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CARBONIFEROUS FORAMINIFERAL PALEOBIOGEOGRAPHY IN TURKEY AND ITS IMPLICATIONS FOR PLATE TECTONIC RECONSTRUCTIONS

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Abstract. Four foraminiferal paleobiogeographic realms are distinguished in the Carboniferous – North Paleotethyan, Perigondwanian, Siberian and North American. The Carboniferous foraminiferal faunas of both the Istanbul and Anatolide-Tauride zones distinctly differ from both Cimmerian terranes (Central Afghanistan, Qiangtang) and Libya and Egypt of the Perigondwana Realm and show close relation to the North Paleotethyan Realm, especially to the Fennosarmatian Province of southeastern Laurussia (Moesian and Scythian platforms) or to the Central Asiatic Province. A model that best fits with available evidence is that the Anatolide-Tauride Zone was either a part or located close to Laurasia in Carboniferous. The Istanbul Zone represents an equivalent of the Rhenohercynian Zone of the Central Europe and can not be compared with Intra-Alpine or south Variscan terranes which may be correlated with the Anatolide-Tauride Zone. Later, in the Permian, the Anatolide -Tauride Zone may has been separated from the Eurasian mainland by the Karakaya back-arc ocean.

Riassunto. Nel Carbonifero si possono distinguere quattro reami paleogeografici: Paleotetide settentrionale, Perigondwana, Siberia e Nord America. Le faune a foraminiferi del Carbonifero, sia delle zone di Istanbul che delle Anatolidi/Tauridi sono significativamente diverse da quelle di blocchi Cimmerici come l'Afghanistan centrale e il Qiangtang, e da aree del Reame perigondwanano, come Libia ed Egitto. Invece mostrano maggiori affinità con il Reame Nord Paleotetidiano, in modo particolare con la Provincia Fennosarmatica della Laurussia sudorientale (piattaforme Moesica e Scitica) o con la Provincia Centro Asiatica. Un modello che sembra meglio corrispondere alle evidenze disponibili è che la Zona Anatolide-Tauride fu sia una parte o fu posizionata vicino a Laurasia nel Carbonifero. La Zona di Istanbul rappresenta un equivalente della Zona Rhenohercinica dell'Europa Centrale e non può venir confrontata con i terrani di tipo Intra-Alpino o sud-Varisico. Più tardi, nel Permiano, la Zona Anatolide -Tauride potrebbe esser stata separata dalla massa Eurasiatica dal retro-arco del Karakaya.

Introduction

The study concentrates on a group of the Pontide and Anatolide -Tauride blocks that were affected by Cimmerian and Alpine orogenic events and, at the same time, contain data on Carboniferous foraminiferal fauna. In the original conception of Sengör and Yilmaz (1981) and Sengor et al. (1984) the West Cimmerian terranes were originally situated at the northeastern margin of Gondwana, in late Paleozoic divided from Laurasia by a wide Paleotethyan ocean. By the end of Carboniferous only the small continental fragment of western Kun-Lun had already collided with Eurasia (Sengör 1985). The Paleotethyan ocean was then closed by the northward drift of ribbon-like Cimmerian Block opening Neotehys. On the other hand Robertson & Dixon (1984) and Okay (1989) placed the Paleotethyan suture more to the south between the Istanbul and Sakarya Zones and Okay et al. (1996) even to the south of the Sakarya Zone. According to Okay (2000) the model of Sengör (1979) and Sengör et al. (1984) for the Cimmeride deformation, involving the collision of a Cimmerian continent with Laurasian margin, is difficult to maintain as no coherent Cimmerian continent can be defined in northern Turkey.

Currently, there is a need to test alternative tectonic models, using well constrained data (Robertson & Pickett 2000; Altiner et al. 2000). The aim of this paper is to test the relations of the Turkish Carboniferous terranes to the major continental blocks of Gondwana and Laurussia, based on the study of the benthic calcareous foraminifers. The study is favored by the paleoclimatic differences that existed between the Laurussia and NE Gondwana during much of the Carboniferous and early Permian. Laurussia was situated in low latitude tropic-subtropic zone while the northeast margin of Gondwana was glaciated in Arabian peninsula, peninsular India, Australia and in Cimmerian blocks as Sibumasu, Baoshan

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and Qiangtang (Al Belushi et al. 1996; Golonka & Ford 2000; Garzanti & Sciunnach 1997; Ueno & Igo 1997; Ueno 2000). The Carboniferous – early Permian glaciation reached during its peaks relatively to low latitudes. In this respect also West Cimmerian microcontinents that were located in the eastern part of the Gondwana outside the reach of glaciation must have been influenced by cooler or temperate climate.

Geological setting

It is generally inferred that all the Turkish terranes with a Panafrican basement were originally part of Gondwana and were welded step by step to Eurasia. Three major units are generally distinguished – Pontide and Anatolide-Tauride units and Arabian plate in SE Anatolia (Fig. 1). The present-day structure of units is a result of Paleozoic, Mesozoic and Cenozoic processes of rifting, collision, translation and shearing (Okay & Sahintürk 1997; Altiner & Özgül 2000; Göncüoglu et al. 2000).

The northern part of Turkey - the Pontides - are divided by the Intrapontide Suture in the Istanbul Zone and the Sakarya Zone (Okay et al. 1994). The Istanbul Zone (Okay 1989) was divided by Göncüoglu et al. (1997) into the Istanbul Terrane in the west affected only by Variscan deformation and the Zonguldak Terrane in the east with distinct Caledonian movements and thermal alteration. The former is bounded to the west by the Strandja Massif, the latter to the east by the Sakarya Zone (Okay et al. 1994; Kozur & Göncüoglu 1998; Okay 2000). The Istanbul Zone of the Pontides was located originally along the Odessa shelf between the Moesian Platform and the Crimea and drifted southward along to major transform faults to form the western Black Sea Basin between the Albian and early Eocene (Okay et al. 1994; Pharaoh 1999). The Sakarya zone is a major block which extends from the Biga Peninsula in the west to the Lesser Caucasus in the east (Okay 2000), separated from the Anatolide-Tauride Terrane in the south by Izmir-Ankara-Erzincan suture. It contains a Variscan basement and underwent a short lived orogeny in late Triassic (Kozur & Göncüoglu 1998; Okay 2000). The Caledonian-Variscan accretion of Pontide terranes to the East European platform has been assumed (Robertson & Dixon 1984; Okay 1989; Stampfli et al. 1991; Okay et al. 1994; Görür et al. 1997). Stampfli (1996) regards the Istanbul Zone as an equivalent of Intra-Alpine Terrane. On the other hand Sengör & Yilmaz (1981) put the entire area of Turkey to the northern margin of Gondwana in the late Paleozoic.

The Anatolide - Tauride Zone comprises generally south-vergent nappe pile of Paleozoic and Mesozoic partly metamorphosed sediments, Menderes Massif and Beydagi Autochthone, and the north-vergent Alanya and Antalya Nappes. It is separated by the Bitlis suture from the autochthonous Arabian platform. The south-vergent nappes comprise, in the western Taurides, the Lycian Nappes, and in the central Taurides, the Aladag, Kütahya-Bolkardag and Bozkir units. According to Kozur & Göncüoglu (1998) the Karaburun Unit of the Ka-

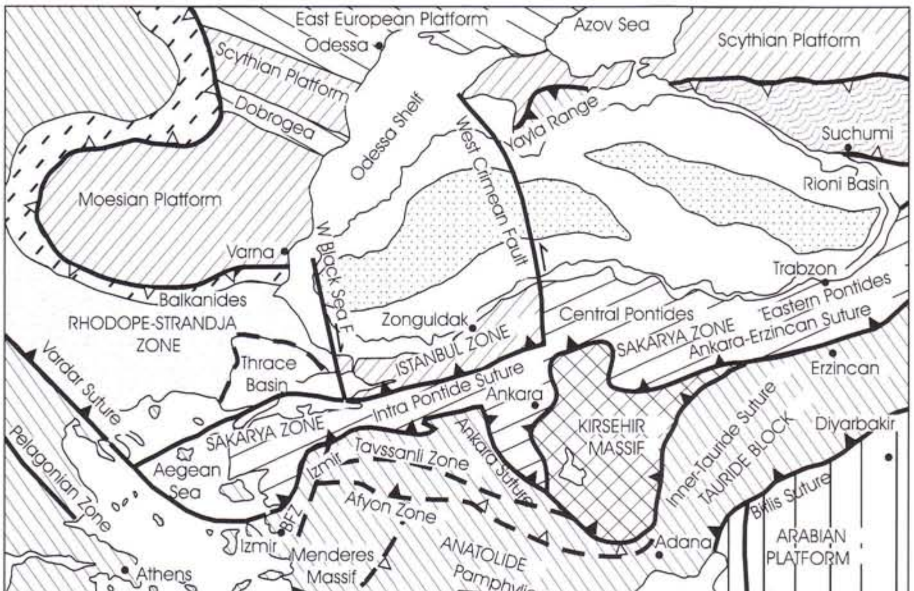

Fig. 1 - Tectonic map of Turkey and surrounding area with the situation of major terranes discussed in the article. Modified after Okay & Tüysüz (1999).

raburun Peninsula and Chios are in a tectonic position between the Bolkardag and Bozkir units. The highest units, represented by Lycian Nappes and Bozkir Unit, were originally situated in a northernmost position, adjacent to the Izmir-Ankara-Erzincan Ophiolite Belt (Kozur & Göncüoglu 1998; Özgül 1997).

