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GEOLOGIC EVOLUTION OF THE ANATOLIAN SEGMENT OF THE TETHYAN BELT

Tetis Kuşağı Anadolu kesiminin jeolojik evrimi

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ÖZ: Tetis kuşağının Jeolojik evrimi, Gondvana kuzeyinden kopan ince bir kıtasal parçanın coğrafik boyutunun belirlenmesi ve bu parçanın Avrupa'ya eklenmesine ilişkin sürecin kinematik parametrelerinin saptanması ile özdeşleşir. bu makalede Tetis kuşağının Anadolu bölümüne ait jeolojik sınırlamalar tartışılmakta ve yayınlanmış paleomanyetik verilerle entegre edilerek bazı yeni görüşler kapsayan bir jeolojik evrim modeli önerilmektedir.

1. Gondvana kuzeyinden kopan kıtasal parçanın kuzeyi, Balıkesir - Bursa - Eskişehir - Ankara - Kastamonu - Tokat - Erzincan ve Kars'tan geçen Tetis keneti ile sınırlanır. Güney sının ise Bitlis/Pütürge masiflerinin hemen kuzeyinden geçerek kapanmasını henüz tamamlamamış Doğu Akdeniz'e bağlanır.

2. Neotetis'in kuzey kolu yoktur. Bu görüşü destekleyen üç temel veri ayrıntılı olarak tartışılmıştır, a. Pontidler'deki Mesozoyik magmatizma yay magmatizmasıdır. b. Yayardı havzaya ait çökeller Liyas'ta başlar ve üste/kuzeye doğru derinleşen bir karbonat/fliş kaması ile temsil edilir. Bu çökel paketin altında ise üst doğru tane incelmesi gösteren (regresif), serpantinit kapsayan, granitlerle kesilmiş, esas olarak Triyas yaşlı, Tetis kenetine bitişik ve diğer bir anlatımla bu kenete jenetik olarak bağlı bir flişoid paket yer almaktadır, c. Kenetin güneyinde Triyas - Üst Kretase yaşlı, Triyas öncesi bir temel üzerinde uyumsuz, faunal ve sekansiyel olarak kenetin kuzeyinden tamamen farklı bir çökel paket vardır. Bu veri, tek başına, bu kenetin en azından tüm Mesozoyik süresince varolmuş bir okyanusa ait olduğunun somut kanıtıdır.

Zonguldak, Azdavay ve İstanbul Palezoyiğinde Karbonifer ve Permiyen çoğunlukla karasal çökellerle temsil edilirken, kenetin kuzeyindeki kenete komşu alanda varolan denizel Karbonifer - Triyas güneye bakan bir paleomorfolojiye işaret eder. Diğer yandan Toroslarda Paleozoyik istiflerin kuzeye bakışımlı olması Tetis'in sadece Mesozoyik'te değil, Paleozoyik'te de var olduğunu düşündürür. Diğer yandan, Atlantik okyanusuna ait verilerin, Gondwana ile Avrazya arasında çok büyük bir açıklığa işaret etmesi, yukarıdaki görüşü desteklemekte olup, Permo - Triyas'ta riftleşme olmadığını ve diğer yandan bu dönemde Gondvana - Avrasya çarpışmasının da sözkonusu olamayacağını göstermektedir.

Batı Pontidler Triyas'ta saat yönünde dönerken, marjinal ofiyolitler aktif kıta kenarı üzerine itilmiş, yay önü havza sınırlı olarak yükselmiş ve Batı Karadeniz'de kabuk incelmesi başlamıştır. Tetis'in kuzeye dalması Gondwana kuzeyinde gerilme rejimi yaratırken, Üst Permiyen'den itibaren gelişen çanaklarda (İzmir - Ankara zenu, Balıkesir yöresi ve Kütahya civan) tüm Mesozoyik boyunca derinleşen istifler çökelmiştir. Gondvana kuzeyinde kabuk incelmesi Üst Permiyen'de başlamış, ancak kıtasal parçanın kopması, paleomanyetik verilere göre, Liyas'a kadar gerçekleşmemiştir. Karakaya formasyonu içinde arakatkı olarak bulunan bazik volkanikler ile granitlerle kesilmiş gabroyik kayaçlar fraksiyonal kristallenmeye bağlı olarak biyotit ve/veya hornblendli granitle ve daha sonra da hololökokrat granitlerle devam etmiştir. Bu magmatizmanın üst yaş sının Liyas'tır. Erken Liyas'ta gerçekleşen dalma-batma zonu gerilemesi yay önü havzadaki sıkışma rejiminin okyanus tarafına göçüne neden olurken, yay-ardı havzaya ait gerilme rejimi de okyanus tarafına göç etmiş ve Liyas döneminin çukur alanlan yayardı havza çökelleri ile transgeressif olarak örtülmüştür. Bu dönemin pozitif alanlan Portlandiyen - Berriaziyen'den itibaren progresif olarak çökmüş ve kuzeye bakışımlı Liyas - Lütesiyen yaşlı bir karbonat - flis kaması ile örtülmüştür.

Kretase döneminde çarpışma başlamış ve pasif kıta kenarları şiddetle deforme olmuştur. Aktif kıta kenarında ise tüm Kretase öncesi deformasyonlan silen, 30 - 50 km. genişliğinde YB/DS metamorfizması gelişmiştir. Bu deformasyon kuzeye doğru aralığı genişleyen ritmik makaslama zonları ile devam etmekte ve Kimeriyen ile Kretase deformasyonlan yanyana görülebilmektedir.

Ofiyolitler, erken çarpışma döneminde pasif kıta kenarları üzerine itilmiş, imbrike bindirmelerle yükselmiş ve çarpışma döneminin rotasyonal süreçlerine bağlı olarak gelişen önçukurlara kaymıştır.

Neotetis'in Bitlis - Pütürge kuzeyindeki keneti Lütesiyen sonunda tamamen karasallaşmıştır. ancak, kıtasal parçaların tam olarak uyuşması Miyosen'e kadar tamamlanmamıştır. Kıtasal parçaların uyumunda doğrultu atımlı fayların önemi vurgulanmış ve Doğu Akdeniz'in kapanmasının sayısız sol atımlı fayla sağlanmakta olduğu görüşü getirilmiştir.

ABSTRACT: The geological constraints presented in this paper show that the northern strand of Neotethys is non-existent and the existing suture is actually of the Tethys (Paleotethys). Geologic and published paleomagnetic evidence has been integrated to the conclusion that this ocean has persisted for the entire Palaezoic and Mesozoic and has been consumed through periodically recessing northward subduction between the Triassic and Lutetian in western and central Anatolia.

Western Pontides has been rotated dextrally during the Permo - Triassie, contributing to upwarp of the Triassic arc, initiation of rifting of the western Black Sea and obduction of marginal ophiolites onto the active margin. The enigma for the coeval Pontian and Gondwanian Karakaya formations is briefly discussed with emphasis on regressive nature of Triassic - Early Liassic sedimentation in Pontides versus the continuous fining - upward Mesozoic sequences of the passive margin.

The Jurassic (Late Triassic - Early Liassic) granitoids of the Pontides are suggested to correspond to the fractionated residue of the basic volcanism of the Triassic arc. These granites have intruded the Karakaya formation and have been transgressed by a carbonate - flysch wedge of the southward onlapping back - arc basin, the Black Sea, in liaison with oceanward shift of the respective compressive and dilatational systems of the fore-arc and back-arc basins due to a presumable recess of subduction. The deposition in the extensional basins has started in troughs of earlier colapse and the intervening areas have been subject to progressive submergence between Portlandian - Berriasian and the uppermost Cretaceous.

There has been an incipient collision during the Cretaceous with intense shearing of the fore-arc and the premontories of the passive margins of the intermediate and Arabian plates. A HP/LT deformation deletes all pre - Cretaceous deformations along the 50 km. wide Tethyan suture. The Cretaceous shear zones repeat with widening, towards the north, deformation being resticted to planes of movement when sufficiently away from the suture, enabling observation of juxtaposed Cimmerian and Cretaceous deformations.

Ophiolites have been obducted onto the passive margins of both Tethys and Neotethys during the early stages of the collisional period, uplifted by imbricate thrusting on the passive margin, finally gliding into foredeeps (exogeosynclines) that have been forming due to rotational processes.

The Neotethys has sutured along immediate north of Bitlis/Puturge massives by Late Lutetian. However, the completion of colage has lasted until the Late Miocene in between these massives. The role of transform faults for acquisition of the fit of continental masses has been emphasised. Numerous left-lateral transforms are still active, aiming to push Western Anatolia southwards, onto the oceanic crust in the Eastern Mediterranean, the part of the Neotethys which has not completed its obliteration.

THE ANATOLIAN SEGMENT OF THE TETHYAN BELT

INTRODUCTION

The argumentation on the Tethyan systems is essentially based on comprehensive kinematic approaches of Smith (1971) and Pitman and Talwani (1972), leading to several plate-tectonic syntheses (Dewey et. al., 1973; Stocklin, 1974, 1977; Adamia et. al. 1977; Biju - Duval et. al., 1977; Zonenshain et. al., 1979; Şengör and Yılmaz, 1981; Livermoore and Smith, 1984; Robertson and Dixon, 1984; Dercourt et. al., 1986).

