara oceanic seaway between the Sakarya microcontinent and the Taurides during the Late Triassic contrasts with the recent geodynamic model of STAMPFLI (2000) and STAMPFLI *et alii* (2001).

In their model, these authors consider the Taurides as a part of their Cimmerian Terrane Assemblage. This consideration is mainly based on the following criteria:

a) like the other Cimmerian terranes from Apulia to South Tibet, the Taurides are devoid of any Variscan deformation.

b) during the Triassic, the Taurides (together with other Cimmerian terranes) were involved in the Eocimmerian phase of «PalaeoTethys» closure.

The first assumption is not completely supported by the field data from the KBB and other parts of the Taurides, as it does not consider the new findings in this region. Our new findings from the Karaburun (KOZUR & GÖNCÜOGLU, 2000) and Konya areas (fig. 1, locations 3 and 7) of the KBB clearly indicate the presence of a back-arc-type development during the Viséan (GÖNCÜOGLU *et alii*, 2000b). In the Fethiye region (fig. 1, location 5), the Tekedere Series within the Tavas Nappe of the Lycian nappes includes Lower Carboniferous (middle to early Late Viséan) deep-sea turbidites and olistostomes with lydite and cherty limestone olistoliths (KOZUR *et alii*, 1998). Pillow lavas within the same nappe display chemical characteristics of within-plate alkali basalts, typical for ocean islands, and are interpreted as representatives of upper Moscovian-lower Kasimovian oceanic seamount (GÖNCÜOGLU *et alii*, 2000c). Both in Konya and Fethiye areas, Lower Permian sediments are not represented and Guadalupian basal conglomerates, quartzites and shallow-marine limestones rest with a distinct angular unconformity on the Carboniferous successions. This late Middle Permian unconformity is of regional extend and had been reported from different parts of the northern part of the Taurides (ÖZGÜL, 1976), thus indicative for an event during the late Variscan time at the northern edge of the TAP. If the available paleobiogeographic considerations (e.g. ALTINER *et alii*, 2000) are accepted, during the Late Paleozoic the TAP was not in the close vicinity of the Eurasian active margin but still attached to Gondwana. By this, we suggest that the Late Paleozoic event in the KBB was not related to the eastern European Variscan deformation but was generated due to the gentle docking of an arc (fig. 5a; Sakarya arc) with the TAP that closed the Carboniferous back-arc-basin in Konya and probably also in Karaburun areas.

The second assumption of STAMPFLI (2000) and STAMPFLI *et alii* (2001) is mainly based on the subsidence curve of the Taurides and on a single study (MONOD & AKAY, 1984) that suggested the presence of Eocimmerian events on the TAP.

The subsidence curve for the Taurides (fig. 2 in STAMPFLI, 2000) is mainly based on the stratigraphic data of DEMIRTASLI (1984). This data only regards the southern Taurides but not the KBB part of the TAP. Moreover, recent work (e.g. SARMIENTO *et alii*, 1999) has shown that the stratigraphy and the structural relations between the tectonic units in this area are unreliable.

The study of MONOD & AKAY (1984) is even more crucial for the «Eocimmerian event» of STAMPFLI (2000) and STAMPFLI *et alii* (2001) in the Taurides and deserves therefore a more detailed evaluation. MONOD & AKAY (1984) list in their study several localities where a «Cimmerian unconformity» has been detected. Recent studies in these areas have shown that most of these stratigraphic and tectonic «evidences» for «Cimmerian events» are either based on structural misinterpretations or inaccurate age dating.

In the Tavsanlı area of the KBB (fig. 2, log 3 in MONOD & AKAY, 1984) to the NW of Kütahya (fig. 1, location 2 in the present study), the «polymict basal conglomerates of Liassic age» are shown to be olistostromal conglomerates within the Upper Cretaceous wild-flysch and the conformably overlying «thick-bedded dolomites and recrystallized limestones of Mesozoic aspect» belong to an exotic mega-block within the wild-flysch (ÖZCAN *et alii*, 1989; KAYA *et alii*, 1995).

In Sandıklı area (fig. 2, log 4 in MONOD & AKAY, 1984) it has been shown that the metamorphism of the «meta-rhyolites and associated greenschists» is not «within the age range of the Cimmerian movements» but Precambrian in age (GÜRSU & GÖNCÜOGLU, 2001).

In Fethiye area (fig. 2, log 5 and fig. 6 in MONOD & AKAY, 1984), as already mentioned, the Tekedere Series of the Tavas Nappe is not Permian but Carboniferous in age and is unconformably overlain by Middle Permian and Late Triassic successions (Cenger Formation in MONOD *et alii*, 1983) respectively (KOZUR *et alii*, 1998). As correctly mentioned in MONOD & AKAY (1984), the Cenger Formation in this locality has not been observed in direct contact with other allochthonous units or to seal the tectonic contact between them and thus can not be considered as an evidence for «juxtaposition by thrusting of two Palaeozoic units to reflect a significant pre-Liassic tectonism».

