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LATE PERMIAN UNCONFORMITY AROUND ANKARA AND NEW AGE DATA ON THE BASEMENT ROCKS, ANKARA, TURKEY

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ABSTRACT

At southwest of Gölbaşı (Ankara) there are two different sequences in tectonic contact. The one at the bottom with low-degree metamorphism is represented by phyllite, metabasite, crystallized limestone, schist and quartz porphyry veins. Above them are early Carboniferous-late Permian neritic and pelagic carbonates which are unconformably overlain by late Permian clastics and carbonates. Samples collected from neritic carbonates yielded early Carboniferous (Visian-Serpuhovian) to middle Carboniferous (Bashkirian-Moskovian) ages. These carbonates of shallow facies character are overlain by radiolarite-bearing pelagic deposits of middle Carboniferous-Permian age. Fossils from the upper most neritic carbonates gave Kubergandian-Murgabian age. This Permo-Carboniferous sequence is unconformably overlain by a sequence consisting of clastics and carbonates. Basal conglomerates and sandstones contain abundant quartz and fewer amounts of carbonated-cemented metamorphic rock fragments and they change to medium-thick bedded dolomitic limestone and limestones to the top. The age of these carbonates of shallow marine character is found Murgabian-Dorashamian. It is suggested that late Paleozoic carbonate basement was deposited in a neritic environment during early-middle Carboniferous, in a pelagic environment during middle Carboniferous-Permian and again in a neritic environment during Kubergandian-Murgabian. Following a deformation stage, it was accreted onto the Variscan basement at north and carbonate deposition took place as a result of late Permian transgression and finally some of exotic blocks within the upper Karakaya Complex were derived from this basement.

1. Introduction

In the Sakarya Zone which is one of the main tectonic units in Turkey (Figure 1a), high-degree metamorphics of pre-Liassic basement which consist of gneiss, amphibolite and marbles were affected by the Variscan orogeny and cut by Devonian and/or early Carboniferous granitoids. These rocks are known as Kazdağ massif and Çamlık granitoids in the Biga peninsula (Okay et al., 1991), Söğüt metamorphics and Sarıcakaya granitoid in Eskişehir (Göncüoğlu et al., 2000; Ustaömer et al., 2012), metamorphic Serveçay group (Aydın et al., 1995; Kozur et al., 2000) and Deliktaş and Sivrikaya granites (Nzegge et al., 2006) in central Pontides and Pulur massif and Gümüşhane granitoids in the eastern Pontides (Keskin et al., 1989; Topuz et al., 2010).

One of the most controversial issues as regards the Sakarya Zone is the geologic evolution of the Karakaya Complex of the pre-Liassic basement (Tekeli, 1981). The term of "Karakaya Complex" was first used by Bingöl (1968) for low-degree metamorphic rocks in northwest Turkey and then by Tekeli (1981) and Şengör (1984) for pre-Jurassic orogenic rocks. Tekeli (1981) described late Paleozoic-early Mesozoic rocks around Ankara and Tokat as the accretionary complex and differentiated