The Anatolide-Tauride Unit has been traditionally believed to have Gondwanian paleogeographic affinities (Sengör 1979, 1985; Okay et al. 1994). On the other hand, Stampfli et al. (1998) include some elements of the Taurides together with elements of the Hellenides and the Dinarides in the Pelagonian Superterrane welded to the Laurussia during Variscan events.

Sengör (1990) stressed that there is no place for the Variscan collision of peri-Gondwanian fragments with SE margin of Laurussia and "Variscan" events of the Podataksasi Zone were regarded as Gondwanian. Other studies, however, advocated the Variscan accretion of both Istanbul and Sakarya Zones (Okay et al. 1994; Leven & Okay 1996; Okay 2000). According to Okay et al. (1994) and Okay (2000) Strandja - Istanbul zones were originally located along the southern margin of Laurussia contiguous to the Moesian Terrane and rifted away in middle Cretaceous leaving behind the Black Sea. Göncüoglu (1997) and Göncüoglu et al. (2000) argued for the importance of Variscan events in the Anatolide-Tauride Unit, however, placed them at the northern Gondwana margin.

Paleobiogeography

Foraminiferal provincialism in Carboniferous

Traditionally three freely interconnected late Devonian-early Carboniferous paleobiogeographical realms have been distinguished: the tropical/subtropical Paleotethyan Realm, North American Realm and the northern boreal Siberian Realm (Mamet & Belford 1968; Lipina 1973; Kalvoda 1990). The foraminiferal fauna of the tropic-subtropic Paleotethyan Realm was characterized by highly diverse calcareous assemblages with many forms with thick-walled tests on the shelves, whereas agglutinated forms dominated in basinal environments. The North American Realm was characterized by calcareous foraminiferal fauna of lower diversity than the Paleotethyan one, containing some endemic taxa. Even though positioned in tropic-subtropic belt, the realm shows some similarities with the temperate to boreal Siberian Realm (Mamet & Belford 1968).

In accordance with Leven (Leven 1993; Leven & Okay 1996) for the late Carboniferous, a southern, cool Perigondwana Realm, displaying some features in common with the cool northern Siberian Realm, is distinguished here in the early Carboniferous to include the Central Mountains Terrane in Afghanistan, and Himalayan Tethyan Zone (Vachard 1980; Vachard & Montenat 1996; Colchen & Vachard 1975). In higher latitudes were situated Cimmerian Qiangtang as well as Libya (Cyrenaica Basin) and Egypt (Western Desert, Sinai) where more diversified foraminiferal associations were reported (Luo 1998; Vachard et al. 1993; Brenckle & Marchant 1987). Nevertheless, they lack many important taxa of the North Paleotethyan Realm and in the Carboniferous are regarded as a part of the Perigondwana Realm. Contrary to the NW Africa (10° S during the Westphalian), Libya and Egypt were located in higher latitudes (at 25° degrees S during the Westphalian - Izart et al. 1998). The Perigondwana Realm was under the influence of a cool climate, the glaciation of Peninsular India has been documented in the Visean (Garzanti & Sciunach 1997) and in Oman during

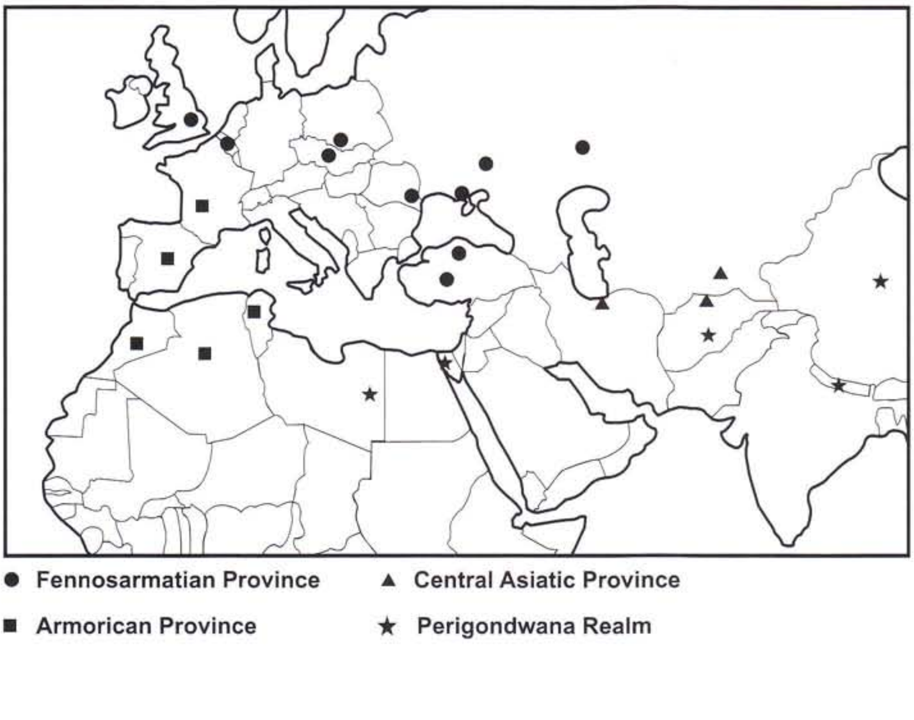

Fig. 2. - Map showing the distribution of provinces of the North Paleotethyan Realm (Fennosarmatian, Armorican and Central Asiatic) and the Perigondwana Realm in Visean.

the middle Carboniferous – early Permian (Al Belushi et al. 1996; Fluteau et al. 2001). Libya may have been located close to glaciated areas in the late Famennian (Streel et al. 2000). The movement of the paleo-South Pole into Central Africa in the late Devonian and early Carboniferous, where it was located until at least the early Visean, is assumed (Chen et al. 1994; Li & Powell 2001). This position may be consistent with the assumed presence of Carboniferous glacigenic sediments in North Africa (Legrand-Blain 1986; Lang et al. 1991) that is compatible with data of Streel et al. (2000) for latest Famennian of southern Libya.

In the original concept of Mamet (Mamet & Belford 1968; Mamet 1977), the Paleotethyan Realm included both the Laurussian and Gondwana shelves. Vdovenko (1980) distinguished within the Paleotethyan Realm (=Eurasiatic Realm of Vdovenko) the West European, Moesia-Dobrogea, East European, Central Asiatic and East Asiatic (South China and Indochina blocks). In this interpretation, which is followed here with some modifications specified below, all provinces are situated along or to the north of the northern margin of Paleotethys or in the central Paleotethys (East Asiatic Province) and consequently, it is referred to North Paleotethyan Realm. In the west Paleotethys was already closed as the Northwest Africa collided with Iberia during the Famennian (Ziegler 1989).

Kalvoda (2001) somewhat modified the scheme of Vdovenko (1980). He defined the Fennosarmatian Province (see Fig. 2) to include the East European Platform, the Urals and the pre-Variscan accreted Brunovistulian group of terranes (the Malopolska, Lysogory, Brunovistulian, Moesian, Zonguldak terranes) and, with some reservation, Eastern Avalonia as well, without discussing the further subdivision of this province. The East European Platform and the Urals represented a diversification center for many groups of late Devonian and early Carboniferous calcareous foraminifers (Kalvoda 2001).

In SW and W Europe he defined the Armorican Province to include the Variscan accreted Perigondwana terranes (Armorican, Iberian, Intra-Alpine). The province includes provisionally also NW Africa from middle-late Visean. The Armorican province is characterized by incomplete foraminiferal phylogenies and foraminiferal assemblages lower in diversity than the assemblages of the East European Platform and the Urals. The differences progressively decreased over the course of Visean.

Based on the summarizing data by Lys (in Wagner et al. 1988; Lys 1979) and paper by Izart et al. (2001), Northwest Africa is not regarded as a part of the North Paleotethyan Realm until the middle or late Visean. Evidently, this was connected with the above mentioned position of the paleo-South Pole. The foraminiferal fauna of NW Africa, however, does not show a uniform affinity. While the North Paleotethyan associations of central Morocco start already in the middle Visean and compare well with Eastern Avalonia (Izart et al. 2001), the foraminiferal fauna of West and Central Sahara basins (e.g. Bechar Basin) and Tunisia shows close ties to the Armorican Province (Lys in Wagner et al. 1988).