This paper will report evidence from Turkey, some of which have already been published in Turkish, to link Anatolian sutures to neighbouring areas, targeting a time-space synthesis for Tethyan sutures. The discussion will be based on the idea that a sliver of continental crust has started to rift, in Early Triassic, off northern Gondwana and accreted to Eurasia in the course of consumption of the westward narrowing gulf of the Panthalassa ocean, named as Tethys (Suess, 1904 - 1924) or Paleotethys (Stocklin, 1977). Evidence will be introduced to show that the northern strand of Neotethys of Sengor and Yilmaz (1981) is non-existent, and the existing suture is the Paleotethyan's (Fig. 1). It will be defended that the Paleotethys had lied roughly between Pontides and Anatolids and had persisted through entire Palaeozoic and Mesozoic, having been consumed through progressively or periodically recessing northward subduction, suturing by Late Eocene in western and Central Pontides.

Topics of debate are so diverse that ambiguities arise in usage of related terminology. Thus, it is suggested that the reader should refer to Fig. 1 to avoid any misunderstanding of the sense in which the related terminology has been used in this text. Tethys is used for a long - lived Palaezoic - Mesozoic ocean which separates roughly Anatolids and Pontides of Ketin (1966), omitting Paleotethys because of its time-space implications. Neotethys is used in the sense of Robertson and Woodcock (1981) for the Eastern Mediterranean, but it is suggested that it is linked to Zagrids not through the immediate south of (Hall, 1976), but immediate north of Bitlis Pütürge massives. The term Pontides is used to denote the area lying north of the Tethyan suture proposed in this text (Fig. 1).

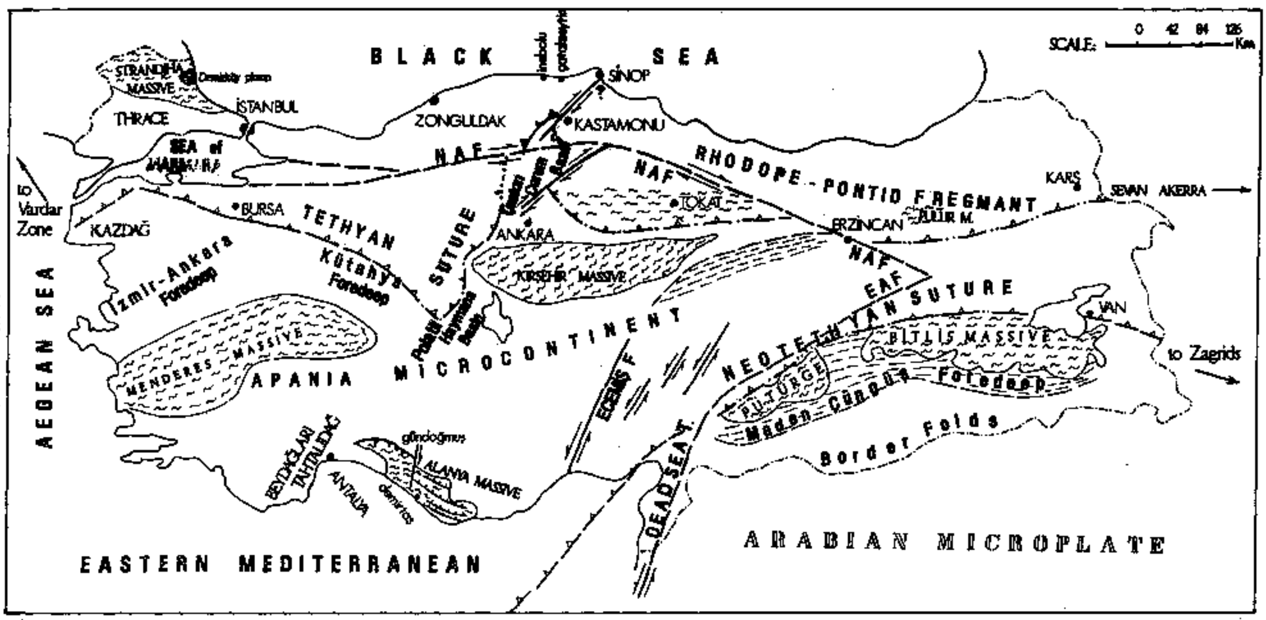

Figure 1. Map showing geographic locations of crystaline massives, important lineaments and sutures of Anatolia.

Şekil 1. Anadolunun kenetlerini, kristalin masiflerini, ve önemli çizgiselliklerini gösteren harita.

A new term "Apania" is proposed and used hereafter, to denote the intermediate microcontinent defined to be comprising of Apulia, part of Anatolia, Central Iran and Central Afghanistan.

CRITICAL REVIEV OF THE BACKGROUND RELATED TO NEOTETHYS

The proposal of Early Triassic rifting of the Pamphylian basin of Dumont et. al. (1972) and comprehensive plate - tectonic syntheses of Dewey et al, (1973) and suggestions of Stocklin (1974) for Iran have affirmed the idea that a sliver of continental crust has rifted off northern Gondwana, from Triassic onwards, to collide with the Eurasian margin (Stocklin, 1977; Adamia et al, 1977; Biju Duval et al, 1977; Şengör and Yılmaz, 1981; Robertson and Dixon, 1984). This idea was supported by Robertson and Woodcock (1980) with further suggestion that rifting, possibly caused by slab-pull, has created alternating strips of oceanic and thinned continental crust in the Eastern Mediterranean and that the Western Taurids had been a passive margin throughout the Mesozoic. On the other hand there has been a strong and live opposition to this idea by Ricou et. al., (1974) and Delaune - Mayere et. al., (1977) that the Tauric platform had not detached off Africa before the Cretaceous (Ricou et. al., 1986; Dercourt et.al., 1986), implying that the Mediterranean ophiolites including Hatay, Troodos and Antalya originated from a northern root zone. Ricou et.al. (1974) have also accepted "Antalya nappes" of Lefevre (1967) as allochtonous units originating from the southern margin of Tethys, overriding the Tauric carbonate platform to a geographic position in between the Troodos massive and 'Taxe calcaire du Taurus" of Ricou et.al. (1975). However, there are several locations in the Taurus belt where sedimentation is continous from early Palaezoic to Late Eocene (Demirtaşlı, 1967; Özgül et, al., 1973; Metin et. al., 1982; Şenel, 1986; Ayhan, 1987) so that ophiolite nappes cannot pass over and flyshoid sediments of "Antalya nappes" are laterally gradational to shallow marine carbonates deposited on relatively stable regions. This idea was thus opposed not only in the sense that "Antalya nappes" are more or less in situ (Şengün et.al., 1978), but they are related to break up of a passive margin (Robertson and Woodcock, 1981).

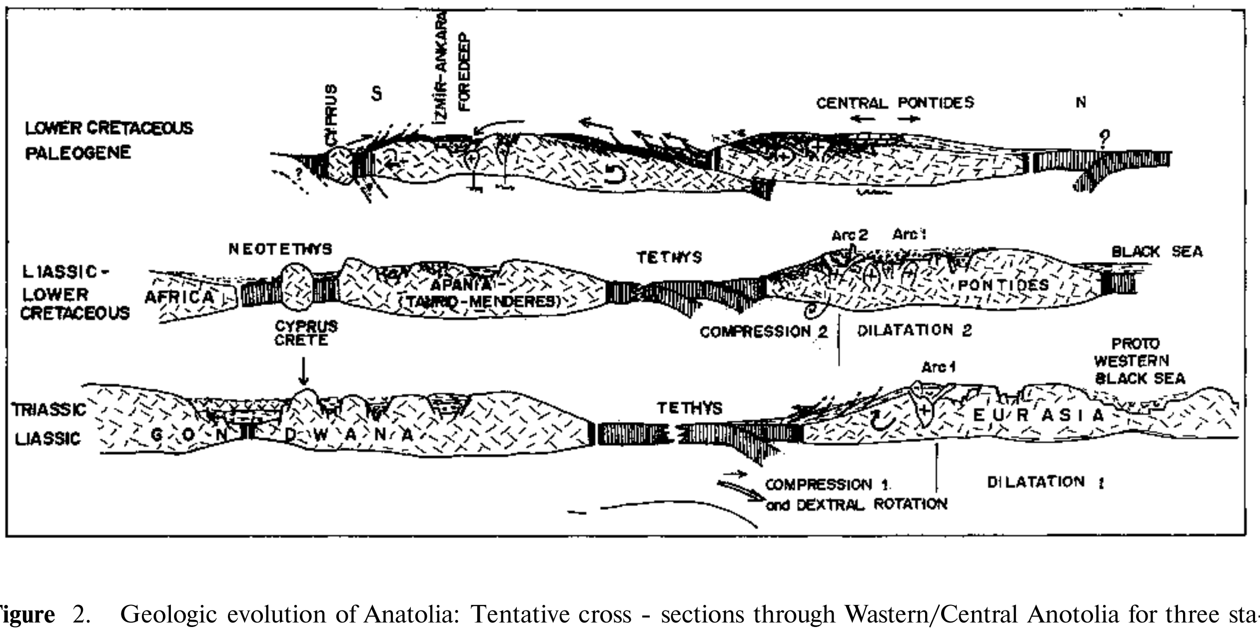

Figure 2. Geologic evolution of Anatolia: Tentative cross - sections through Wastern/Central Anotolia for three stages of evolution. A. Onset of Tethyan subduction and initiation of Neotethyan rifting. B. - Period of northward drifting of the intermediate plate (Apania). C. The collisional period.