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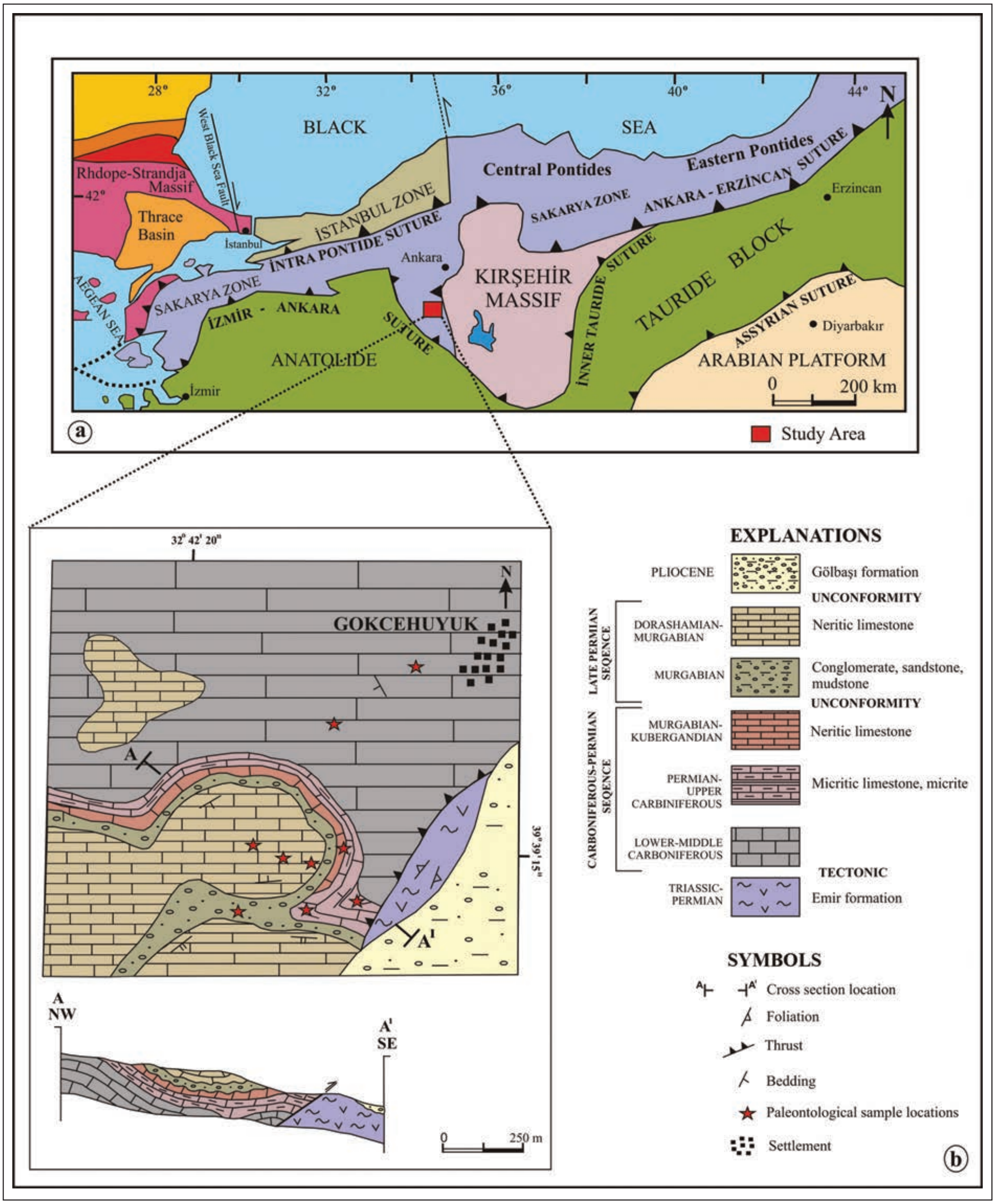

Figure 1- a) Map showing tectonic units of Turkey (Okay and Tüysüz, 1999), b) Geology map and cross section of the study area.

them as lower metamorphic series and upper blocky series. A similar differentiation was made by Okay and Göncüoğlu (2004). They differentiated extremely deformed low-degree metamorphites consisting of phyllite, metabasite and marbles at the bottom as the Lower Karakaya Complex and deformed slightly metamorphosed clastics and volcano-sedimentary rocks which also contain late Paleozoic limestone blocks as the Upper Karakaya Complex.

The Lower Karakaya Complex was studied under different names; from west to east, they are Çavdartepe formation in the Kozak region (Akyürek and Soysal, 1983), Nilüfer unit in the Biga region (Okay et al., 1991), İznik metamorphites in the Armutlu peninsula (Göncüoğlu et al., 1987), Tepeköy metamorphites at north of Eskişehir (Göncüoğlu et al., 2000), Yenişehir metamorphic group in the Yenişehir-İnegöl area (Genç and Yılmaz, 1995), Emir formation around Ankara (Akyürek et al., 1984), Gümüşoluğu and Kunduz formations in central Pontides (Yılmaz and Tüysüz, 1984), the lover Yeşilırmak group (Tüysüz, 1996; Yılmaz et al., 1997) and Turhal metamorphites (Yılmaz and Yılmaz, 2004) in the Tokat massif and Ağvanis group (Okay, 1984) and Hossa Group (Okay, 1996) in the further east. Limited fossil and radiometric data are available for these low-degree metamorphites. For this unit, fossil ages were determined; middle Triassic for conodonts from the Kozak Mountain (Kaya and Mostler, 1992), Early Triassic for conodonts around Bursa and Early Triassic for foraminifera around Ankara (Akyürek et al., 1979).

Metamorphism ages of the Lower Karakaya Complex were found as late Triassic around Bandırma and Eskişehir (Okay and Monie, 1997; Okay et al., 2002) and early Permian in the Pulur massif at east (Topuz et al., 2004*b*) (Rb-Sr for hornblende mineral and 264±3.4 Ma with $^{40}Ar/^{39}Ar$ method on albite-epidote-amphibolite sample).