In middle Carboniferous, Solovieva (1974) distinguished a subtropic-tropic West Eurasiatic and Central American realms and the subarctic North Eurasiatic Realm. The West Eurasiatic Realm (= approximately North Paleotethyan Realm) characterized by the predominant development of Archaediscidae - *Eostaffella* and *Pseudostaffella-Profusulinella* association in the lower and upper Bashkirian, respectively. In the lower Moscovian the predominant development of *Profusulinella-Aljutovella* and in the upper Moscovian *Fusulinella-Neostaffella-Fusulina* associations were regarded as characteristic. A similar paleobiogeographic division was presented by Rui et al. (1991) in the upper Moscovian, distinguishing the Midcontinent-Andean and Tethyan provinces in low latitudes, the Arctic Province in high northern latitudes and an intermediate Ural Province. The Tethyan Province was marked by diverse and *abundant Fusulinella, Neostaffella, Beedina* and *Fusulina* and by rare *Pseudoendothyra*. A similar paleobiogeographical subdivision was applied for early Late Carboniferous by Villa et al. (2001) who adverted to the growing differences between the foraminiferal faunas at the southern margin of Laurasia (Cantabrian Mountains, Carnic Alps, Chios Island and Central Asia) and that situated more to the north, as the Donets Basin, Russian Platform and the Urals.

In the late Carboniferous and early Permian Leven (Leven 1993; Leven & Okay 1996) distinguished the foraminiferal fauna of the northern Paleotethyan margin in Laurasia from the southern cool water Perigondwana Province displaying some features in common with the northern boreal province.

Pontides

Istanbul Zone. In the Istanbul Zone, the Carboniferous foraminiferal fauna has been described from Zonguldak and Istanbul terranes. The Carboniferous foraminiferal fauna in the Zonguldak Terrane was reported in several papers by Dil (Dil 1975, 1976; Dil in Catal et al. 1978). In the terrane, late Devonian foraminiferal associations are also known, showing a close similarity with the Fennosarmatian Province (Kalvoda 2001). In the early Carboniferous, rich associations of the middle Tournaisian contain typical representatives of the North Paleotethyan fauna as *Chernyshinella glomiformis*, *Chernyshinella multicamerata* and *Palaeospiroplectammina tchernyshinensis*. The presence of *Brunsia* not known at this level in Western Europe, points to close connection with the Fennosarmatian Province and the same affinity shows the late Tournaisan-earliest Visean Kosvin association (Kalvoda 2001). Within the Visean, foraminiferal fauna contains typical North Paleotethyan elements as *Ninella, Pseudolituotubella, Forschia, Omphalotis omphalota, Uralodiscus, Glomodiscus, Pojarkovella nibelis, Pojarkovella efremovi, Koskinotextularia, Cribrostomum, Archaediscus gigas* and *Endothyranopsis crassus.* The Visean association as a whole compares best with the southern part of the Fennosarmatian Province. The presence of rich and diversified dasycladacean algae of the genus *Koninckopora* is also signficant.

Data on the Carboniferous of Istanbul come from Kaya & Mamet (1971) and Kaya (in Catal et al. 1978). Kaya (in Catal et al. 1978) also presents late Tournaisian and early Visean foraminiferal fauna but the list is rather poor and therefore only middle and late Visean association will be discussed. Already Kaya & Mamet (1971) pointed to the close similarity of the middle and late Visean foraminiferal fauna in the Cebeciköy Limestone to both European and Russian assemblages of the North Paleotethyan Realm. In their interpretation, the association of *Archaediscus karreri, Endothyranopsis crassus, Globoendothyra globulus, Omphalotis omphalota* and bilayered paleotextulariids is characteristic of the late Visean of Eurasia (North Paleotethyan Realm in the present paper). Their faunal list contains also other typical North Paleotethyan taxa as representatives of *Eostaffella, Forschiella, Lituotubella magna, Vissarionovella tujmasensis.* According to Cozar & Vachard (2001), *Vissarionovella* is a marker for western Paleotethys and the Urals. The provenance of the Cebeciköy Limestones is, however, problematic as they may represent olistholiths in the Thracian Carboniferous flysch.

Blocks in the Karakaya Complex. The foraminiferal fauna has been described from limestone blocks in the Karakaya Complex of the Sakarya Zone, however it is argued (Leven 1995; Leven & Okay 1996) that the blocks were derived from a no-longer existing southern margin of the Karakaya Ocean (? Anatolide-Tauride microcontinent) and had been displaced a considerable distance to the north.

In the Early Carboniferous, blocks relatively rich in late Visean-Serpukhovian foraminiferal associations contain some typical North Paleotethyan elements such as *Eostaffella proikensis, Forschia mikhailovi, Eoforschia subangulata, Howchinia gibba, Archaediscus gigas, Bradyina* sp., *Eostaffella ikensis* and *Biseriella parva* that are not recorded or rare in this interval in the cool-water Perigondwana Realm.

In the Late Carboniferous, relatively abundant association of the Moscovian were described with typical elements of the North Paleotethyan Realm, including *Profusulinella* found only in East European Platform, Tien Shan, South China and Indochina. In one sample, several species of abundant *Fusulinella* were described, all characteristic of many sections of the Moscow syneclise and Russia. Moscovian fauna in similar limestone blocks of the Karakaya Complex was also mentioned by Kahler and Kahler (1979), who reported *Eofusulina* cf. *mosquensis* and *Ozawainella* cf. *vozhgalica*. According to Rui et al. (1991), abundant and diversified *Fusulinella*, together with *Fusulina*, indicate in the Moscovian tropic-subtropic Tethyan Province (corresponding largely to the North Paleotethyan Realm in early Carboniferous). *Fusulina* is restricted to this province and it is not present in the warm temperate Arctic Province.

In Gzhelian, one clast in Hodul olistostrome yielded among others *Daixina (Ultradaixina) postgallowayi*. The species is common along the southern margin of Laurasia (Donbas, South Ural, Fergana, Darvaz) and not yet observed in the Perigondwana part of the Paleotethys (Leven & Okay 1996).

The same trend was reported also in Permian associations of fusulinids, which are very close to the associations of the southern *Laurasian* margin especially Darvaz. The presence of some taxa not recorded in the Perigondwana (e.g. *Paleofusulina*) seems to emphasize the mentioned North Paleotethyan affinity.

Anatolide-Tauride Zone. The rich Carboniferous foraminiferal fauna of the Anatolide-Tauride Zone has been described from western part of Eastern Taurus Belt in the area between Pinarbasi and Sariz, in the central part of the Outer Taurus Belt in Silifke area (Catal & Dil in Catal et al. 1978; Altiner 1981) and in the Aladag Unit of the central Taurus (Altiner & Özgül 2001; Okuyucu & Güvenc 1997; Okuyucu 1999).

It is supposed that the Aladag Unit had been originally situated near the northern margin of the Anatolide-Tauride microcontinent and during the Mesozoic and Tertiary orogenic events thrust to the south (Özgül 1997). The foraminiferal fauna of the mentioned parts of the Anatolide-Tauride Zone is in many respects similar and will be therefore treated together.

In all regions, the Tournaisian associations are impoverished in comparison with the typical North Paleotethyan ones recognized e.g. above in the Zonguldak Terrane. Associations of eurytopic foraminifers predominate, which may be due to unsuitable facies and/or some paleobiogeographic factors. In some respects the associations seem to be similar to those of Elburz (Bozorgnia 1973; Ueno et al. 1997) or to the Armorican Province.

Most detailed data on Carboniferous foraminiferal associations come from Altiner and Özgül (2001) who distinguished five foraminiferal zones in Visean, all of which contain typical associations closely related to the East European ones. The *Eoparastaffella* Zone contains some elements typical of the tropic-subtropic North Paleotethyan Realm not occurring or very rare outside its limits at this level as *Eoparastaffella simplex, Pseudolituotubella, Endospiroplectammina, Dainella, ?Ninella*. Such faunistic elements are absent in the early Visean both in NE and NW Africa. In the *Uralodiscus-Glomodiscus* and

Endothyranopsis compressa zones, the presence of massive *Uralodiscus* and *Glomodiscus* as well as of *Forschiella prisca, Forschia parvula, Endothyranopsis compressa* is characteristic, not reported or rare outside the North Paleotethyan Realm (Vdovenko 1980). The localities in NE Africa yielded quite different impoverished associations (Brenckle & Marchant 1987; Vachard et al. 1993). The impoverished association of the same age was reported also in the Cimmerian Qiangtang Terrane (Luo 1998).