MONOD & AKAY (1984) further state that in the western Taurus (Isparta, Seydisehir and Beysehir areas, logs 6 and 7 in fig. 2 in MONOD & AKAY, 1984) «no polygenetic detritial units» and regional unconformities «are known before and after» the interval «from latest Triassic to Mid-

dle/Upper Jurassic». However, MONOD (1977) has shown that the Tarascı Limestone of Anisian age in this area rests with an angular unconformity above the Lower Paleozoic Seydisehir Formation and starts at its base with polygenetic basal conglomerates.

Summarizing the discussion above, we put forward that most of the «evidences» for the «Cimmerian events» in the Taurides are questionable. This statement does not exclude the presence of stratigraphic gaps or Liassic, Dogger and even Malm unconformities on older units in different parts of the Taurides as recently shown by ALTINER *et alii* (1999). On the contrary, their presence is in accordance with our model concerning a rift-related intra-platformal extension with successive transgressions on the rift-shoulders.

The last and most critical discrepancy between the previous field data and the model proposed by STAMPFLI (2000) and STAMPFLI *et alii* (2001) is the suggested location of the «Palaeotethys Suture» in the Taurides. In their evolutionary reconstructions (figs. 6 and 8 in STAMPFLI, 2000; fig. 2 in STAMPFLI *et alii*, 2001) these authors locate a distinct Late Triassic suture zone between the Menderes-Taurides-Munzur units of the TAP and the Pelagonian Zone of Greece with foreland basin sedimentation in the former unit. The suture belt is assumed to be formed by northward subduction of the Palaeotethys, leaving the Taurides in the footwall-block setting within the subduction zone. Yet, neither any subduction-accretion prism material, nor related volcanism, metamorphism and foreland-type rocks of Late Triassic age had been reported from the Taurides. By this, there are no reliable evidences for such a suture belt in the TAP.

The recent work of DE BONO *et alii* (2001) on the stratigraphy of the Pelagonian Zone in central Evia island in southeastern Greece on the other hand, clearly show that until the Late Jurassic the stratigraphy of this zone is almost identical to that of the KBB. DE BONO *et alii* (2001) further suggests «the northern passive margin sequence of Pelagonia is interpreted as related to the opening of the Maliac Ocean during the Early Mesozoic». Based on this interpretation, the KBB (and the internal units of the Tauride-Anatolide Platform) units were very probably located at the northeastern continuation of the Pelagonian Zone. If our interpretation is accurate, the KBB and related units will fill the gap at the southeastern passive margin of the Maliac Ocean (STAMPFLI, 2000; fig. 6) and the Izmir-Ankara Ocean will be placed to the eastern continuation of this oceanic seaway. By this, the Maliac-Izmir-Ankara oceanic system should have opened between the Rhodope-Sakarya terranes in the north and the Pelagonia-Tauride-Anatolide Platform in the south.

CONCLUSIONS

In different parts of the KBB of the Tauride-Anatolide Platform, red continental clastic rocks rest with a distinct angular unconformity on variably deformed and metamorphosed pre-Triassic successions. The oldest ages obtained from the carbonates in the upper part of these polygenetic conglomerates are indicative for an Early Triassic rift-type deposition. The pebbles and boulders of the basal conglomerates contain variably metamorphosed basement rocks, including recrystallized limestones of Middle Permian age. Middle Triassic conformably overlies the continental clastics to Upper Jurassic/Lower Cretaceous platform-type carbonates and Lower Cretaceous to Upper Cretaceous slope-type sediments respectively.

Based on our mainly unpublished field-studies in different parts of the KBB it is suggested that the initial rifting phase on the Tauride-Anatolide Platform started during Early Triassic. It resulted in the separation of the Tauride-Anatolide and the Sakarya microplates by the formation of the Izmir-Ankara rift basin in between. The sea-floor spreading and the oceanization of the Izmir-Ankara basin were already realized during the Middle to early Late Carnian. Late Triassic basaltic volcanism with a small plume-influenced geochemical signature in Antalya and Mamonia complexes on the other hand, is attributed (e.g. DIXON & ROBERTSON, 1999; SMITH, 1999) to the opening of another oceanic seaway to the south of the Taurides (Southern Neotethyan Ocean, now represented by the Southern Neotethyan Suture on fig. 1). By this, it may be assumed that the separation of the TAP from Arabia by the opening of the southern branch of the Neotethys and the opening of the IAO (and separation of the TAP from the northerly Sakarya Microcontinent) is synchronous and related to the southward subduction of the Paleotethys (fig. 5a) as previously suggested by various authors (e.g. SENGÖR *et alii*, 1984).

Based on the new data, it is suggested that the geodynamic models postulating a Liassic rifting and opening of the Izmir-Ankara Ocean (e.g. GÖRÜR *et alii*, 1983; SENGÖR *et alii*, 1984; YILMAZ *et alii*, 1997; OKAY *et alii*, 1996; STAMPFLI, 2000) should be revised. The new field and stratigraphic data also contrast with the plate-tectonic model of STAMPFLI (2000) and STAMPFLI *et alii* (2001) that suggests an «Eocimmerian» suturing within the TAP in western Anatolia.

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