Ophiolitic rocks are found as tectonic slices within these different metamorphic units at the basement which include Tozlu formation (metaophiolite) in the Biga peninsula (Duru et al., 2012), Tozman metaophiolite around Eskişehir (Göncüoğlu et al., 2000), metaophiolite around Ankara (Akyürek et al., 1984), Boğazköy metaophiolite around Bilecik (Genç and Yılmaz, 1995), Turhal metaophiolite in Tokat (Yılmaz et al., 1997) and metaultramafites within the Pulur Complex (Dokuz et al., 2015).

Arguments are not just on lithology and stratigraphy of this metamorphic basement but also on its paleogeographic setting, age and type of environment as well as relations with overlying Mesozoic units and the origin of exotic blocks within the Triassic rocks.

Although it is generally accepted that autochthonous Permo-Carboniferous carbonates do not overlie the Sakarya Zone and rather they occur as blocks within the Triassic Upper Karakaya Complex, there are also different opinions that these carbonates are derived from Gondwana (Altıner et al., 2000; Göncüoğlu et al., 2000) or Eurasia (Okay et al., 1996; Leven and Okay 1996).

Regarding the relation between basement and cover rocks, Göncüoğlu et al. (1987) suggested that early Permian limestones discordantly set on the basement. According to Saner (1977), micaschists around the Yenişehir-Geyve area gradually change to metasandstone and Permian recrystallized limestones. Akdeniz (1988) states that in the Bayburt region a Permo-Carboniferous sequence composing of clastics and carbonates to the top unconformably covers crystalline basement. Okuyucu and Göncüoğlu (2010) propounded that early Permian lagoon type carbonate rocks in south of Geyve discordantly set on the Variscan metamorphic basement. According to Yılmaz et al. (1997), around Amasya there is a late Permian unconformity above the metamorphic basement consisting of metaquartzite, phyllites and schists. The clastics of Triassic Upper Karakaya Complex contain Silurian (Alp, 1972), Early Devonian (Çapkınoğlu and Bektaş, 1999) and Permo-Carboniferous (Akyürek et al., 1982/1984) neritic limestone blocks and late Paleozoic (Devonian-Carboniferous-Permian) radiolarite and pelagic limestone blocks as well (Okay and Mostler, 1994; Okay et al., 2011).

Setting of Paleotethys is another controversial issue (Stocklin, 1977; Şengör, 1979) that is basement of Sakarya Zone is a part of Gondwana or Eurasia. It was suggested by Yılmaz (1981), Şengör and Yılmaz (1981), Şengör et al. (1984), Koçyiğit (1987), Genç and Yılmaz (1995) and Göncüoğlu et al. (2000) that Paleotethys was southerly subducted into northern margin of Gondwana and a Permo-Triassic basin was opened in the backarc region. According to Adamia et al. (1977), Tekeli (1981), Şengün (1990), Pickett et al. (1995), Pickett and Robertson (1996) and Okay (2000), Paleotethys was subducted into southern margin of Eurasia at north. The subduction of

Paleozoic-Mesozoic oceans at north and south of the Sakarya Zone during Mesozoic are another alternative (Stampfli and Borel, 2002). Two different models were proposed for occurrence of Karakaya Complex. The first is the rift model of Bingöl et al. (1975), Yılmaz (1981), Şengör and Yılmaz (1981), Şengör et al. (1984), Koçyiğit (1987), Genç and Yılmaz (1995) and Göncüoğlu et al. (2000) and another is subduction/accretion model by Tekeli (1981), Pickett et al. (1995), Pickett and Robertson (1996) and Okay (2000).

2. Stratigraphy

The studied area is located in the Sakarya Zone in the vicinity of Gökçehöyük village at southwest of Gölbaşı along the Ankara-Haymana road (Figure 1b). In the region there are two different units that are tectonically related and covered by Pliocene deposits. The Emir formation at the bottom (Figure 2; Akyürek et al., 1984) consists of extremely deformed rocks that were metamorphosed under green schist facies conditions (Lover Karakaya Complex). Above this unit is early Carboniferous-Permian neritic and pelagic carbonate sequence (Figure 2) which is unconformably overlain by Murgabian-Dorashamian sequence consisting of terrestrial clastics which change to shallow marine dolomitic limestones and limestones (Figures 1b, 2 and 3). During Lutetian basement and overlying late Permian cover were southerly transported over the İzmir-Ankara ophiolitic rocks (Figure 4a, b). MT profiles obtained from the ongoing MTA Crust Project also support this consideration (MTA 2015 project presentations).