The *Pojarkovella nibelis* and *Endostaffella parva-Biseriella parva* zones also contain typical elements restricted to or typical of the North Paleotethyan Realm such as *Pojarkovella nibelis, Forschia subangulata, Forschia parvula, Forschiella prisca, Endothyranopsis compressa, Archaediscus gigas, Bradyina rotula, Eostaffella ikensis, Biseriella parva, Pojarkovella efremovi, Endothyranopsis crassus* and double-walled paleotextulariids. As was already mentioned, *Vissarionovella tujmasensis* is a marker species of the western North Paleotethyan Realm (Cozar & Vachard 2001). The associations are very similar to those in the Zonguldak area (Dil 1975, 1976; Dil in Catal et al. 1978) or to associations from limestone blocks in the Karakaya Complex (Leven & Okay 1996) and are closely related to the foraminiferal fauna described in the southern margin of the Fennosarmatian Province. On the other hand, such fauna has not been recorded anywhere in the cool water Perigondwana Realm. *Pojarkovella nibelis* is a species typical of the southern margin of the Fennosarmatian Province and of the Central Asiatic Province, not reported even in the NW African part of the North Paleotethyan Realm. Another species with even more limited regional occurrence is *Chomatomediocris brevisculliformis*. It has been reported in the Moesian-Dobrogean Subprovince of Vdovenko (1980) - especially from the Dobrogea and Odessa region (Vdovenko et al. 1981) - and outside this subprovince only in the Dnieper-Donets Basin and the South Urals.

The foraminiferal associations described by Dil (in Catal et al. 1978) from the Ziyaret Tepe Formation between Pinarbasi and Sariz in the early-middle Visean (V1-V2) are very similar also including *Lysella*. Even richer associations come from Member F of the Korucuk Formation in the Silifke area. They are of V1-V3a in age and besides typical North Paleotethyan elements of the East European Platform such as diversified *Dainella, Florenella, Endothyra laxa, Uralodiscus, Glomodiscus, Eoparastaffella simplex, Forschiella prisca, Lituotubella magna, Pojarkovella nibelis*, also include *Lysella* and diversified dasycladacean *Koninckopora,* whose abundant presence is typical of the North Paleotethyan Realm as well. The reported coral fauna (Kiragli in Catal et al. 1978) contains *Kueichouphyllum* type of corals.

In the Serpukhovian of the Aladag Unit the dominant lithology is quartzarenitic sandstone and therefore foraminiferal associations are not so rich as in Visean. Nevertheless, the presence of *Eostaffella* ex gr. *ikensis, Eostaffella pseudostruvei, Bradyina cribrostomata* and *Plectostaffella* species suggests close relations to the North Paleotethyan Realm.

The middle and late Carboniferous foraminiferal fauna reported by Altiner & Özgül (2001), Sen et al. (2001) and Okuyucu (2001) in the Aladag Unit correlates very well with the East European representation and includes many marker species of the East European Platform. The presence of *Eolasiodiscus donbassicus*, abundant and diversified representatives of *Bradyina, Semistaffella, Plectostaffella, Profusulinella, Eofusulina, Neostaffella, Fusulinella, Beedina, Aljutovella, Paraeofusulina* in the middle Carboniferous underlines the affinity to the southern margin of Eurasia and is in distinct contrast to the West Cimmerian or East Gondwana terranes of the Perigondwana Realm (Solovieva 1975; Leven & Okay 1996).

The late Carboniferous in the Aladag Unit has not been studied in detail and Altiner & Özgül (2001) listed only some genera that mostly belong to the Gzhelian. The association of *Rauserites, Jigulites, Daixina, Rugosofusulina, Quasifusulina* shows the similar trend as the previous ones, namely a close connections to the southern Eurasian margin (Villa et al. 2001).

A diversified association of Moscovian fusulinids containing different *Fusulinella, Fusulina* and *Beedina* was also reported in another nappe units in the Silifke area (Catal in Catal et al. 1978). Member H and Member I of the Korucuk Formation comprise a Moscovian fauna with typical North Paleotethyan association of *Fusulinella, Neostaffella, Beedina* and *Fusulina* found only in low latitudinal zones (Rui et al. 1991; Leven & Okay 1996).

Similar trends showing similarity to the southern Laurasian margin have also been traced in the early Permian. Early Permian foraminiferal fauna has not been studied in detail in the Aladag Unit, nevertheless the diverse generic association given by Altiner & Özgül (2001) indicates a close relation to southern Eurasia (e.g. *Dutkevitchia*). *Rugosofusulina stabilis* is reported from the unit by Okuyucu (1997, 1999). According to Leven & Okay (1996) the species is abundant in the Asselian and Sakmarian deposits of the Urals, East European Platform and northern margin of Paleotethys.

Interesting information also comes from the island of Chios in the eastern Aegean Sea. The Chios sequence is correlated with the Karaburun Mélange (Robertson & Pickett 2000) which is assumed by some authors to be in a tectonic position between the Bolkardag and Bozkir units of the Anatolide-Tauride Zone (Kozur & Göncuoglu 1998). The late Carboniferous foraminiferal fauna here shows, according to Villa et al. (2001), distinct biogeographic affinities to the Cantabrian Mountains, Carnic Alps and Central Asia, i.e. to the southern Laurasian shelf. Bashkirian foraminiferal association of the *Pseudostaffella antiqua* Zone correlating well with the fauna of the East European Platform and South Tien Shan was described by Isintek & Altiner (2001) in the upper part of the Karaburun Mélange.

Discussion

The Carboniferous paleogeographic position of the Istanbul Zone forming a south facing passive margin of Laurussia is now generally accepted (Okay et al. 1994; Göncüoglu 1997) and the foraminiferal associations are well in accord with this view. The zone is a part of the Brunovistulian group of terranes (Kalvoda 2001), which were amalgamated to Laurussia during Caledonian events or sooner, and in Devonian and Carboniferous also shows very similar lithological development to this group (Kalvoda et al. 2003). Consequently, the Istanbul Zone represents an equivalent to the Rhenohercynian Zone of the Central Europe and cannot be compared with the southern side of the Variscan chain (Görür et al. 1997) or with the Intra-Alpine Terrane (Stampfli 1996).

The strong effect of the later Cimmerian and Alpine deformation, the probable but unconfirmed lateral movement of the Sakarya and Anatolide-Tauride zones during the Paleozoic and the paucity of radiometric data make it very hard to elaborate a convincing model for their Paleozoic evolution (Okay et al. 1996; Okay & Sahintürk 1997). As far as the Late Paleozoic position of the Anatolide-Tauride Zone is concerned, the zone is traditionally attached to Gondwana in most recent tectonic reconstructions (Robertson & Pickett 2000; Ziegler & Stampfli 2001) and Gondwana affinity is generally accepted, really based more on tradition or geologic considerations than direct evidence. Based on the analysis of Carboniferous foraminiferal fauna, this scenario seems, however, not very probable for the following reasons.

1) The Visean foraminiferal fauna of the Aladag Nappe Unit is very similar to the southeastern margin of Laurasia, more exactly to the Odessa and Moesia-Dobrogea regions or to the Central Asiatic Province. This view is supported by the presence of rich diversified foraminiferal associations absent in the Perigonwana Realm including NE Africa. In NW Africa, North Paleotethyan associations are absent in the early and mostly also in the middle Visean and in the late Visean some typical Eurasian taxa are lacking (e.g. *Pojarkovella nibelis*, *Vissarionovella*, *Janishewskina*, *Bradyina*, *Eostaffella proikensis*). The ties of the Anatolide-Tauride Zone to the Fennosarmatian Province are reflected in the presence of endemic *Chomatomediocris* so far reported only in the southern part of this province. A close similarity to southern margin of Laurasia is also maintained in the Late Carboniferous and Permian and contrasts with distinct faunistic differences reported by Okay & Sahintürk (1997) between Pontides and Taurides in Mesozoic.

2) Similar paleobiogeographic affinities can be attributed to the middle Carboniferous foraminiferal associations of the Karaburun Mélange (Alandere Formation) (Isintek & Altiner 2001).

3) Similar paleobiogeographic affinity indicates also coral fauna. In the middle and late Devonian, Flügel & Hubmann (1993) point to the similarity of south Anatolia corals with those of Western Europe but in no case to the neighbouring Cimmerian blocks of central Iran and Afghanistan. The whole of Turkey is included in their West European Province. In the Tournaisian, and also in the Visean, coral fauna consists mainly of European immigrant genera, with the exception of *Kueichouphyllum* and may be *Kueichowpora* which indicate East Asiatic migration (Fedorowski 1981; Flügel & Hubmann 1993).