Şekil 2. Anadolu[1] nun jeolojik evrimi: Evrimin üç safhası için Batı - Orta Anadolu'nun jeolojik kesitleri. A. Tetis'te dalma batma ve Neotetis'te riftleşme başlangıcı. B. Orta levhanın (Apania) kuzeye doğru sürüklenme dönemi. C. Çarpışma dönemi.

Alanya massive has been considered to be a helvetic type nappe originated from north of the Menderes massive in earlier discussions. However, a southern origin has later been proposed (Özgül, 1983) following investigations showing that stratigraphic relations do not allow a northern origin. Allochthonous nature of this massive has also been questioned (Şengün et.al., 1978). The western block of the left-lateral Ecemis fault (Central Taurids) was suggested (Şengün et. al., 1990 a) to have been rotated clockwise, so that the oceanic crust in the vicinity of Antalya gulf had been compressed and imbricately thrusted onto the Beydağlan (Tahtalıdağ) platform (Robertson and Woodcock, 1981; Yılmaz, 19Ş4) and western parts of the Alanya massive. There is a well marked imbricated northward thrusting in western parts of Alanya with diagnostic parageneses of blueschist facies. On the other hand, northward dipping ecailles of Central and Eastern Alanya, in contrast to northward thrusting of the west, displays a morphologically distinct dextral torsion, with a possible tear of limited extent east of Gündoğmuş (Fig. 1). This phenomenon is belived to have caused exposition of the Pan-African basement of the massive in the vicinity of Alanya township where the basement has been siliced with incipiently deformed Palaeozoic - Mesozoic sediments. The present author believes that the Alanya massive and the "Antalya nappes" are in situ and the latter is itself the substantial evidence for Triassic rifting (Şengün etal., 1978) and that Robertson and Woodcocks (1981) E-W trending basins and continental chips fit well into the regional geologic setting. However, juxtaposition of continental chips by strike - slip movements seems an alternative solution for the western half of the İsparta angle (Lycian nappes) so that only a few thin slivers may be preferable to many.

Eastern Taurids

The second major controversy is the geographic setting of Neotethys (southern branch of Sengor and Yılmaz, 1981) with respect to Bitlis/Pütürge massives. It was suggested that the Pamphylian basin of Dumont et. al. (1972) was linked to Zagrids through immediate south of Biüis (Hall, 1976; Şengör and Kidd, 1979). However, this idea was partly debated with the argument that Bitlis/Pütürge lied on the northward extension of the Arabian plate (Ricou, 1980; Özkaya, 1982; Yazgan et. al., 1983; Çağlayan et. al., 1983,1984) for the entire Mesozpic. It was further suggested that Neotethys lied immediate north of Pütürge (Yazgan, 1984) and Bitlis (Şengün, 1990). These massives represent the deformed passive margin of the north-facing Arabian platform, deformed by colage of Arabia with a sliver of continental crust (Apania) comprising Keban (Yazgan, 1984) and East Anatolia corresponding to westward extension of Central Iran. The following reasons were given (Şengün, 1990) to justify the northern position of Noetethys relative to Bitlis.

1. Mesozoic - Lower Tertiary sedimentary units are entirely undeformed throughout the northern margin of border folds, contary to what one would expect along deformed passive margins.

2. A complete Mesozoic section south of Bitlis province, exactly the same as that of the Arabian platform (Çağlayan et. al., 1983), suggests not only in situ position of Bitlis during the Mesozoic, but also implies that Bitlis and border folds were on the same north - facing platform during the Mesozoic.

3. The northern segments of Bitlis were subject to intense Alpine deformation with complete Alpine zoning. On the other hand, Precambrian parageneses have been preserved either in the lithons/microlithons or cores of amphibolite lenses, towards the south, where Alpine deformation had been weak and had not completely eradicated the Precambrian parageneses of the infrastructure (Şengün, 1984). Alpine deformation of northern Bitlis resulted in formation of a coeval extensional basin (Maden - Çüngüş foredeep. Fig. 1) ascribed to block rotations to close up relicts of Neotethys (Şengün et. al., 1990 b).

4. There is an undeformed sequence of Cretaceous - Tertiary age, located north of Lake Van. It is incorrelatable with medial Eocene syndeformational sedimentation of northern Bitlis, suggesting conclusively existence of an oceanic domain immediately north of Bitlis, consistent with deformational aspects of Biuis and other relevant geological data (Özkaya, 1982; Yazgan, 1984; Çağlayan et. al., 1984; Göncüoğlu and Turhan, 1984).

On the basis of the preceeding discussion, the present author belives that there has been a second ocean (Neotethys) which is sutured north of Bitlis/Pütürge and Zagrids but its western extension (the Eastern Mediteiranian) has not yet completed its obliteration.

GEOLOGIC CONSTRAINTS OF TETHYAN EVOLUTION

Non-existence of Northern Neotethys

The geographic setting of Paleotethys of the Anatolian segment has been an enigma. The northward polarity of subduction proposed by Stocklin (1974, 1977), Adamia et. al. (1977) and Biju-Duval et.al. (1977) was challenged by a plate tectonic model by Şengör and Yılmaz (1981) suggesting a southward polarity and a vague suture in medial Pontides. However, this model has met a strong opposition (Bergougnan and Forquin, 1982; Robertson and Dixon, 1985; Yilmaz and Boztuğ, 1986; Dercourt et. al., 1986; Şengün et. al., 1990 a). The objections were based mostly on island-arc type of geochemistry of the Mesozoic magmatic activity in the Pontides, with additional criticism based on paleogmagnetic evidence and Eurasian affinity of the Zonguldak Palaeozoic (Kerey, 1982; Toprak, 1984; Robertson and Dixon, 1984; Dercourt et. al., 1986). Other geologic constraints were introduced (Sengun etal., 1990 a) to show that the northern strand of Neotethys had never existed and this suture was actually of the Paleotethys (Tethys).

1. It is widely accepted that Pontides is characterized by an intense Mesozoic - Cenozoic magmatic activity (Kazmin etal., 1986; Tokel, 1992), marking the active margin of Europe. Kastamonu granitoids of Central Pontides, also, point to an island-arc setting (Boztuğ et.al., 1985). The granitic bodies are extremely shallow seated, and intrude a flyschoid sequence of essentially Triassic age (Karakaya or Akgöl formation) displaying wide aphanitic peripheries with incipient crystallization of the host rock, suggesting not only a slight upwarp and limited erosion, but also a cold country rock as typically expected in island arc settings. However, this is in discrepancy with Şengör and Yılmaz (1981) who ascribe these plutons to crustal thickening, for the reason that these granites intersect mutually the nappes (Zonguldak Palaezoic and the Akgöl formation) that they defend to have been piled up through colage of Europe with the Cimmerian continent. These granites have to postdate the Middle Jurassic collision (Şengör and Yılmaz, 1981), in contradiction to the large amount of granitic detritus feeding the conglomeratic base of the Liassic - Lutetian sedimentary wedge.

2. The pre - Liassic basement of Pontides is covered by an undeformed sedimentary wedge. The sedimentation started during the Liassic in locations of earlier colapse (Saner, 1980), forming the gradational base of a north-facing carbonate - flysch wedge which can be seen as a continous fining upward sequence along the road section from Devrekani to Çatalzeytin (Fig. 1). The lowermost part of this section consists of a conglomeratic base and a gradational carbonate sequence of Portlandian-bemasian age. The section grades into a flyschoid sequence with basaltic intercalations of Campanian - Maastrichtian age. The chemistry (Ercan and Gedik, 1983) and geologic setting implies a magmatism of the within - plate type generated by extensional tectonics in an island-arc setting or back-arc basin. The sequence continues with a turbiditic uppermost Cretaceous - Lutetian section along the Black Sea coast while the coeval sedimentation in inland areas is represented by a southward onlapping shallow marine carbonate sequence. The Liassic sedimentation has been ascribed to (Gorur. et. al., 1983) rifting of the northern strand of Neotethys of Sengor and Yılmaz (1981). It is agreeble that this sedimentation is related to extensional tectonics (Gorur et. al., 1983), but, its northfacing nature shows conclusively that it is related to the Black Sea and not to the southward located northern Neotethys.

3. A continuous Triassic - Cretaceous sequence has been reported (Özcan et. al., 1988) from Kütahya region in northernmost Anatolids (Fig. 1), showing, very clearly, a chronologically and sequentially different sedimentation on each side of the suture.

Each item of the above presented evidence, on its own, or preferably complementing one another can logically be integrated to the conclusion that there has been an ocean separating the Anatolids from the Pontides for the entire Mesozoic, in place of the proposed northern Neotethys of Şengör and Yılmaz (1981). Has this ocean been formed by a Late Palaeozoic or Permo - Triassic rifting? Permo - Carboniferous paleomorphology of Pontides, tectonostratigraphic features of Karakaya formation and published evidence on paleomagnetism, will be critically reviewed to come to the conclusion that this ocean, Tethys or Paleotethys has persisted throughout the Palaeozoic and Mesozoic.