The late Paleozoic sequence and late Permian cover under investigation are not given formation names and the unit was named as Carboniferous-

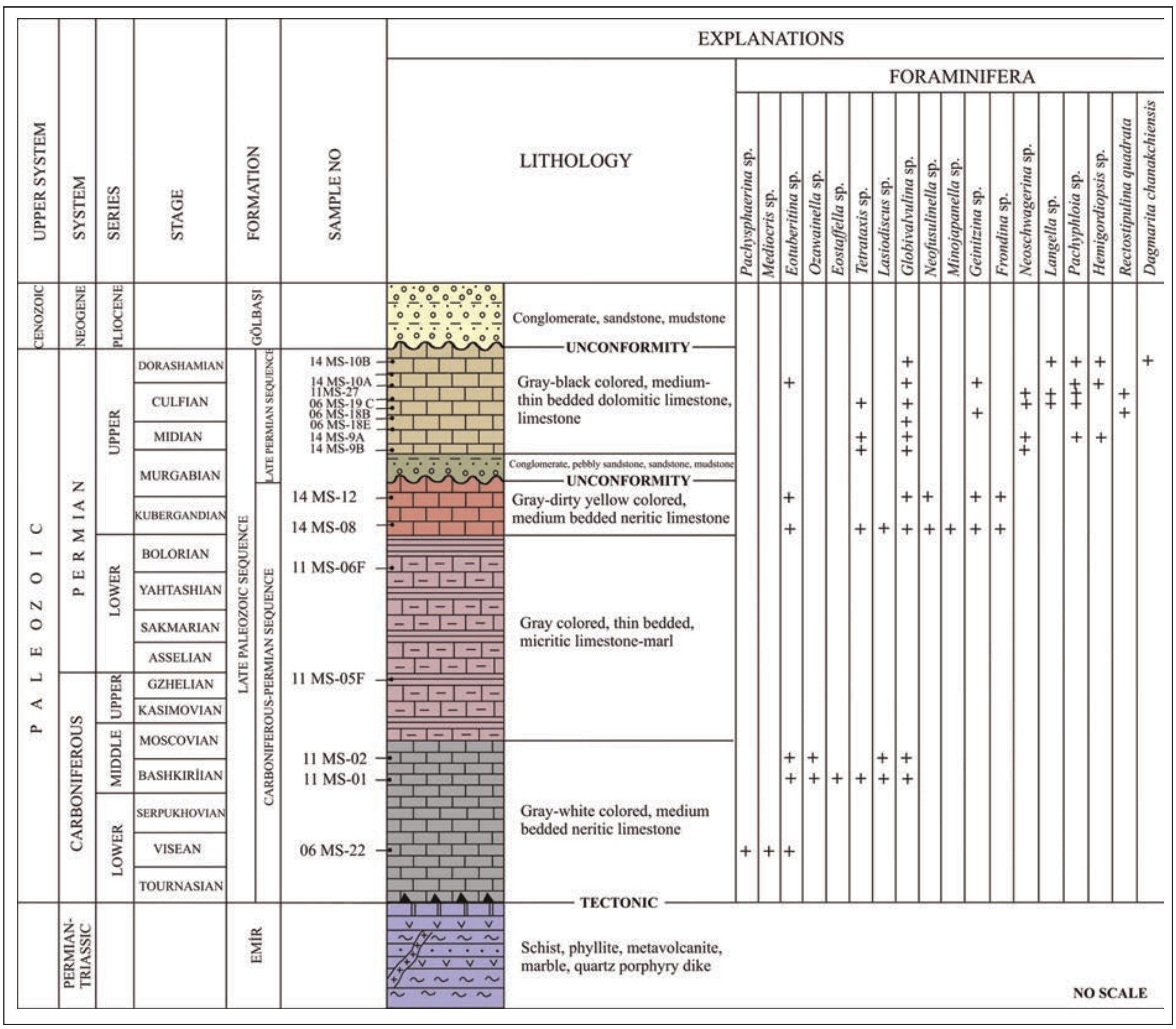

Figure 2- Generalized columnar section of the study area and foraminifera distribution of late Paleozoic sequence.