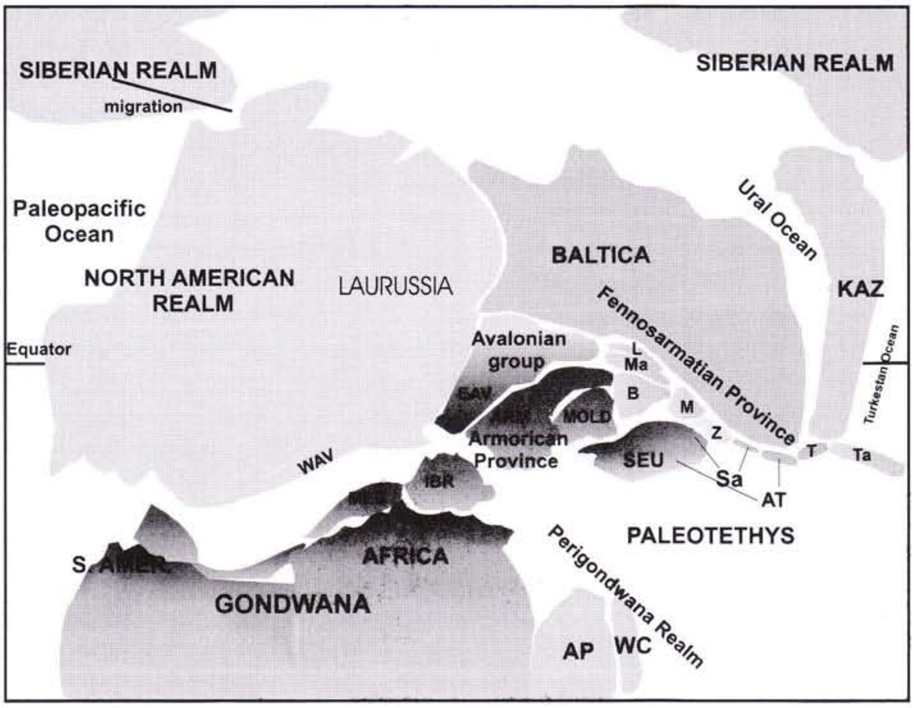

Fig. 3 - Early Carboniferous paleogeographic scheme showing the location of paleobiogeographic units and terranes discussed in the text with alternative positions of the Sakarya and North Anatolide-Tauride Terranes. Another alternative not illustrated here is a more southern location of the Anatolide-Tauride Terrane. Abbreviations: KAZ - Kazakh microcontinent, AP - Arabian Plate, WC - Western Cimmeria, AT - Anatolide -Tauride Terrane, Sa - Sakarya Terrane, SEU - group of Souh European terranes, Z - Zonguldak Terrane (= Istanbul Zone), M - Moesian Terrane, B - Brunovistulian Terrane, Ma - Malopolska Terrane, L - Lysogory Terrane, Mold - Moldanubian Terrane, ARM- Armorica, EAV - Eastern Avalonia, WAV - Western Avalonia, IBR - Iberia, MEG - Meguma, T - Turan Terrane, Ta - Tarim Terrane, AT - Anatolide-Tauride Terrane.

4) The Carboniferous Aladag fauna is very different from other Cimmerian terranes of the Perigonwana Realm (Central Afghanistan, Qiangtang) as well as from Northeast Africa (Libya, Egypt and Arabian Plate - Sinai) or Tethyan Zone of the Himalayas. The difference is both in the foraminiferal associations and in their climatic signal. The fauna of the Anatolide-Tauride Zone clearly indicates a tropic-subtropic climate while the fauna of the Afghan Central Mountains as well as Tethyan Zone of Tibet accounts for a cooler climate in the vicinity of a glaciated India (Gaetani 1997) and Oman (Garzanti & Sciunnach 1997; Al Belushi et al. 1996; Fluteau et al. 2001). Izart et al. al. (1998) locate Oman and Salt Range in Pakistan at 40° during the Westphalian. Egypt, Libya and Arabian peninsula were located in higher latitudes of the cooler southern hemisphere (Izart et al. 1998) and impoverished foraminiferal associations indicate temperate climatic belt.

Thus, the problem is where to locate the Anatolide-Tauride Zone at the northern margin of Gondwana. A possible solution would be to place the Anatolide-Tauride Zone to North African margin of Gondwana. However, even this part of Africa (e.g. Libya, Egypt) yielded impoverished Carboniferous and Permian foraminiferal associations (Vachard et al. 1993; Brenckle & Marchant 1987) quite distinct from the Aladag Unit, indicating cooler climate.

In our interpretation, a more plausible alternative, supported by available paleobiogeographic data, is that in the Carboniferous, the Aladag Nappe, and thus the Anatolide-Tauride Terrane, were located in the northern Paleotethys, close to the Turan Terrane or Scythian Platform where Variscan crustal shortening persisted into the Permian (Nikishin et al. 1996). There are two possible models for the Carboniferous location:

1) A position in low latitudes within Paleotethys as e.g. Chinese terranes;
2) A late Paleozoic Variscan gentle docking to Laurussia (Laurasia).

There are two possibilities of Variscan docking of the Anatolide-Tauride Terrane - either to the Turan Terrane or to Laurussia (Fig. 3). In this case, the terrane docked either to the Scythian Platform or to the Sakarya Unit. In the first alternative (docking to the Scythian Platform), then post-Liassic strike-slip movements of the Anatolide-Tauride Zone along the southern margin of Laurussia are inferred (Okay & Sahintürk 1997).

In a second alternative, the closure of Paleotethys by a southward subduction-accretion beneath Anatolide-Tauride Terrane in the Karaburun trench (Robertson & Pickett, 2000) and Kütahya-Bolkardag Unit may have been followed by a collision, or rather gentle docking, of the Anatolide-Tauride Terrane with the Sakarya Unit (Göncüoglu et al. 2000). In this case Anatolide-Tauride Terrane can be correlated with south Variscan Intra-Alpine terranes.

However, it should be noted that the role of the Variscan and Caledonian orogenies in the Afyon Zone (=Karaburun and Kütahya-Bolkardag units) has been recently a matter of debate. Göncüoglu (1997), Göncüoglu et al. (2000), Kozur and Göncüoglu (1998) and Kozur (1998) advocated the presence of Variscan and Caledonian events respectively. On the other hand, Okay (Pers. Comm.) doubts their presence. Whatever the solution to this problem may be, it has only a small impact on the inferred Carboniferous paleogeographic position of the the Aladag Unit. It represented, evidently, a distal foreland and the gentle docking of the Anatolide-Tauride Terrane need not necessarily show any great impact in its metamorphic and sedimentary record.

The outlined model of Variscan docking may be compatible with different views that compare the Anatolide-Tauride Zone or its part with Variscan units in Greece. Nevertheless, it should be stressed that the correlation does not necessarily mean the lateral continuity of the units but may rather suggest similar geotectonic position or tectonostratigraphic development.

Göncüoglu et al. (1997) mention the similarity of the tectono-stratigraphical units of the Tauride Belt with the non-metamorphic platformal nappes (Pre-Apulian, Plattenkalk, Ionian, Tripoliza and probably Almyropotamos Units) of the Hellenides. According to Okay et al. (1996), the Anatolide-Tauride Block extends partly in the west to the Pelagonian Zone in Greece. Stampfli et al. (1991) correlate some northern elements of the Taurides with Pelagonian and sub-Pelagonian units and Stampfli et al. (1998) include them together with elements of the Hellenides and the Dinarides in a Pelagonian Superterrane welded to the Laurussia during Variscan events (Stampfli 1996). De Bono et al. (1998), Vavassis et al. (2000) and Dornsiepen et al. (2001) conclude that the Pelagonian basement was consolidated during the Carboniferous due to an oblique northward subduction of the Paleotethys beneath the Eurasian margin. According to Ziegler & Stampfli (2001) the Pelagonian unit was located on the southern margin of Laurasia along with Alpine terranes in early Permian.

Robertson & Pickett (2000) distinguish the Chios – Karaburun unit linking Pelagonian Zone with NW Taurides and place the unit at the northern margin of Gondwana. The middle Carboniferous foraminiferal fauna of the Karaburun Mélange shows, however, rather Eurasian affinity.

Conclusions

1) In Carboniferous the North Paleotethyan Realm does not include the foraminiferal faunas of the terranes at the northeastern margin of Gondwana, which was under the influence of cold climate. Consequently, in accord with Leven (1993) and Leven and Okay

(1996) four foraminiferal paleobiogeographic realms are distinguished: Paleotethyan, Siberian, Perigondwanian and North American.

2) The Carboniferous foraminiferal fauna of the Istanbul Zone shows close connections to the East European Platform and the Ural and is a part of the Fennosarmatian Province of Kalvoda (2001).
3) Both terranes of the Istanbul zone are viewed as being located at south facing passive margin of Laurussia similarly as the Brunovistulian terrane in Central Europe (Kalvoda et al. 2003). The Istanbul Zone represents, thus, an equivalent of the Rhehohercynian Zone of the Central Europe and can not be compared with Armorican group of terranes (Kalvoda 2001).
4) The tropic-subtropic Carboniferous foraminiferal fauna of the Aladag Nappe rooted in the northern part of the Anatolide-Tauride composite zone is very different from cold water Perigondwana faunas of the Cimmerian terranes (Central Afghanistan, Qiangtang) as well as from northeast Africa (Libya, Egypt) and Arabian plate (Sinai) or Tethyan Zone of Himalayas. It is also very different from the foraminiferal fauna of the NW Africa which became a part of the North Paleotethyan Realm only in late Visean.
5) In the Visean, the Aladag fauna is very similar to the Central Asiatic Province and even more to the southeastern margin of Laurussia, more exactly to the Odessa and Moesia-Dobrogea regions. It is reflected in the presence of some endemic taxa, occurring only in those regions, as well as in the presence of other typical Fennosarmatian elements. The close similarities to southern margin of Laurasia are also maintained in the Late Carboniferous.
6) The interpretation that best fits with available evidence is that in Carboniferous the Anatolide - Tauride Zone either was located close or gently docked to Laurasia and later in the Permian was separated from the Eurasian mainland by the Karakaya back-arc basin (Stampfli 1999, 2000; Stampfli et al. 1998).
7) The proposed model may be supported by the correlation of the Anatolide -Tauride unit or its part with Variscan units in Greece (Pelagonian, sub-Pelagonian) (Okay et al. 1996; Stampfli et al. 1998, Dornsiepen et al. 2001) regarded as the northern margin of Paleotethys (Stampfli 1996; Ziegler & Stampfli 2001) and partly by the interpretation that locates Karakaya Ocean south of the Sakarya Zone and views that relate the development of the ocean to the back-arc rifting of the southern Laurasian margin (Stampfli et al. 1991; Stampfli 1996; Ziegler & Stampfli 2001).