Permo - Carboniferous Paleomorphology of Pontides

Palaezoic sedimentation in Western and Central Pontides are represented essentially by shallow marine sequences of interfingering quartzites, shales and metacarbonates which are extremely uniform and incipiently deformed. The Zonguldak - Azdavay region has emerged by the Carboniferous and remanied as a positive area until the Late Jurassic. A shallow marine Permo - carboniferous sequence exists towards the south and grades into a flyschoid sequence (Karakay or Akgol formation) of essentially Triassic age, which was reported (Şengün et. al., 1990a) to overlie unconformably a quartzite outcrop of Lower Palaezoic age. On the other hand, the Kocaeli Triassic of northwesternmost Pontides is also a shallow marine to continental sequence. Its north-facing nature in contrast to the southward located and south facing Carboniferous - Triassic sedimentation implies existence of not only a Triassic ocean northeast of Pontides (Proto - Black Sea) as reported by Zonenshain and Le Pichon (1986), but also a Late Palaeozic oceanic domain south of the Pontides. The continental Carboniferous cropping out in Bayburt region of Eastern Pontides is suggestive that the Proto - Black Sea is separated from the the Tethys also by the Eastern Pontides during the Late Palaezoic.

Karakaya Formation

At this point, tectonostratigraphic features of the Karakaya formation has to be outlined, because it is critical to testing of existing plate-tectonic interpretations of Tethyan evolution. The nomenclation, which is generally used for Triassic sedimentation, has first been defined by Bingöl (1968) and it has since become an enigma. The Triassic sedimentation is represented by a fining - upward sequence in northernmost Anatolids whereas it is invariably regressive north of the Tethyan suture. The nomenclation has been applied to both of these flyschoid sequences, which are essentially Triassic in age, and comprise blocks of Permian limestones and intermittent basaltic lava flows. North of the suture, it has ultrabasic rock associations with sedimentary contacts at the top and sheared zones at the bottom. The ophiolite body in the Kure region of Central Pontides consists of dismembered units of ultrabasic rock followed by a sheeted dyke complex carrying an alternation of deep marine sediments and pillow lavas. This ophiolite was suggested (Sengun et. al., 1990 a) to correspond to the ocean floor between the Eurasian margin and the northward diving Paleotethys and has been retrocharriaged onto the European margin coevally with deposition of the Triassic flysch. In summary,

1. Flyschoid sediments are imbricated with lenses of ophiolites of various size disfaouring deposition on a passive margin, in fact implying unavoidably, an active margin.

2. The Pontian Karakaya (Akgöl) formation is invariably regressive, also implying deposition on an active margin.

3. It ajoines the Tethyan suture, thus it is genetically related to the Triassic ocean separating the Anatolids and the Pontides.

4. While the Pontian Karakaya formation is regressive, the coeval sedimentation is represented by a fining - upward sequence in northernmost Anatolids. Thus, a passive margin of the south, versus an active margin of the north, disfavours rifting during the Triassic, in fact it is a conclusive evidence for a previously existing ocean.

5. Along the suture, there is a Cretaceous - Tertiary HP/LT deformation along a 30-50 km. wide belt with intense shearing and a well-developped tectonic fabric. This deformation weakens towards the outer Pontides, through rhythmic planes of shear which have a widening spacing towards the north where Cretaceous deformations are restricted to thrust planes while the lithons display deformations related to a previous episode (s). Recognition of Karakaya formation in the Pontides becomes difficult towards the south because of this southward intensifying

deformation. In other words, a belt with intense Cretaceous deformation is recognised along the suture with an ajoining terrain in the north with pre-Liassic deformations showing rhythmic and progressive southward augmentation of its Cretaceous imprint.

REVIEW OF PUBLISHED PALEOMAGNETIC CONSTRAINTS FOR ANATOLIA

Published evidence on the relative motions of Africa and Europe in the vicinity of Anatolia is indicative of a simpler convergence than that previously envisaged (Livermoore and Smith, 1984). However, the motions of the intermediate plate(s) must be more complex on consideration and analyses of the limited data on the Pontides and Taurides (Lauer, 1981; Westphal et. al., 1986).

If the argument given in the preceeding pages is acceptable as conclusive evidence of the non-existence of the northern strand of Neo-Tethys, it may be concluded that there is no discrepancy between the geologic constraints and the paleomagnetic data with the implications that the Taurids has not detached off Africa until the Late Liassic and there was a well - marked separation between Europe and Pontides during the Jurassic. The intermediate plate is suggested to have collided, by Late Paleogene, with the Rhodope - pontide fregmant which might have started to separate from Europe as early as Late Permian, having been quite away from Europe during the entire Jurassic implying existence of a discrepancy (Sanbudak, 1989) between the paleomagnetic evidence and the suggested Middle Jurassic colage (Şengör and Yılmaz, 1981) of Europe and the Cimmerian continent. Paleomagnetic evidence implies also that there connot be a Triassic rifting to separate Anatolids and Pontides, and that Arica (including Apania) was separated from Europe by at least a 4000 km wide ocean (Robertson and Dixon, 1984) during the Triassic.

The problem with Jurassic latitudes (Dercourt et. al., 1986) seems to have an interpretational character. The paleomagnetic data and geologic constraints are quite compatible on the basis of interpretation of geologic data used for the scenario of evolution herein presented. One of the discrepancies forwarded by Dercourt et. al. (1986) is based on the suggestion that the Western Black Sea has not rifted until the Cretaceous (Zonenshain and Le Pchon, 1986), based on the reported existence of Upper Jurassic elastics derived from a southern province, in Crymea. However, this is not conclusive for non-existence of oceanic domains for the entire Western Black Sea during the Triassic - Jurassic because these sediments could have been derived from a stripe of E-W trending postive area separating the Black Sea from the Crymea, in consistency with back-arc extension during the Jurassic backed up by substantial evidence related to history of sedimentation (Yılmaz, 1979; Saner, 1980; Gedik et. al., 1984, Şengün et. al., 1990a) in the Pontides. The Jurassic separation of Pontides and Europe (Sanbudak, 1989) is also consistent with the left - lateral transform (Dercourt et. al., 1986) separating Eastern and Western Pontides Furthermore this fault is compatible with ophiolite emplacement which may be ascribed to dextral rotation of Western Pontides during the Triassic. This rotation is believed to be the cause of the limited upward of the Triassic arc. The paleomagnetic and geologic data for the Taurides may be interpreted to be compatible with the suggestion that the crustal attenuation has started in Early Triassic (Robertson and Woodcock, 1981) and the intermediate plate has detached off Africa by Early Liassic. The Liassic detachment is in consistency also with intensification of the extensional regime that has coevally prevailed in the Pontides.

GEOGRAPHIC LOCATION OF THE TETHYAN SUTURE

The discussion presented so far, comprises conclusive evidence showing that a Palaezoic - Mesozoic ocean has existed roughly between Pontides and Anatolides. However, an accurate location of the Tethyan suture in Anatolia, requires a discussion for its eastern and western ends. It is generally agreed on existence of a suture between Bursa and Ankara where the geologic parameters are different on each side. Towards the west, the geographic location of the suture becomes vague, and the present author believes that it passes through north of Kazdağ as shown in Fig. 1, for reasons outlined below. First of all, there is no deformation in Mesozoic units of the İzmir - Bursa line of the Izmir - Ankara zone of Brinkmann (1972) and secondly a Triassic - Cretaceous fining - upward sequence existing in this zone in addition to several other locations reported from south of the suture line (Özcan et. al., 1988; Erdoğan, 1990; Koçyiğit and Altıner, 1990) is conclusive evidence for invalidity of Liassic rifting along the Izmir - Bursa line. Therefore, the Tethyan suture has to be searched for somewhere north of Kazdağ which is an intensely deformed terrain (Bingöl, 19689) compatible with a deformed passive margin. The HP-LT metamorphism reported from north of Kazdağ mountains (Gözler, 1986) may implicitly be accepted as evidence supporting a location very close to southern coast of the Sea of Marmara. In the Central Pontides, the suture runs roughly N-S, possibly coinciding with the paleotransform fault proposed by Dercourt et. al. (1986). A repetition of the geology of the Daday - Devrekani, İlgaz and Tokat massives is recognisable in small scale geologic maps, so that an inferred set of paleo - transform faults have been proposed to explain the marked offsets of the suture, although further structural work is needed along the graben separating the Ilgaz massive from Daday - Devrekani.

There is also a problem for connection of the suture line from Erzincan eastwards. If the triangular area in East Anatolia between Kars, Van and Erzincan represents a Cretaceous acretionary prism, as suggested by Şengör and Yılmaz (1981), then the northern branch of Neothethys should pass north of this prism, such that the acretionary prism should have been obducted onto the passive margin in conformity with formation of a thick crust in this region. This would imply a connection of Northern Neotethys to the Paleotethys which would not be logically possible on a time - space basis. Thus, the present author suggests that slicing of continental crust and ophiolites are restricted to the Erzincan - Sevan Akerra line. The deformation weakens towards the central part of East Anatolia where incipiently deformed Paleozoic sediments of Gondwanian affinity are seen. Further south, along the northern coast of Lake Van, it is possible to diagnose magmatic rocks in a geologic setting which is quite similar to that described by Yazgan (1984) and Asutay (1987) for the Baskil arc (A Cretaceous arc set on the intermediate plate by the northward diving Neotethys). Thus following the proposition of Stocklin (1974, 1977) for Iran, Central Iran extends westwards between immediate north of Bitlis/Puturge and the suture line proposed herein for Tethys (Fig. 1).