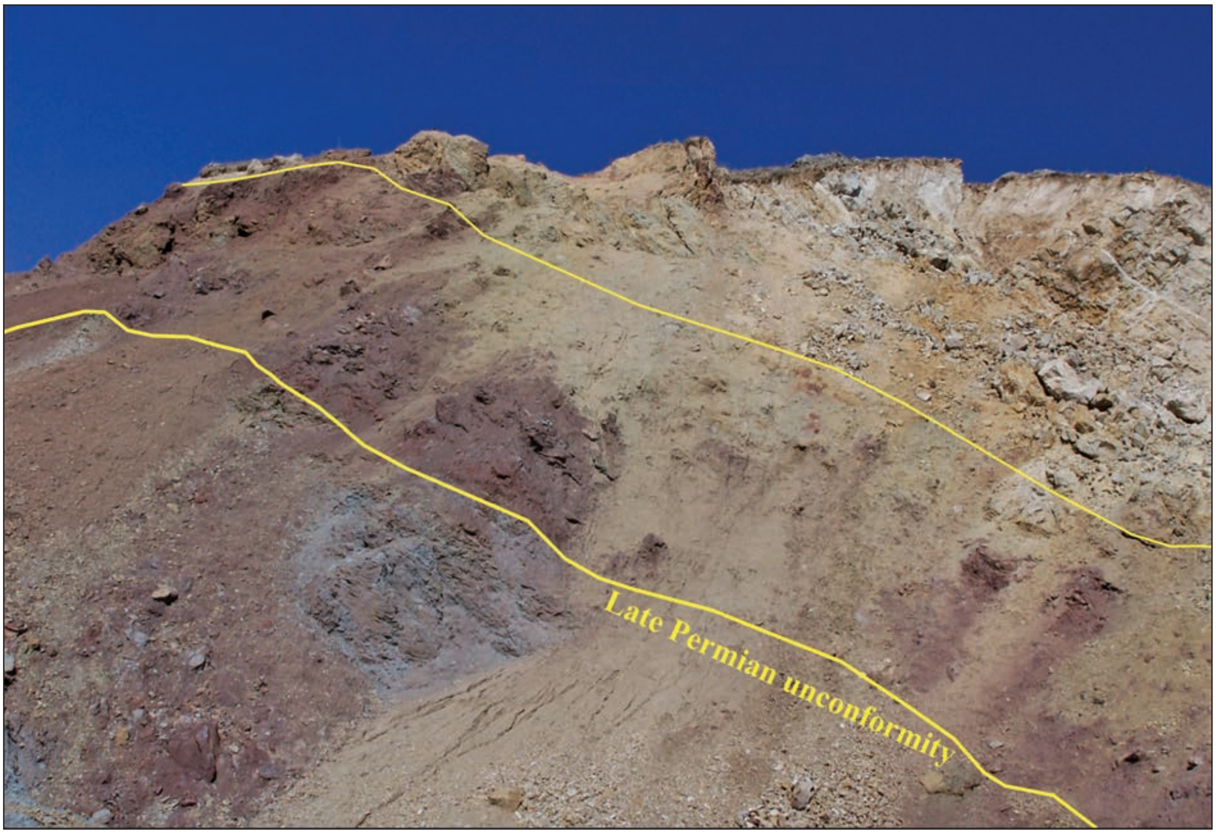

Figure 3- Late Permian unconformity; below is gray pelagic micritic limestone-marl alternation, above is reddish late Permian terrestrial clastics and beige dolomitic limestone-limestone (X: 36476488, Y: 4390205).

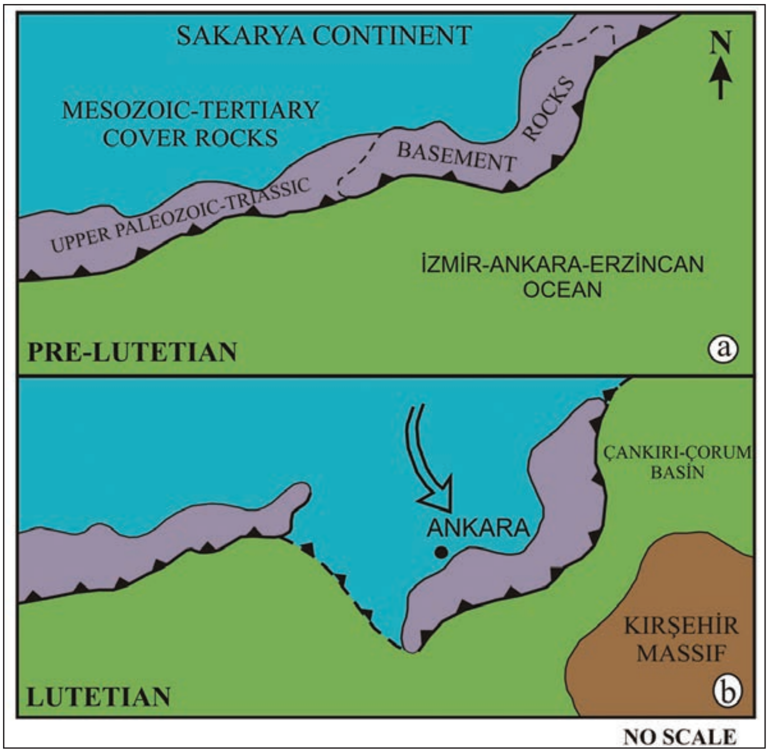

Figure 4- Map showing pre-Lutetian and Lutetian tectonism of the region.