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REFERENCES

Al Belushi J. D., Glennie K. W. & Williams B. P. J. (1996) - Permo-Carboniferous Glaciogenic Al Khlata Formation, Oman: A New Hypothesis for Origin of its Glaciation. *GeoArabia 1,* 3: 389-404, Boston.

Altiner D. (1981) - Recherches stratigraphiques et micropaléontologiques dans le Taurus oriental au NW de Pinarbasi (Turquie). Doctoral thesis, Université de Geneve, Thèse No. 2005, 450 p.

Altiner D. & Özgül N. (2001) - Carboniferous and Permian of the allochtonous terranes of the Central Tauride Belt, Southern Turkey. Paleoforams 2001. International Conference on Paleozoic Benthic Foraminifera, 20-24 August 2001, Ankara, Turkey. Guide Book., 1-35. Ankara.

Altiner D., Özkan-Altiner S. & Kocyigit A. (2000) - Late Permian foraminiferal biofacies belts in Turkey - paleobiogeographic and tectonic implications. In: Bozkurt E., Winchester J. A., Piper J. D. (eds.) - Tectonics and Magmatism in Turkey and the Surrounding Area. *Geol. Soc. London, Special Publ.,* 173: 83-96, London.

Bozorgnia F. (1973) - Paleozoic foraminiferal stratigraphy of Central and East Alborz Mountains, Iran. *Natl. Iranian Oil Co., Geol. Lab., Publ.* 4: 1-185, Teheran.

Brenckle P.L. & Marchant T.R. (1987) - Calcareous microfossils, depositional environment and correlation of the Lower Carboniferous Um Bogma Formation at Gebel, Nukhul, Sinai, Egypt. *Journ. Foram. Res.* 17, 1: 74-91, Washington.

Catal E., Demirtasli E., Dil N., Kaya O., Kiragli C. & Salanci A. (1978) - Field Excursions on the Carboniferous Stratigraphy in Turkey. Guidebook. IUGS Subcommision on Carboniferous Stratigraphy. 45 p. Ankara.

Chen Z., Li Z. X., Powell C. McA. & Balme B. (1994) - An early Carboniferous paleomagnetic pole for Gondwanaland: new results from the Mount Eclipse Sandstone in the Ngalia Basin, central Australia. *J. Geophys. Res.* 99 B2: 2909-2924, Washington.

Colchen M. & Vachard D. (1975) - Nouvelles données sur la stratigraphie des terrains carboniferes et permiens du domain tibétain de l'Himalaya du Népal. *C. R. Acad. Sci. Paris,* 281: 1963-1966, Paris.

Cozar P. & Vachard D. (2001) - Dainellinae, Subfam.nov. (early Carboniferous Foraminiferida), review and new taxa. *Geobios,* 34, 5: 505-526, Villeurbanne.

De Bono A., Vavassis I., Stampfli G.M., Martini R., Vachard D. & Zaninetti L. (1998) - New stratigraphic data on the Pelagonian pre-Jurrasic units of Evia Island (Greece). *Ann. Geol. Pays Hellen.,* 38/A: 11-24, Athenes.

Dil N. (1975) - Etude micropaléontologique du Dinantien de Gökgöl et Kokaksu (Turquie). *Ann. Soc. Géol. Belgique,* 98, 1: 213-228, Bruxelles.

Dil N. (1976) - Assemblages charactéritiques de foraminiferes du Dévonien Supérieur et du Dinantien de Turquie (Basin Carbonifere de Zonguldak). *Ann. Soc. Géol. Belgique,* 99: 373-400, Bruxelles.

Dornsiepen U. F., Manutsoglu E. & Mertmann D. (2001) - Permian-Triassic paleogeography of the external Hellenides. *Paleogeogr., Paleoclimat., Paleoecol.,* 172: 327-338, Amsterdam.

Fedorowski J. (1981) - Carboniferous Corals - Distribution and Sequence. *Acta Palaeontol. Polonica,* 26, 2: 87-160, Warszawa.

Flügel H. W. & Hubmann B. (1993) - Paläontologie und Plattetektonik am Beispiel Proto- und Paläotethyder Korallenfaunen. *Jb. Geol. B.-A.,* 136, 1: 27-37, Wien.

Fluteau F., Besse J., Broutin J. & Berthelin M. (2001) - Extension of Cathaysian flora during the Permian: Climatic and paleogeographic constraints. *Earth Planet. Sc. Lett.,* 193: 603-616, Amsterdam.

Garzanti E. & Sciunnach D. (1997) - Early Carboniferous onset of the Gondwanian glaciation and Neo-tethyan rifting in South Tibet. *Earth Planet. Sc. Lett.,* 148: 359-365, Amsterdam.

Golonka J. & Ford D. (2000) - Pangean (Late Carboniferous–Middle Jurassic) paleoenvironment and lithofacies. *Palaeogeogr., Palaeoclim., Palaeoecol.,* 161: 1–34, Amsterdam.

Göncüoglu M. (1997) - Distribution of Lower Paleozoic Rocks in the Alpine Terranes of Turkey - Paleogeographic Constraint. In: Göncüoglu M. & Derman A.S. (eds.) - Early Paleozoic Evolution in NW Gondwana, IGCP Project No 351 II. International meeting, November 5-11, 1995, Ankara - Turkey. *Turkish Ass. Petroleum Geol., Spec. Publ.,* 3: 13-23, Ankara.

Göncüoglu M. C., Turhan N., Sentürk K., Uysal S., Özcan A. & Isik A. (1997) - Rock units and geodynamic evolution of the Central Sakarya area and its correlation with the Serbo-Macedonian Terrane. Proceedings of the 15th Carpato-Balcan Congress. *Ann. Géol. Pays Hellen.,* 39: 217-228, Athenes.

Göncüoglu M. C., Turhan N., Sentürk K., Özcan A., Uysal S.& Yaliniz M. K. (2000) - A geotraverse across northwest Turkey- tectonic units of the Central Sakarya region and their tectonic evolution. In: Bozkurt E.,Winchester J.A. & Piper J. D. (eds.) - Tectonism and Magmatism in Turkey and the Surrounding Area. *Geol. Soc. London, Spec. Publ.,* 173: 139-161, London.

Görür N., Monod O., Okay A. I., Sengör A. M. C., Tüysüz O., Yigitbas E., Sakinc M. & Akkök R. (1997) - Palaeogeographic and tectonic position of the Carboniferous rocks of the western Pontides (Turkey) in the frame of the Variscan belt. *Bull. Soc. géol. France,* 168, 2: 197-205, Paris.

Isintek I. & Altiner D. (2001) - Foraminiferal content and stratigraphic position of marine Carboniferous in the Ildir region of the Karaburun Peninsula (West Turkey). Paleoforams 2001. International Conference on Paleozoic Benthic Foraminifera, 20-24 August 2001, Ankara, Turkey. Abstracts, 22, Ankara.

Izart A., Vaslet D., Briand C., Broutin J., Coquel R., Davydov V., Donsimoni M., El Wartiti M., Ensepbaev T., Geluk M., Goreva N., Görür N., Iqbal N., Joltaev G., Kossovaya O., Krainer K., Laveine J.-P., Makhlina M., Maslo A., Nemirovskaya T., Kora M., Kozitskaya R., Masa D., Mercier D., Monod O., Oplustil S., Schneider J., Schönlaub H., Stschegolev A., Süss P., Vachard D., Vai G.B., Vozarova A., Weissbrod T. & Zdanowski A. (1998) - Stratigraphic correlation between the continental and marine Tethyan and Peri-Tethyan basins during the Late Carboniferous and the Early Permian. *Geodiversitas,* 20, 4: 521-592, Paris.

Izart A., Tahiri A., El Boursoumi A., Vachard D., Saidi M., Chèvremont P. & Berkhli M. (2001) - Nouvelles données biostratigraphiques et sédimentologiques des formations Carbonifères de la région de Bouqachmir (Maroc central). Implications sur la paléogéographie des bassins Carbonifères nord-mésétiens. *C. R. Acad. Sci. Paris, Sc. Terre Planètes,* 332: 169-175, Paris.