The geologic and paleomagnetic constraints are in favour of a long - lived ocean separating the Pontides and Anatolids Tectonostratigraphic features of the Karakaya formation is suggestive for an active margin coeval with the emplacement of the marginal ophiolites without obligation of a colage or an orogen during the Permo - Triassic. A Triassic orogen or rifting would imply a single Gondwanian - Eurasian continental mass during the Permo - Trassic which would be unacceptable on the basis of atlantic ocean data showing that there has been a wide westward - narrowing Tethys during the Permo - Triassic.

GEOLOGIC EVOLUTION

Background

Palaezoic existence of the westward - narrowing gulf of the Panthalassa ocean, the Tethys of Suess (1904 - 1924), has been accepted as a working hyphothesis in this paper. Recent tectonic models related to Tethys have exclusively defended that a sliver of continental crust has rifted off northern Gondwana (Stocklin, 1974, 1977; Biju - Duval et. al., 1977; Adamia et. al., 1977; Şengör and Yılmaz, 1981; Robertson and Dixon, 1984; Dercourt et. al., 1986) and has drifted to collide with Eurasia at the expense of Tethys. However, radical differences have arisen due to timing of events as well as several parameters of the detached sliver(s). Prior to presentation of a scenario of evolution for the Anatolian part of the Tethyan belt, controversial aspects of the evolutionary frame will be briefly discussed.

Plate tectonic models of the 1980's for the Tethyan evolution all had a common question. How is it that the Neotethyan active margin with Cretaceous deformations ajoines in its immediate north, a belt with Cimmerian deformations covered by an undeformed Jurassic deposition? The obvious answer has come from Şengör and Yılmaz, 1981) who emplaced the ophiolite root zone to north of a vague suture running through northern Pontides. They have suggested a new ocean (northern branch of Neotethys) very close to the Paleotethyan suture, rifting more or less coevally with colage of the intermediate plate and Eurasia. However, this model has been opposed with the claim that it was incompatible with geologic and paleomagnetic constraints (Robertson and Dixon, 1984; Dercout et. al. 1986; Üşümezsoy, 1987; Şengün et. al., 1990a).

A long - lived ocean has been suggested by Robertson and Dixon (1984) with the intermediate plate having been torn into several fragments. The ones in the northernmost position have been suggested to collide with the Rhodope - Pontide fragment such that the Taurids had not been far from Africa during the Liassic and the wide Neotethyan ocean can be diffused between the suggested thin slivers. However, there is no evidence or indication of suturing of these tiny slivers of continental crust. In fact, the undeformed sedimentation of the Izmir - Ankara zone or Kütahya foredeep, with continous deposition between the Triassic and Late Cretaceous not only shows that there is no suturing along this zone, but also presents comprehensive evidence for non - existence of Liassic initiation of rifting of Northern Neotethys. The continental fragment between Izmir - Ankara zone and the suture line proposed in this paper, connot be accepted to correspond to the suggested fragments, for the reason that this theory would require a Cimmerian orogen followed by rifting along the same suture line for fulfillment of a Cimmerian deformation with a Cretaceous imprint. However, the idea that there has been extremely thin slivers masked by the Cretaceous deformations, cannot be proven wrong. Yet, it must be emphasised that the width of these slivers should never exceed the width of Cretaceous deformations (30-50 km) since the deformation displayed by the Karakaya formation is very uniform and no sign of Cimmerian suturing has been detected in the Pontides.

Dercourt et. al. (1986) have accepted the idea of continental slivers which have been chipped off northern Gondwana with the exception of Anatolia. The present author agrees with debaters of this exclusion (Şengör and Yılmaz, 1981; Robertson and Dixon, 1984) and other argumentation by Robertson and Woodcock (1981) for initiation of a rifting passive margin south of the Taurides during the Triassic and suggests that the detachment of the intermediate plate must have occured in Liassic in accordance with published paleomagnetic data.

Collision of the Kırşehir block by Lower Cretaceous (Dercourt et. al., 1986) will be debated on the basis of reported history of sedimentation for the Ankara melange (Çalgın et. al., 1973; Batman, 1978, Akyürek et. al., 1984; Norman, 1984 and Koçyiğit, 1991) which is suggestive for an incipient collision during the uppermost Cretaceous with dextral rotation of Kırşehir massive during the Paleogene until the closure of the Polatlı - Haymana basin and the deposition in the coevally extending Çankırı - Çorum basin.

Palaezoic

A north - facing (Şenel, 1986, Ayhan, 1987) Palaezoic sedimentation rests unconformably on the Pan -African basement. Precambrian rocks have been exposed on both the Gondwanian and European margins in relation to rotational processes (Menderes, Alanya, Kırşehir and Strandjha massives), thrusting along active margins (Daday - Devrekani, Pulur, İlgaz and Tokat massives) and deformed passive margins (Bitlis/Puturge and Kırşehir massives) The Palaezoic sedimentation on the continental margins have been incipiently deformed when sufficiently away from deformed passive or active margins. There is generally a rhythmic and gradual dimunition of intensity of deformation away from the source of stress. The development of tectonic fabric is restricted to planes of movement or shear in weakly deformed terrains and the lithons generally preserve their primary features.

Triassic

Marked facies changes occur in the Taurides in relation to initiation of rifting in northern Gondwana. The Permian limestones grade into variegated marls of Schytian age followed by elastics forming a fining upward sequence which has been nomenclated as Karaova formation (Philipson, 1915), "Antalya nappes" (Lefevre, 1967) and Karakaya formation (Bingöl, 1968), all of the nomenclations being related to deposition in relation to extensional tectonics. With advance of crustal attenuation in northern Gondwana or Apania, basic volcanics have started to erupt in subsiding troughs of Taurides during the Camian - Norian occurring along the entire Neotethyan suture (Fig. 1). The metabasic rocks intercalated with Permian marbles and Triassic metasediments, in northeast Bitlis massive, are also believed to be related to Neotethyan rifting. The cessation of the volcanism probably marks the onset of ocean-floor spreading in the Neotethyan basins and initiation of new eruptions in northern Taurides during the Liassic (Öztürk, 1990). The intervening areas have mostly been positive as the case is for Kemer (Antalya) and northwest of Alanya massive where the Palaeozoic basement has been transgressed in Liassic.

While there has been extension due to slab - pull in northernmost Gondwana during the Triassic, a flyschoid sedimentation has taken place on the south-facing continental slope of the Rhodope - Pontide fragment very likely marking the.onset of northward subduction of Tethys. A regressive flysch, the Karakaya formation (anonymous correlation with that of the passive margin) has been laid down with blocks of Permian limestones and intercalations of basic lavas in the proximal part of the European (Pontides) continental slope. Features of the deeper segments have been destroyed by the Cretaceous deformations except for Küre and Elekdağ ophiolites. The Karakaya or Akgöl formation has been obducted by ophiolites which have been suggested to correspond to the ocean floor between the continental margin of Eurasia and the northward diving Tethys. The ophiolite emplacement is ascribed to dextral rotation of Western Pontides. This rotation is believed to be responsible also for the upwarp of the Triassic arc. The arc is represented by an initial basic volcanism followed by the fractionated granitoidic melt. The basic volcanism has been dated as pre-Lower Triassic for the Küre region (Şengün et. a1, 1990a) and granitic rocks have intruded limestones of Middle - Upper Triassic ege and have been covered by Upper Jurassic - Lower Liassic as this age is also constrained by the north - facing sedimentary wedge, and there is nowhere any sign of granitic magmatism after Liassic. The cessation of granitic magmatism may be ascribed to shift of the arc or subduction zone, possibly in relation to an increased rate of convergence, compatible with the suggestion of Liassic detachment of the intermediate plate.

Jurassic

During the Jurassic, the rate of convergence of Apania and Europe must have exceeded the rate of ocean floor spreading at the Tethyan ridges resulting in northward drifting of Apania. There has been continuous Triassic - Cretaceous deposition along subsiding troughs of Apania while positive areas have started to be transgressed during the Liassic showing rapid facies changes perpendicular to axes of subsided troughs suffering progressive submergence during the rest of the Mesozoic and possibly Early Tertiary.

The back - arc sedimentation of Pontides during the Liassic has started along E - W trending depressions and the intervening areas have been subject to progressive submergence with onlap of the Black Sea, resulting in a north - facing fining - upward sequence. The granitic bodies of the pre - Liassic arc show wide aphanitic perypheries and incipient crystallization of the cold country rock, implying the granites are shallow seated compatible with a fore - arc setting. The Triassic arc has started to experience an extensional regime from Liassic onwards following a slight upwarp during the Late Triassic - Early Liassic. This implies an oceanward migration of the compressional phase, either caused by a shift in relation to recess of the subduction zone, or may be related to steepening of the subducting slab. However, the change is so sharp that the former solution seems more plausible. It is thus suggested that there had been a recess in Liassic resulting in cessation of magmatism and erosion of the upwarped Triassic arc. The Liassic arc reported to be exposed in the vicinity of Genek village (Akyürek et. al., 1979), within the Ankara melange, comprise basic volcanics cemented by pink carbonates (ammonitico rosso) with well - preserved ammonites. This location is closer to the suture than the previous arc. The ensimatic Cretaceous arc of Capan and Floyd (1985) lies on the suture zone backing up the suggestion that the island arcs and the genetically related compressional and distensional regimes periodically migrate oceanwards.