Permian sequence and late Permian sequence. The Carboniferous-Permian carbonate sequence and unconformably overlying late Permian clastics and carbonates along the Sakarya Zone were first described in the present study.

2.1. Carboniferous-Permian sequence

Carbonates of this sequence which are in tectonic contact with underlying Emir formation are represented at the bottom by gray-white colored, thick bedded, fractured, partly crystallized neritic limestones and to the top by gray colored, thin bedded, deformed pelagic micritic limestone-marl alternation and gray colored, medium-thick bedded, neritic limestones with abundant calcite veins (Figure 2).

In samples collected from gray colored thick bedded basal limestones following fossils were determined from bottom to the top (Figure 5): *Bradyina* sp., *Pachysphaerina* sp., *Eotuberitina* sp., *Tuberitina* sp., *Mediocris* sp., *Koktjubina?* sp., *Biseriella?* sp. indicating early Carboniferous (Visian-Serpuhovian) age; *Ozawainella* sp., *Eostaffella* sp., *Tetrataxis* sp., *Lasiodiscus* sp., *Globivalvulina* sp., *Eotuberitina* sp. indicating middle Carboniferous (Bashkirian-Moskovian) and *Ozawainella* sp., *Lasiodiscus* sp., *Eotuberitina* sp., *Globivalvulina* sp., *Beresella* sp. (Figure 2, Plate I) indicating middle Carboniferous (Bashkirian-Moskovian) (TMMOB JMO, 2004).

Two samples taken from radiolarian-bearing pelagic micritic limestone (Figure 6) above the early-middle Carboniferous carbonates yield middle Carboniferous-Permian time based on radiolarite assemblage of Follicullidae Ormiston and Babcock, Albaillellidae Deflandre families.

Topmost neritic limestones that contain benthic fossils (Figure 2) yield Kubergandian-Murgabian age based on *Neofusulinella* sp., *Minojapanella* sp., *Rauserella* sp., *Parafusulina*? sp., *Kahlerina* sp., *Frondina* sp., *Geinitzina* sp., *Globivalvulina* sp.,

Figure 5- Gray colored, thick bedded early-middle Carboniferous neritic carbonates (X: 36476578, Y: 4390577).

Figure 6- Middle Carboniferous-Permian radiolarian-bearing micritic limestone-marl alternation (X: 36476400, Y: 4390180).

Hemigordius sp., *Tetrataxis* sp., *Climacammina* sp., *Lasiodiscus* sp., *Eotuberitina* sp., *Girvanella* sp., *Gymnocodium* sp., *Mizzia* sp., *Tubiphytes* sp. (Figure 2, Plate I).

Carboniferous neritic limestones in close vicinity to the study area appear to be blocks within the Triassic Elmadağ formation (Akyürek et al., 1980/1982) and Devecidağ Complex (Özcan et al., 1980); however, middle Carboniferous-Permian pelagic deposits are not mentioned in any of previous studies.

2.2. Late Permian sequence

In the Bilecik-Geyve region clastics and overlying carbonates that unconformably overlie the Carboniferous-Permian sequence are named by Saner (1977) and Eroskay (1965) as Cambazkaya formation and Derbent limestone, respectively, however the basement of sequence is thought to be transitional. In the study area, clastics are thick bedded, grayish, reddish and bluish in color and composed of conglomerate, pebbly conglomerate, sandstone and mudstone with massive appearance (Figure 7). Conglomerates are in a matrix of clay and carbonate and composed commonly of late Permian (Kubergandian-Murgabian) limestone, quartz-porphyry and lesser amount of metamorphic rock fragments of the Emir formation. Grains are 0.5-10 cm in size, partly rounded and tightly compacted. Overlying sandstones are reddish and bluish colored, thick bedded, quartz-grained and contain no fossil. In thin section, it is composed chiefly of quartz, biotite, muscovite, plagioclase and lesser amount of chlorite, chert, metamorphic and sedimentary rock fragments and opaque minerals. Clay- and carbonate-cemented, sub-rounded, well sorted and iron-oxide coated these rocks are classified as lithic arenite. The clastics are overlain by thick bedded, algae-bearing, black colored macro fossiliferous dolomitic limestone and limestone of tens of meter thickness (Figure 8a, b). Several samples of these carbonate rocks yield late Permian age (Murgabian-Midian) based on fossil assemblage of *Neoschwagerina* sp., *Langella* sp., *Pachyphloia* sp., *Globivalvulina* sp., *Hemigordius* sp., *Dunbarula* sp., *Pseudovermiporella* sp. and late Permian age (Midian) based on *Rectostipulina quadrata* Jenny-Deshusses, *Neoschwagerina* sp., *Charliella* sp., *Paraglobivalvulina* sp., *Baisalina* sp., *Langella* sp., *Climacammina* sp., *Pachyphloia* sp., *Agathammina* sp., *Pseudovermiporella* sp. and late Permian age (Midian-Dorashamian) based on

Figure 7- A view of conglomerate, sandstone, mudstone at the base of late Permian. Pebbles are mostly derived from Kubergandian-Murgabian limestone and quartz porphyry dikes (X: 36476381, Y: 4390122).