Kahler F. & Kahler G. (1979) - Fusuliniden (Foraminifera) aus dem Karbon und Perm von Westanatolien und dem Iran. *Mitt. Österr. Geol. Ges.,* 70: 187-269, Wien.

Kalvoda J. (1990) - Late Devonian - Lower Carboniferous paleobiogeography of benthic foraminifera and climatic oscillations. In: Kauffman E.G. & Walliser O.H. (eds.) - Extinction events in Earth history. *Lecture Notes in Earth Sciences* 30: 183-188, Springer Verlag, Berlin.

Kalvoda J. (2001) - Upper Devonian - Lower Carboniferous foraminiferal paleobiogeography and Perigondwana terranes at the Baltica - Gondwana interface. *Geologica Carpathica,* 52, 4: 205-215, Bratislava.

Kalvoda J., Leichmann J., Bábek O. & Melichar R. (2003) - Brunovistulian Terrane (Central Europe, Czech Republic) and Istanbul Zone (NW Turkey) - a comparison of Paleozoic development. *Geologica Carpathica,* in press, Bratislava.

Kaya O. & Mamet B. (1971) - Biostratigraphy of the Visean Cebeciköy Limestone near Istanbul, Turkey. *Journ. Foram. Res.,* 1, 2: 77-81, Washington.

Kozur H. (1998) - The age of the siliciclastic series (Karareis Formation) of the western Karaburun Peninsula, western Turkey. In: H. Szaniawski (ed.) - Proceedings of the Sixth European Conodont Symposium (ECOS VI). *Palaeontologia Polonica,* 58: 171-189, Warszawa.

Kozur H. & Göncüoglu M. (1998) - Main features of the pre-Variscan development in Turkey. *Acta Universitatis Carolinae – Geologica,* 42, 3-4: 459-464, Prague.

Lang J., Yahaya M., El Hamet M.O., Besombes J.C.& Cazoulat M. (1991) - Dépots glaciares du Carbonifere inferieur a l'ouest de l'Air (Niger). *Geol. Rdsch.,* 80, 3: 611-622, Stuttgart.

Legrand – Blain M. (1986) - Iullemedden Basin. In: Wagner R.H., Winkler Prins C.F. & Granados L.F. (eds.) - The Carboniferous of the World. II: Australia, Indian Subcontinent, South Africa, South America & North Africa: 323-325. Instituto Geologico Y Minero de Espana, Madrid & Nationaal Natuurhistorisch Museum, Leiden.

Leven E. Y. (1993) - Main events in the Permian history of the Tethys and Fusulinids. *Strat. Geol. Correlation*, 1, 1: 51-65, Moscow.

Leven E. Y. (1995) - Lower Permian fusulinids from the vicinity of Ankara (Turkey). *Riv. It. Paleont. Strat.*, 101: 235-248, Milano.

Leven E. Y. & Okay A. (1996) - Foraminifera from the exotic Permo-Carboniferous Limestone blocks in the Karakaya Complex, Northwestern Turkey. *Riv. It. Paleont. Strat.*, 102: 139-174, Milano.

Li Z. X. & Powell C. McA. (2001) - An outline of the palaeogeographic evolution of the Australasian region since the beginning of the Neoproterozoic. *Earth Sci. Reviews*, 53: 237-277, Amsterdam.

Lipina O. A. (1973) - Zonal stratigraphy and paleogeography based on Tournaisian foraminifers (Zonalnaya stratigrafiya i paleogeografiya turne po foraminiferam) (In Russian). *Voprosy mikropaleontologii*, 16: 3-34. Moskva.

Luo H. (1998) - Devonian and Carboniferous foraminifers from northwest Qiangtang. In: Wen Shixuan (ed.) - Palaeontology of the Karakorum and Kunlun Mountains: 50-64. Beijing.

Lys M. (1979) - Micropaléontologie (foraminiferes) des formations marines du Carbonifere Saharien. Huit. Congr. Int. Stratigr. Geol. Carbonifère, *C. R.*, 2: 37-47, Moskva.

Lys M. (1986) - Foraminifera. In: Wagner R.H., Winkler Prins C.F. & Granados L.F. (eds.) - The Carboniferous of the World. II: Australia, Indian Subcontinent, South Africa, South America & North Africa: 354-364. Instituto Geologico Y Minero de Espana, Madrid & Nationaal Natuurhistorisch Museum, Leiden.

Mamet B. L. (1977) - Foraminiferal zonation of the Lower Carboniferous - methods and stratigraphic implications. In: Kaufmann E.G. & Hazel J.E. (eds.) - Concepts and Methods of Biostratigraphy: 445-462, Dowden, Hutchinson & Ross, Stroudsburg.

Mamet B. L. & Belford D. (1968) - Carboniferous Foraminifera, Bonaparte Gulf Basin, North-Western Australia. *Micropaleontology*, 14: 339-347, New York.

Nikishin A. M., Ziegler P.A., Stephenson R.A., Cloething S. A. P. L., Furne A.V., Fokin P. AA., Ershov A.V., Bolotov S. N., Korotaev M.V., Alekseev A. S., Gorbachev V. I., Shipilov E.V., Lankreijer A., Bembinova E. Y. & Shalimov I.V. (1996) - Late Precambrian to Triassic history of the East European Craton: dynamics of sedimentary basin evolution. *Tectonophysics*, 268: 23-63, Amsterdam.

Okay A. I. (1989) - Tectonic units and sutures in the Pontides, northern Turkey. In: Sengör A. M. (ed.) - Tectonic evolution of the Tethyan region: 109-115, Kluwer, Dordrecht.

Okay A. (2000) - Was the Late Triassic orogeny in Turkey caused by the collision of an oceanic plateau?. In: Bozkurt E., Winchester J. A. & Piper J. D. (eds.) - Tectonics and Magmatism in Turkey and the surrounding area. *Geol. Soc. London, Sp. Publ.*, 173: 25-41, London.

Okay A. I., Sengör A.M.C. & Gorür N. (1994) - The Black Sea-kinematic history of opening and its effect on the surrounding regions. *Geology*, 22: 267-270, Boulder.

Okay A. I., Satir M., Maluski H., Siyako M., Monie P., Metzger R. & Akyuz S.(1996) - Paleo- and Neo-Tethyan events in northwestern Turkey - Geologic and geochronologic constraints.. In: Yin A. & Harrison T.M. (eds.) - The tectonic evolution of Asia: 420-441, Cambridge University Press. Cambridge.

Okay A. & Leven A.Y. (1996) - Stratigraphy and Paleontology of the Upper Paleozoic Sequences in the Pulur (Bayburt) Region, Eastern Pontides. *Tr. Journ. Earth Sciences*, 5: 145-155, Istanbul.

Okay A. & Sahintürk O. (1997) - Geology of Eastern Pontides. In: Robinson A.G. (ed.) - Regional and petroleum geology of The Black Sea and surrounding region. *AAPG Memoir*, 68: 291-311, Tulsa.

Okuyucu C. (1999) - A new *Multidiscus*? species (Foraminifera) from a fusulinacean-rich succession encompassing the Carboniferous-Permian boundary in the Hadim Nappe (Central Taurus, Turkey). *Riv. It. Paleont. Strat.*, 105: 439-444, Milano.

Okuyucu C. (2001) - Late Moscovian and Kasimovian fusulinid fauna of the Özbek Tepe section, Eastern Taurids, Turkey. Paleoforams 2001. International Conference on Paleozoic Benthic Foraminifera, 20-24 August 2001, Ankara, Turkey. Abstracts: 34. Ankara.

Okuyucu C. & Güvenc T.(1997) - Hadim Napi'nda Karnonifer-Permiyen gecisi, Girvanella kirectasi olusum paleontoljisi. *Geosound*, 30: 463-473, Ankara.

Özgül N. (1997) - Stratigraphy of tectono-stratigraphic units in the region Bozkir-Hadim-Tashkent (northern central Taurides). *Min. Res. Expl. Inst. Turkey (MTA) Bulletin*, 119: 113-174, Ankara.

Papanikolaou D. (1999) - The Triassic Ophiolites of Lesvos Island within the Cimmeride Orogene Event. Symposium D06 Inter-Relations Between Palaeotethys and Neotethys in Eurasia EUG 10 28th March - 1st April, 1999 Strasbourg, France. *Journ. Conf. Abstracts*, 4/1: 315. Strasbourg.

Pharaoh T.C. (1999) - Palaeozoic terranes and their lithospheric boundaries within the Trans-European Suture Zone (TESZ) - a review. *Tectonophysics*, 314: 17-41, Amsterdam.

Robertson A. H. F. & Dixon J. E. (1984) – Introduction: aspects of the geological evolution of the Eastern Mediterranean. In: Dixon J.E. & Robertson A.H.F. (eds.) - Geological Evolution of the eastern Mediterranean. *Geol. Soc. London, Spec. Publ.*, 17: 1-74, London.