Cretaceous

Carbonates have been predominant in the passive margins of Neotethys and Tethys during most of the Cretaceous period. The active margin of Tethys has been severely deformed into rocks of blueschist facies during the Upper Cretaceous so that primary features of sedimentation can hardly be recognised. In the proximal part of the fore-arc basin, the flyschoid sedimentation has been tightly folded and coevally sliced followed by refolding of the previous structures (Şengün et. al., 1986). In the outer Pontides, a widespread transgression has taken place during the Berriasian on positive areas which have been subject to progressive submergence in relation to extensional regime prevailing as a consequence of the northward subducting Tethyan slab. The initial clastic and carbonate deposition has been followed by a flysch sequence in the course of development and southward progression of the back - arc basin, the Black Sea.

The southern margin of Tethys has also been the site of carbonate deposition during most of the Cretaceous period as part of Lower Triassic - Late Cretaceous sedimentation. The continuity of Mesozoic sedimentation, a conclusive evidence for non - existence of the northern branch of the Neotethys, has been reported for the Kütahya foredeep (özcan et. al., 1988), Izmir - Bursa segment of the İzmir - Ankara zone (Akdeniz ve Konak, 1979; Akdeniz, 1985, Erdoğan, 1990) and the Balıkesir area (Koçyiğit and Altmer, 1990). These are believed to have been preserved in the extensional terrains of the deforming passive margin.

The southern margin of Neotethys (Bitlis/Pütürge and border folds) has been the site of continuous carbonate deposition during the Jurassic - Cretaceous. A complete and continuous Mesozoic sequence reported from southern Bitlis (Çağlayan et. al, 1983) has been claimed to be exactly the same as that of the border folds. This is a strong and conclusive evidence, as previously stated, not only for in situ position of Bitlis during the Mesozoic, but also for Bitlis/Pütürge massives and border folds[1] having been on the same north - facing Neotethyan platform of the Arabian plate.

On the northern margin of Neotethys, the Taurides, there has been a steady extensional regime after the detachment of Apania from Africa in Early Liassic, resulting in deposition of carbonates. The rotational processes, possibly having started during the Uppermost Cretaceous, have caused augmentation of tectonic activity so that carbonate deposition has been replaced by the flyschoid type. At the end of the Cretaceous period, many left-lateral transform faults have been initilated in relation to the left - lateral Dead Sea transform. The Ecemiş fault, an en echelon of the Dead Sea transform, has caused a dextral rotation of Central Taurides, causing a compression in the Antalya gulf which has led to obduction of the ocean floor onto Beydağlan (Tahtalıdağ) and western Alanya massive. While the western Alanya massive has been imbricately thrusted northwards, the eastern segments have been thrusted southwards in conformity with subduction of Neotethys beneath Cyprus. There must be many undefined paleo-transforms that must have played important roles in the initiation and fulfillment of amalgamation of oceanic and continental crust slivers (Robertson, 1990) in the Taurides. The transportation of Lycien nappes on undeformed strata seems inconvincing and the existing geology implies that the role of rotational processes has been underestimated in the amalgamation of slivers of continental and intervening oceanic crust (Robertson, 1990).

There has been a northward subduction of Neotethys as described by Yazgan (1984) in the Malatya region of Southeast Anatolia. An island arc magmatism has been active for most of the Mesozoic which has ceased by the end of Cretaceous. The cessation has been ascribed to colage of the Arabian plate with East Anatolia (Yazgan and Chessex, 1991).

The Collisional Period

An incipient collision has taken place towards the end of the Cretaceous period between the Apania and Pontides as well as Apania and Arabia. The collision has been extremely effective on the premontories of the downgoing plate with intense progressive multistage deformation and progressive southward diminishing of grade of metamorphism both in Kırşehir (Erkan, 1975; Seymen, 1982 and Tolluoğlu, 1987) and Bitlis / Pütürge (Şengün, 1984; Yazgan, 1984). Pockets of unsubducted oceanic crust have been consumed through the aid of strike - slip faulting. Block rotations have occurred in areas juxtaposing the deformed segments of the downgoing plate, leading to formation of foredeeps in addition to partial preservation of primary features of the deformed passive margin. The Paleocene granites of the passive margin, to the author's mind, can be ascribed to extensional tectonics, although there has been a general tendency to atribute these plutons to crustal thickening. However, these magmatic bodies may have been subject to subsequent deformation during the latest stage of the collisional period. Izmir - Bursa segment of the Izmir - Ankara zone of Brinkman (1972) is a good example of these foredeeps. There is a continuous Triassic - Upper Cretaceous sedimentation along this zone. The sequence is extremely well-preserved and gravitational gliding of Upper Cretaceous age has been reported (Erdoğan, 1990), implying that there is no suture along this zone and the Tethyan suture lies somewhere further north.

There has also been an incipient collision between the Arabian plate and the Apania during the Upper Cretaceous (Yazgan and Chessex, 1991). However, the collisional process has not been completed until the end of Eocene as indicated by the geologic data. It must be emphasised that sedimentation has not come to a complete stop until Late Eocene. In northern Bitlis, Eocene sediments have been tilted to acquire a dip of over 70 degrees. Eocene sedimentation in Kırşehir massive has been overturned underthrusting medium-high grade marbles and amphibolites. This sedimentation can only be possible along zones of colapse in a regionally uplifting domain.

There has been volcanism of Lutetian age along the Maden - Çüngüş - Kastel foredeep and transtensional segments of paleotransforms where feeders of this volcanism can be seen as extremely dense, N-S trending diabase dykes. The volcanism has the maximum density in the point of intersection between the Maden - Çüngüş foredeep and the paleotransform fault trending NNE in the medial segment of Bitlis massive. The sedimentation may be continuous between the Upper cretaceous and Eocene along troughs of the collisional period as the case is in the Maden - Guleman region located between Bitlis and Pütürge massives. Although, there has been a general tendency to interpret maden volcanism as an island arc of the north-diving Neotethys, it has been claimed (Şengün et. al., 1990 b) that the geologic constraints are suggestive for a within-plate (passive margin) magmatism that can be ascribed to rototional processes of the collisional period. The following geologic constraints support this suggestion assuming that the suture line passes not through the immediate south of but north of Bitlis/Pütürge. I. Maden volcanism and the related sedimentation are in situ relative to Bitlis/Pütürge. 2. The feeders tend N - S so that the volcanism is located on both extremities of Bitlis. The reasons suggested for geographic location of the suture and the preceeding constraints can be integrated to the conclusion that the island arc interpretation is invalid. Freeders tending perpendicular to the E - W tending Neotethyan belt also supports that this magmatism is related to rotational processes of the collisional period rather than back-arc extension.

The geologic parameters of the Tethyan and Neotethyan passive margins is indicative of foredeep formation coevally with deformation of the passive margins, northward movements of the Menderes - Taurid block as well as the Arabian plate, have put a brake on rifting and caused low angle thrusting simultaneously with rotational processes targeting closure of pockets of unsubducted oceanic domains. The sedimentation has mostly ceased by the end of Eocene on the Neotethyan belt and central / western parts of the Tethyan suture Although, this may be accepted as marker of the upper limit of the collisional period, the Miocene sedimentation which may be ascribed to the latest stage of rotations and post - Miocene thrusting are suggestive that the fit of continental slivers have not been completed until the end of Miocene as defended by Dewey et.al. (1986).

The role of strike - slip faulting and related block rotation is also prominent in the Ankara region of Central Pontides. There has been a collision in the Kalecik region followed by a dextral rotation in the Kırşehir massive. Right lateral transforms of the southern Strandjha massive (Çağlayan et. al., 1992) have played a role in creation of a pressure relief in that region leading to formation of the Demirköy granitoid and N-S extension in the westernmost Black Sea. Strike-slip faulting plays also a role in closure of Eastern Mediterranean. There are numerous left lateral faults paralleling the Dead Sea transform. The Ecemiş fault is responsible for dextral rotation of Central and

Western Taurides so that there have been compression in the Eastern Mediterranean and dilatation in the vicinity of the Salt Lake of Central Anatolia where there has been an extremely thick Plio-Quaternary sedimentation in addition to extensive alkaline basaltic magmatism of mantle origin.

CONCLUSION

The controversial aspects of Tethyan evolution has been partly discussed in this critical review. Conclusions are listed below.

1. There are two sutures passing through Anatolia. The Neotethyan or the southern Tethyan suture passes through immediate north of Bitlis/Puturge massives which represent the deformed edge of the passive margin, the Arabian plate.

2. Northern branch of Neotethys of Şengör and Yılmaz (1981) has never existed. The northern suture (Fig 1) is actually of the Tethys.and partly coincides with Neotethys of Şengör and Yılmaz (1981). New suggestions have been made for its eastern and western ends (Fig. 1).

3. The Tethys, a Palaezoic - Mesozoic ocean, has been consumed beneath Eurasia (Rhodope - Pontide fregmant) through periodically recessing northward subduction.

4. The collisional period is characterised by rotations to close up unsubducted pockets of oceanic domains, leading to extensions causing magmatism of the collisional period, followed by uplifting of the deformed passive margin.

5. The eastern segment of the Black Sea has been reported to be existing since the Permian (Zonenshain and Le Pichon, 1986). The Western Black Sea is suggested to have started to rift coevally with dextral rotation of Western Pontides. This rotation is believed to have caused obduction of ophiolites onto the south facing continental slope of Western Pontides synchronously with deposition of Karakaya formation of Triassic age.