Dagmarita chanakchiensis Reitlinger, *Eotuberitina* sp., *Kamurana* sp., *Neoendothyra* sp., *Rectostipulina* sp., *Globivalvulia* sp., *Hemigordius* sp., *Reichelina*? sp., *Tubiphytes obscurus* Maslov, *Pseudovermiporella* sp. (Figure 2, Plate I) (TMMOB JMO, 2004).

As mentioned above, late Permian aged unconformable terrestrial-shallow marine (shelf-lagoon) sequence above the Carboniferous-Permian carbonate unit indicates the presence of an autochthonous carbonate sequence on the Sakarya Zone.

Early-middle Carboniferous, middle Carboniferous-Permian and late Permian (Kubergandian-Murgabian) ages obtained are the first paleontological data on autochthonous carbonates under the late Permian unconformity that were not affected by the Variscan orogeny. The middle Carboniferous-Permian radiolarite age from the sequence is also the first pelagic age data for non-blocky carbonates under the late Permian unconformity along the Sakarya Zone.

2.3. Emir Formation

Low-degree metamorphites considered within the Lower Karakaya Complex (Okay and Göncüoğlu, 2004) are described around Ankara by Akyürek et al. (1982, 1984) as clayey, sandy volcanic rocks displaying greenschist metamorphism and named as Emir formation. They are generally gray, greenish brown, grizzly colored, often folded, well foliated and intensely fractured, and therefore, do not show a regular sequence. Folding is distinct in fine-grained and thin bedded parts. Low-degree metamorphites are described as mica-chlorite-quartzschist, sericite-quartzschist, muscovite-quartzschist, graphite schist, phyllite, slate, marble and quartz porphyries cutting them. Early Triassic age data from Emir formation (Akyürek et al., 1982, 1984) which is represented solely by phyllite and graphite schist are problematic since the contact between this formation and Triassic Elmadağ formation is not apparent. Conodonts from similar rocks at south of Bursa (Kozur et al., 2000) and Kozak Mountain (Kaya and Mostler, 1992) yielded early Triassic and middle Triassic ages, respectively. On the contrary, these rocks are

Figure 8- a-b) Murgabian-Dorashamian aged brachiopod- and algae-bearing dark colored dolomitic limestone, limestone (X: 36476545, Y: 4390247).

considered as the base of blocky Triassic (Akyürek et al., 1984; Rojay and Göncüoğlu, 1997) and late Paleozoic basement (Koçyiğit et al., 1991; Altıner and Koçyiğit, 1993).

Emir formation consisting of low-degree metamorphites, starting from the Biga peninsula, can be correlated with epimetamorphites (Bingöl et al., 1975), Nilüfer unit (Okay et al., 1991), Lower Karakaya Complex (Okay and Göncüoğlu, 2004) Yenişehir Metamorphites (Genç and Yılmaz, 1995), Tepeköy Metamorphites (Göncüoğlu et al., 2000), Tokat Metamorphites (Özcan et al., 1980), Ağvanis Group (Okay, 1984). The base of unit is not recognized in the study area and it is in tectonic contact with underlying ophiolite rocks of the İzmir-

Ankara Ocean and overlying Paleozoic carbonate sequence (Figure 2).

3. Discussion

The Sakarya Zone, particularly pre-Liassic basement, has been the focus of a number of studies. The Variscan basement extends along an east-west zone. Okay and Göncüoğlu (2004) described the Karakaya Complex, which is accepted to be pre-Liassic basement, into two parts; Lower Karakaya Complex consisting of deformed, low grade metamorphites and Upper Karakaya Complex composing of clastic, volcaniclastic rocks with blocky Permian limestone. The nature of metamorphism facies and deposition and metamorphism ages of the Lower Karakaya Complex which extends from Biga peninsula to the east of Tokat are still in debate. Since late Paleozoic autochthonous carbonates above the basement are not mentioned until quite recently, Permo-Carboniferous carbonates within the Triassic Upper Karakaya Complex are considered as exotic blocks and based on their fossil fauna they are suggested to belong to Gondwana or Eurasia. In this case, setting and evolution of Paleotethys become crucial.