Robertson A. H. F. & Pickett E. (2000) - Paleozoic-Early Tertiary Tethyan evolution of melanges, rift and passive margin units in the Karaburun Peninsula (western Turkey) and Chios Island (Greece). In: Bozkurt E., Winchester J.A. & Piper J.D. (eds.) - Tectonism and magmatism in Turkey and the Surrounding area. *Geol. Soc. London, Spec. Publ.*, 173: 43-82, London.

Rui L., Ross C. A. & Nassichuk W. W. (1991) - Upper Moscovian (Desmoinesian) Fusulinaceans from the type section of the Nansen Formation, Ellesmere Island, Arctic Archipelago. *Bull. Geol. Survey of Canada*, 418: 1-121, Ottawa.

Sen A., Altiner D., Yilmaz I. Ö. & Özkan-Altiner S. (2001) - Meter-scale subtidal cycles in the Middle Carboniferous carbonates of Central Taurides, Turkey. Paleoforams 2001. International Conference on Paleozoic Benthic Foraminifera, 20-24 August 2001, Ankara, Turkey. Abstracts: 43.

Sengör A. M. C. (1979) - Mid-Mesozoic closure of Permo-Triassic Tethys and its implications. *Nature*, 279: 590-593, London.

Sengör A. M. C. (1985) - The story of Tethys: How many wives did Okeanos have? *Episodes*, 8: 3-12, Ottawa.

Sengör A.M.C. (1990) - A new model for the late Palaeozoic-Mesozoic tectonic evolution of Iran and implications for Oman. *Geol. Soc. London, Spec. Publ.*, 49: 797-831, London.

Sengör A.M.C.& Yilmaz Y. (1981) - Tethyan evolution of Turkey- a plate tectonic approach. *Tectonophysics*, 75: 181-241, Amsterdam.

Sengör A.MC., Yilmaz Y.& Sungyrlu O. (1984) - Tectonics of the Mediterranean Cimmerides - nature and evolution of the western termination of Paleotethys. In: Dixon J.E. & Robertson A.H.F. (eds.) - The Geological evolution of the Eastern Mediterranean. *Geol. Soc. London, Spec. Publ*, 17: 77-112, London.

Solovieva M. N. (1974) - Paleobiogeograficheskoe raionirovanie akvatorii srednekamennougolnoi epokhi (po fuzulinideam) (Paleobiogeographic division of Middle Carboniferous (according to fusulinideas) (In Russian). *Ser. geol.*, 11: 123-127, Moskva.

Solovieva M. N. (1975) - Paleobiogeographical zonation of the middle Carboniferous seas (on basis of Fusulinacea). *Septième Congr. Int. Stratigr. Geol. Carbonifère, C. R.*, 2: 267-273, Krefeld.

Stampfli G. M. (1996) - The Intra-Alpine terrane- A Paleotethyan remnant in the Alpine Variscides. *Eclogae geol. Helv.*, 89/1: 13-42, Basel.

Stampfli G. M. (1999) - Tethyan Sutures in Europe. EUG 10 vol. 28th March - 1st April, 1999, Symposium D06, *Inter-Relations Between Palaeotethys and Neotethys in Eurasia*, 4/1: 314, Strasbourg.

Stampfli G. M. (2000) - Tethyan oceans. In: Bozkurt E., Winchester J.A. & Piper J.D. (eds.) - Tectonics and Magmatism in Turkey and the Surrounding Area. *Geol. Soc. London, Spec. Publ.*, 173: 1-23, London.

Stampfli G., Marcoux J. & Baud A. (1991) - Tethyan margins in space and time. *Paleogeogr., Palaeoclim., Palaeoecol.*, 87: 373-409, Amsterdam.

Stampfli G. M., Mosar J., De Bono A. & Vavasis I. (1998) - Late Paleozoic, Early Mesozoic plate tectonics of the western Tethys. *Bull. Geol. Soc. Greece*, 32/1: 113-120, Athenes.

Streel M., Caputo M.V., Loboziak S. & Melo J. H. (2000) - Late Frasnian-Famennian climates based on palynomorph analyses and the question of the Late Devonian glaciations. *Earth Sci. Reviews*, 52, 121-173, Amsterdam.

Ueno K. (2000) - Permian fusulinacean faunas of the Sibumasu and Baoshan blocks- implications for the paleogeographic reconstruction of the Cimmerian continent. In: Lee Y. I., Lee I. & Kim J. H. (eds.) - Second Symposium of the Project No. 411 on the Geodynamic Processes of Gondwanaland derived Terranes in Eastern Asia (Aug. 28-29, 2000). *Geosciences Journal*, 4: 160-163, Seoul.

Ueno K. & Igo H. (1997) - Late Paleozoic foraminifers from the Chiang Dao area, northern Thailand - geologic age, faunal affinity and paleobiogeographic implications. Proc. XIII Intern. Congr. Carboniferous and Permian, 1. *Prace Panstwowego Instytutu Geologicznego*, 157: 339-358, Warszawa.

Ueno K., Watanabe D., Igo H., Kakuwa Y. & Matsumoto R. (1997) - Early Carboniferous foraminifers from the Mobarak Formation of Shamirza, NE Alborz Mountains, Northern Iran. In: Ross C. A., Ross J. R. P. & Brenckle P. L. (eds.) - Late Paleozoic Foraminifera - their biostratigraphy, evolution and paleoecology and the Mid-Carboniferous boundary. *Cushman Found. Foramin. Res., Spec. Public.*, 36: 149-152. Bellingham.

Vachard D. (1980) - Tethys et Gondwana au Paleozoique Superieur les Donnees Afganes. *Docum. et Trav. IGAL* 2: 463 p., Paris.

Vachard D. (1996) - Iran. In: R.H. Wagner, C.F. Winkler-Prins & Granados L.F. (eds) - The Carboniferous of the World III, The former USSR, Mongolia, Middle Eastern Platform, Afghanistan, & Iran: 491-521, Instituto Geologico Y Minero de Espana, Madrid & Nationaal Natuurhistorisch Museum, Leiden.

Vachard D., Massa D. & Strank A. (1993) - The Carboniferous of AA1-37 Borehole (Cyrenaica, Libya), biostratigraphical analysis, paleogeographical implications. *Rev. Micropaléontologie*, 36/2: 165-186, Paris.

Vachard D. & Montenat C. (1996) - Afghanistan. In Wagner R. H.,.Winkler Prince C. F. &. Granados L. F. (eds.) - The Carboniferous of the World III: The former USSR, Mongolia, Middle Eastern Platform, Afghanistan and Iran: 461-489. Instituto Geologico Y Minero de Espana, Madrid & Nationaal Natuurhistorisch Museum, Leiden.

Vavassis I., De Bono A., Stampfli G. M., Giorgis D., Valloton A. & Amelin Y. (2000) - U-Pb and Ar-Ar geochronological data from the Pelagonian basement in Evia (Greece) - geodynamic implications for the evolution of Paleotethys. *Schweiz. Mineral. Petrogr. Mitt.*, 80: 21-43, Zürich.

Vdovenko M.V. (1980) - Vizeiskii yarus - zonalnoe raschlenenie i paleozoogeograficheskoe raionirovanie (po foraminiferam), 172 p. (In Russian). Naukova Dumka, Kiev.

Vdovenko M., Reitlinger A., Yovcheva P.& Spasov C. (1981) - Lower Carboniferous foraminifers of the Gomotarci R-3 borehole (nortwestern Bulgaria) (Foraminifery nizhnekamennougolnykh otlozhenii sk. R-3 Gomotarci, Severo-Zapadnaya Bolgariya) (In Russian). *Paleont., Stratigr. and Litol.*, 15: 3-51, Sofia.

Villa E., Dzhenchuraeva A., Forke H. C. & Ueno K. (2002) - Distinctive features of Late Carboniferous fusulinacean faunas from the western Paleo-Tethyan realm. In: Hills L. V., Henderson C. M. & Bamber E. W. (eds.) - Carboniferous and Permian of the World. XIV International Congress on the Carboniferous and Permian. *Canadian Soc. Petroleum Geolog. Mem.*, 19: 609-615, Calgary.

Villa E., Ueno K. & Bahamonde J. (2001) - Late Carboniferous fusulinoideans from the Cantabrian Zone, Spain - characteristic of the westernmost Paleotethys Faunas. Paleoforams 2001. International Conference on Paleozoic Benthic Foraminifera, 20-24 August 2001, Ankara, Turkey. Abstracts, 48. Ankara.

Ziegler P. A. (1989) - Evolution of Laurussia. In: A Study in Late Paleozoic Plate Tectonics. Kluwer Academic, p.102, Dordrecht.

Ziegler P. & Stampfli G. (2001) - Late Paleozoic-Early Mesozoic plate boundary reorganization- collapse of the Variscan orogen and opening of the Neotethys. *Natura Bresciana, Ann. Mus. Civ. Sc. Nat., Monografia* 25: 17-34. Brescia.