REFERENCES

Adamia, S.A., LordMpanidze, M.B. and Zakariadze, G.S., 1977, Evolution of an active continental margin as exemplified by the ALpine history of the Caucasus. Tectonophysics, 40, 183 - 189.

Akdeniz, N., 1985, Akhisar, Gölmarmara, Gördes ve Sındırgı arasının jeolojisi, Ph. D. Thesisis (İn Turkish) 254 p. (unpublished).

Akdeniz. N. ve Konak, N., 1979. Simav - Emet - Tavşanlı - Dursunbey ve Demirci yörelerinin jeolojisi, MTA report No. 6547 (Unpublished).

Akyürek, B., Bilginer, E., Dağer, Z., Sunu. O., 1979. Lower Triassic outcrop in the vicinity of Hacılar village (North of Cubuk - Ankara). Bull. Geol. Soc. Turkey 22, 169 - 174 (In Turkish).

Akyürek, B., Bilginer, E. Akbaş, B. Hepşen N., Pehlivan S., Sunu O., Soysal, Y., Dağer, Z., Çatal, E., Sozeri, B., Yıldırım. H., Hakyemez, Y., 1984, Geology of the Ankara - Elmadağ - Kalecik region Bulletin of the Chambers of Geological Engineers. 20 : 31 - 46 (In Turkish).

Asutay, H.J., 1987, Geology of the Baskıl (Elazığ) Area and the Petrology of Baskıl Magmatics, MTA Bull. 107 : 38 - 60.

Ayhan, A., 1987, Geology of Kozan - Elmadağ region (Adana southern Turkey), Doctorate thesis, 160 p. (Unpublished).

Batman, B., 1978, Geological evolution of northern part of Haymana region and study of melange in the area : Bulletin of Earth Science, application and research centre of Hacettepe University, 4: 95 -124 (In Turkish).

Bergougnan, H. and Fourquin, C, 1982, Remnants of a pre - Late Jurassic ocean in northern Turkey: fregmants of Permian - Triassic Paleotethys. Discussion: Geol. Soc. Amer. Bull., 93: 929 - 932.

Biju - Duval, B., Dercourt, J. and Le Pichon, X., 1977, From the Tethys Ocean to the Mediterranean Seas. A plate tectonic model of the evolution of the western Alpine system. In: B. Biju - Duval and L. Montadert (Editors). Structural

History of the Mediterranean basins. Editions Technip, Paris, p. 143 -164.

Bingöl, 1968, Contribution a l'etude geologique de la partie centrale et Sud est massif de Kazdağ, Turquie: These, Fac. Sci. Univ. Nancy, France (Unpublished).

Boztuğ, D., Debon, F., Le Fort, P. and Yılmaz, O., 1985, Geochemical characteristics of some plutons from the Kastamonu granitoid belt (northern Anatolia, Turkey): Schweizerische Mineralogische und Petrographische Mitteilungen, 64 (3): 389 - 403.

Brinkman, 1972, Mesozoic troughs and crustal structure in Anatolia. Geol. Sco. Am. Bull. 83 : 819 - 826.

Çağlayan, M.A., Dağer, Z., Erkanol, D., înal, R.N., Sevin, M., Şengün, M., 1983, Mesozoic rock units of Bitlis massive and correlation with that of the Arabian platform, 37. th Sci. and Tech. Cong. Geol. Soc. of Turkey. Abstracts 64-65.

Çağlayan, M.A., İnal, R.N., Şengün, M. and Yurtsever, A., 1984, Structural Setting of Bitlis massive. İn Geology of the taurus Belt Procedings, special publication by MTA, Ankara 245 - 254.

Çağlayan, M.A., Şengün, M. and Yurtsever. A., 1992, Structural Evolution of Strandjha Massive Thrace, Turkey, International Symposium on the Geology of the Black Sea Region, Ankara, turkey, Abstracts : 7.

Çalgın, R., Pehlivanoğlu, H., Ercan, T. and Şengün, M., 1973, Geology of Ankara Region. MTA report No. 6487 (Unpublished).

Çapan, U.Z. and Floyd, P.A., 1985, Geochemical and petrographic features of metabasalts within units of the Ankara melange, Ofioliti, 10/1 : 3 - 18.

Delaune - Mayere, N., Marcoux, J., Parrot, J.F. et Poisson, A., 1977, Modele devolution Mesozoique de la paleo - marge tehysienne au niveau des nappes radiolaritque et ophiolitique du Taurus Lycien, d'Antalya ei du baer - bassit : 25. congress de la I.E.S.M. Split 1976, Ed. technip.: 79 - 94.

Demirtaşlı, E., 1967, Lithostratigraphic units and petroleum potential of the region between Pinarbasi - Sariz and Mağara. MTA report (in Turkish) No. 4389. (Unpublished).

Dercourt, J., zonenshain, L.P., Ricou, L.E., Kazmin, V.G., Le Pichon, X., Knipper, A.L., Grandjacquet, C, Sbortshikov, I. M., Geyssant, V., Lapurier, C, Perhersky, D.H., Boulin, J., Sibuet, J.C., Savostin, L.A.., Sorokhtin, O., Westphal, M., Bazhenov, MX., Lauer, J.P. and Biju - Duval, B., 1986, Geological evolution of the Tethys belt from the Atlantic to the Pamirs since the Lias. Tectonophysics, 123: 241 - 315.

Dewey, J.F., Hempton, M.R., Kidd, W.S.F., saroğlu, F. and Sengor, A.M.C., 1986. Shortening of continental lithosphere : the neotectonics of eastern Anatolia - a young collision zone. In : Covard, M.P. and Ries, A.C. (eds.), Collision Tectonics, Geol. Soc. Lond. Spec. Publ., 19: 3-36.

Dewey, J.F. Pitman, W.C., Ryan W.B.F. and Bonnin J., 1973 Plate tectonics and the evolution of the Alpine system : Geol. soc. Am. Bull. 84. 3137-3180.

Dumont, J.F., Gutnic, M., Marcoux, J., monod, O et Poisson, A., 1972, Le Trias des Taurids occidentals (Turquie) Definition bu bassin pamphlien un nouveau domaine a ophiolites a la marge externe de la chaine Taurique. Zeits. deutsch. geol. Gessel., 123 : 385 - 409.

Ercan, T. and Gedik, A., 1983, Volcanism in Pontides. Bulletin of Chambers of Geological Engineers (Turkey), 18 : 3 - 30 (In Turkish).

Erdoğan, B., 1990, Stratigraphy and tectonic evolution of Izmir - Ankara zone between Izmir and Seferihisar. Int. Earth Sci. Cong. Aegean Region, Abtracts : 154 -155.

Erkan, Y., 1975, Petrology of regional metarnorphism in southwestern central Anatolian massive (Kırşehir) Dissertation (in Turkish), 147 p. (Unpublished).

Gedik, A., Ercan, T. and Korkmaz, S., 1984, Geology of

Central Black Sea Basin (Samsun - Sinop) and petrology of volcanic rocks. MTA Bull, 99, Ankara : 34 - 50 (In Turkish)

Göncüoğlu, M.C. and Turhan, N., 1984, Geology of the Bitlis Metamorphic Belt. In: Geology of the Taurus Belt, Proceedings, special publication of MTA, Ankara: 237 - 244.

Görür, N., Şengör, A.M.C., Akkök, R., Yılmaz, Y., 1983, Bull. Geol. Soc. Tur., 26/1 : 11 - 20.

Gözler, Z., 1986, Geologic and petrographic investigation of Mıhlıdere valley (Kazdağ, northwest Turkey). Bull. Geol. Soc. Turkey, 29: 133 - 142. (in Turkish).

Hall, R., 1976, Ophiolite emplacement and the evolution of the Taurus suture zone, Southeastern Turkey. Geol. Soc. America Bull. 87 : 1078 - 1088.

Kazmin, V.G., Sbortshikov, I.M., Ricou, L.E., Zonenshain, L.P., Boulin, J. and Knipper, A.L. 1986, Volcanic belts as markers of the Mesozoic - Cenezoic active margin of Eurasia. Tectonophysics, 123 : 123 -152.

Kerey, Î.E., 1982, Stratigraphical and sedimentological studies of Upper Carboniferous rocks in northwestern Turkey. Doctorate thesis, University of Keele (unpublished).

Ketin, L, 1966, Anadolu'nun tektonik birlikleri, MTA Bull., 66 : 23 - 24.

Kocyiğit, A., 1991, An example of an acretionary fore - arc basin from northern Central Anatolia and its implications for the history of subduction of Neotethys in Turkey. Geol. Soc. Am. Bull, 103: 22 - 36.

Kocyiğit, A. and Altmer, D., 1990, Stratigraphy of the Halılar (Edremit - Balıkesir) area: Implications for the remnant Karakaya basin and its diachronic closure. Int. Earth Sci. Cong. Aegean Region, Izmir - Turkey, Proceedings, 2 : 339 - 352.

Lauer, J.P., 1981, Origine meridionale des Pontides d'apres des nourex resultats paleomagnetics obtenus en Turquie. Bull. Soc. Geol. Fr., 6 : 619-624.

Lefevre, r., 1967, Un nouvel element dans le geologique du Taurus Lycienne : les nappes d'Antalya (Turquie). C.R. Acd. Sc. Paris, 265 : 1365 - 1368.

Livermoore R.A. and Smith, A.G., 1984, Relative motions of Africa and Europe in vicinity of Turkey, In: Geology of the Taurus belt, MTA special publication, Ankara, Proceedings: 1 - 10.

Metin, S., Papak, L, Keskin, H., Ozsoy, I., Polat, N., Altun, I. İnanç, A., Haznedar, H., Konuk, O. and Karabahk, N.N., 1982, Geology of Tufanbeyli - Sanz - Goksun and Saimbeyli area. MTA report, 7129, (unpublished).

Norman, T., 1986, The role of ankara Melange in the development of Anatolia (Turkey), İn: The Geological Evolution of the Eastern Mediterranean. Special publication of the Geological Society, No: 17 : 441 - 447, Blackwell Scientific publications, Oxford, 848 pp.

Özcan, A., Göncüoğlu, CM., Turhan, N., Uysal, S. and Şentürk, K., 1988, Late Palaezoic evolution of the Kütahya - Bolkardağ Belt. M.E.T.U. Jour. Pure and Appl. Sc, 21,1-3:211- 220.

Özgül, N., 1983, Geology of Alanya region. Ph.D.Thessis, Univ. İstanbul, 135 p. (unpublished).

Özgül, N., Göğer, E., Bingöl, I., Baydar. O and Erdoğan, B., 1973, Cambrian - Tertiary rocks of Tufanbeyli Region. Geol. Bull. Tur., 16/1: 82 - 100 (In Turkish).

Özkaya, I., 1982, Marginal basin ophiolites at Oramar and Karadağ, S.E.Turkey. J. Geol., 90: 269 - 278.

Öztürk, E.M., 1982, Geology of Balcikhisar - Karadilli (Afyon) and Derekoy (İsparta) region. In: Int. Earth Sci. Cong. Aegean Region, Abstracts: 125.

Philipson, A., 1915, Reisen und Forschungen in Westlichen Klainasien, Pet. Mitt. Erg. M. 167: 177 -180.

Pitman, W.C., and Talwani, M., 1972, Sea floor spreading in the North Atlantic. Geol. Soc. Am. Bull., 83 : 619 - 649.

Ricou, L.E., 1980, Structure of Taurids between Hellenides and Zagrids (In Turkish). Bull. GeolSoc. Tur., 23/1: 201-211.

Ricou, LE., Argyriadis, I. et Lefure, R., 1974, Propositon d'une origine interne pour les nappes d'Antalya et le massif d'Alanya (Taundes occidentals Turquie) : Bull. Soc. Geol. France, 16: 107-11.

Ricou, LE., Argyriadis, 1. et Marcoux, J., 1975, L'axe calcaire du Taurus, un alignment de fenetres arabo - africaines sous les nappes a materiel radiolaritique, ophiolitique et metamorphic. Bull. soc. Geol. France, 17 : 1024 -1044.

Ricou, L.E., Dercourt, J., Geyssant, J., Grandjacquet, C, Lepvrier, C, and Biju - Duval, B., 1986, Geological constraints on the evolution of the Mediterranean Tethys. Tectonophysics, 123 : 83 -122.

Robertson, A.H.F., 1990, Tectono - sedimentary evolution of the Eastern Mediterranean Neotethys. Summaries, questions and answers. In : Int. Earth Sci. Cong. Aegean Region., İzmir - Turkey, Proceedings, No. 2 : 236 - 270.

Robertson, A.H.F. and Dixon, J.E., 1984, Introduction : aspects of the geological evolution of the Eastern Mediterranean. In : Dixon, J.E. and Robertson, A.H.F. (eds). The evolution of the Eastern Mediterranean. Spec. Publ. geol. Soc, Lond., 17:1-74.

Robertson, A.H.F. and Woodcock, N.H., 1981, Gödene zone, Antalya Complex, S.W. Turkey : volcanism and sedimentation on Mesozoic marginal oceanic crust. Rdsch, 70 : 1177 - 1214.

Saner, S., 1980, Plate - tectonic interpretation of besin formation in Western Pontides and neighbouring areas in northwestern Turkey. MTA Bull., 93/94 : 1 - 19.

Sanbudak, M., 1989, Did the Black Seâ open as a resuiî of back - arc rifting? Or was *it* remnant of Early Mesozoic Tethys? A paleomagnetic approach. 43 th Geol Congr. Turkey, Abstracts: 31.

Şenel, 1986, Geology of Tahtalıdağ and surroundings (antalya - Kemer). Uni. İstanbul, Ph. D. thesis (in Turkish), 218p. (unpublished).

Şengör, A.M.C. and Kidd, 1979, post - collisional tectonics of the Turkish - Iranian plateau and a comparison with Tibe . Tectonophysics, 55 : 361 - 376.

Şengör, A.M.C. and Yılmaz, Y., 1981, tethyan evolution of Turkey : a plate tectonic interpretation. Tectonophysics, 75 : 181 - 241.

Şengün, M., 1984, Geology and petrography of Tatvan region, Bitlis massive, SE Turkey. Ph. d. thesis (in Turkish), 157p. (unpublished).

Şengün, M., 1990, Plate Mosaic of Turkey during the Mesozoic. IESCA, Int. Earth Sci. Congr. Aegean Regions Abstracts: 192 - 194.

Şengün, M., Acarlar, M., Çetin, F., Doğan, Z.O. and Gök, A., 1978, Structural setting of Alanya massive. Bull. Geol. Eng. Turkey, 6 : 39 - 44 (In Turkish).

Şengün, M., Akat, U., Akçören, F. and Keskin, H., 1986, Ophiolite emplacement around Dacky Kastamonu. Geol. Congr. Turkey : Abstracts :27.

Şengün, M., Keskin, H., Akçören, F., Altun, I., Sevin, M., Akat, U., Armağan, F. and Acar, S., 1990a, Geology of the Kastamonu region and geological constraints for the evolution of the Paleotethyan domain. Geol. Bull. Turkey, 33/1 : 1 -16 (In Turkish).

Şengün, M., Asutay, H.J., Ercan, T. and Metin, S., 1990b, Maden formation: sedimentation and volcanism on a synorogenic passive margin (Bitlis/Puturge), SE Turkey. IESCA, Int. E. Sci. Cong. Aegean Regions, Abstracts : 126-127.

Smith, A.G., 1971, Alpine deformation and the oceanic areas of the Tethys, Mediterranean and Atlantic. Geol. Soc. Am. Boil, 82 : 2039 - 2070.

Stocklin, J,, 1974, Possible ancient continental margins In Iran. In : The Gcology of Continental

Margins, Springer, New York, p. 873 - 887.

Stocklin, J., 1977, Structural correlation of the Alpine ranges between Iran and Central asia. Mem. Soc. Geol. France. Hors Ser., 8 : 333 - 353.

Suess, E., 1904 - 1924, The Face of the Earth, 5 Vols., Clarendon press, Oxford.

Tokel, S., 1992, Magmatic and geochemical evolution of the Pontide segment of the northern Tethys subduction system, ISGB - 92, Ankara - Turkey, Abstracts, p. 34.

Tolluoglu, 1987, Petrographical features of Kırşehir metamorphites of Central Anatolian massive. Doğa, 11/3:344-361.

Toprak, S., 1984, Coals of Westphalien A, Karadon region of Zonguldak, Turkey. M. Sc. Thesis, Univ. of Pittsburg, 78 p. (unpublished).

Üşümezsoy, S., 1987, The NW Anatolian accretionary orogeny: western termination of Paleotethyan suture belt. Geol. Bull. Turkey, 30/2: 53 - 62.

Westphall, M., Bazhenov, M.L., Lauer, J.P., Pechersky, D.M. and Sibuet, J.C., 1986, Paleomagnetic implications on the evolution of Tethys belt from the Atlantic ocean to the Pamirs since the Triassic. Tectonophysics, 123 : 37 - 82.

Yazgan, E., 1984, Geodynamic evolution of eastern Taurus region. In : Geology of the Taurus belt, CM. Goncuoğlu and O. tekeli (eds.), special publicattion of MTA, Turkey : 199 - 208.

Yazgan, E, and Chessex, R., 1991, Geology and tectonic evolution of the southeastern Taurides in the region of Malatya (Turquie oriantele) element de la suture sud - tethysienne. Bui. Soc. Geol. France, 15/1: 59 - 69.

Yılmaz, P.O., 1984, The Alakırçay unit, Antalya complex : a tectonic enigma. In : C. M. Goncuoğlu and O. Tekeli (eds.), Geology of the Taurus belt, special publication of MTA, Turkey: 27 - 40.

Yılmaz, O., 1979, Metamorphic petrology of nothwestern Daday - Devrekani massive, Thesis (in Turkish), Hacettepe Univ., Ankara, 176p. (unpublished).

Yılmaz, O. and Boztuğ, D., 1986, Kastamonu granitoid belt of northern Turkey : First arc plutonism product related to the subduction of the Paleotethys. Geology, 14 : 179 - 183.

Zonnenshain, L.F. and Le Pichon, X., 1986, Deep basins of the Black Sea and Caspian Sea as remnants of Mesozoic back - arc basins. Tectonophysics, 123 : 181 - 240.

Zonenshain, L.P., Savostin, L.A., Volodina, A.N. and Varclapetyan, A.N., 1979, Cenozoic plate tectonics and geologic evolution of the middle part of the Alpine - Himalayan belt. In : L.P. Zonenshain (editor), Structure of Lithospheric Plates. Moscow, pp. 54 -124.