In the model in which Paleotethys is located at north of Tauride-Anatolides (Göncüoğlu et al., 2000), what are proposed are southerly subduction of ocean beneath Gondwana, occurrence of active continental margin and Permo-Carboniferous carbonate platform on this margin during the Carboniferous and back-arc spreading beginning from Triassic. According to Turhan et al. (2004), Permian autochthon carbonates at south of Geyve resemble both blocky Permian limestones within the Triassic units and Permian carbonates described at Taurus Mountains (Altıner et al., 2000).

However these assertions become conflicting due to following findings:

a) The absence of Variscan events at Tauride-Anatolides,

b) The fact that Triassic deposits with Permo-Carboniferous limestone blocks are found only in the Sakarya Zone in the area from Biga peninsula at west to Tokat at the east and they are contiguous to the İzmir-Ankara Suture,

c) The presence of pelagic deposits (Önder et al., 1987; Bragin et al., 2002) associated with middle Jurassic ophiolites in the Küre ophiolites that are considered as Paleotethys (Yılmaz and Tüysüz, 1984), and Late Triassic fossil ages in the İzmir-Ankara-Erzincan Zone (İAEZ) which is accepted as northern branch of Neotethys and thought to be opened in Liassic (Uğuz et al., 1999; Tekin et al., 2002), the presence of middle-late Triassic volcanic seamounts of OIB character, late Permian metamorphism age in basic rocks of oceanic crust within the Ankara mélange (Sarıfakıoğlu et al., 2011, 2014) and the presence of Devonian aged radiolarian-bearing chert slices (Okay et al., 2011) within the Triassic Orhanlar greywacke that is adjacent to the suture. Okay (2004) also previously stated that Tauride-Anatolide block and Sakarya Zone that comprises the southern margin of Pontides did not amalgamate until Tertiary.

Tekeli (1981), Pickett et al. (1995) and Okay (2000) who suggest northerly subduction of Paleotethys under the Sakarya continent and describe the Lower Karakaya Complex as a subduction accretionary complex of late Paleozoic-Triassic age. With a similar approach, Kozur (1999) proposes Triassic back-arc basin formation that was opened as a result of northerly subduction of Paleotethys beneath the Sakarya continent.

The pre-Liassic basement of the Sakarya Zone from Biga peninsula to the Eastern Black Sea is composed of metamorphic, magmatic, ophiolite and carbonate rocks of different age. This basement which was affected by the Variscan orogeny from west to eastern Black Sea is known as Kazdağ massif in the Biga peninsula, Söğüt Metamorphites in the central Sakarya region and Pulur Metamorphites at the east. As an autochthon late Paleozoic carbonate sequence above such basement, Demirözü Permo-Carboniferous in the Pulur region (Akdeniz, 1988), late Permian in the central Sakarya region (Saner, 1977) and early-late Permian (Turhan et al., 2004; Okuyucu et al., 2010) shallow marine clastics and carbonates in Geyve are mentioned. Within the Upper Karakaya Complex, exotic blocks of neritic limestones of Carboniferous age are exposed around Tokat (Özcan et al., 1980), those of Silurian and early Devonian age are in Amasya (Alp, 1972; Çapkınoğlu and Bektaş, 1999) and those of early-middle Carboniferous age are found in Ankara, Bursa and Biga peninsula (Akyürek et al., 1984; Duru et al., 2012; Kanar et al., 2013). The reason why these blocks within Triassic deposits along the Sakarya Zone are not affected by the Variscan orogeny is not discussed in detail. We believed that these rocks are derived from Gondwana and before the upper Permian they amalgamated to the Sakarya Zone at north. Okuyucu and Göncüoğlu (2010) also noticed late Carboniferous-middle Permian neritic carbonates unconformably overlying a crystalline complex at south of Geyve. According to these authors, Fusulinid fauna in this time interval are comparable to those in south Urals, central Asia, Caspian basin, Moscow and Carnic Alps and faunal connection with Taurid-Anatolid platform was only possible after the Midian transgression.

There are two different metamorphic units in tectonic contact at pre-Liassic basement along the Sakarya Zone. The period of time these units were amalgamated is one of the main concerns of present study. They comprise Variscan basement at north composing of gneiss, amphibolite and marble cutting by Devonian-Carboniferous granitoids and low-degree metamorphites at south composing of metabasite, phyllite, marble and chert and serpantinite slices. In the central Sakarya region, Göncüoğlu et al. (2000) recognized Söğüt and Tepeköy metamorphites and a Triassic unconformity above them. In the Pulur massif, the Cenci unit representing the Variscan basement at north and the low-degree metamorphic rocks of Doğankavak unit at south are noticeable (Topuz et al., 2004*a, b*). Ar/Ar data on fengite minerals from the Doğankavak unit yielded 260 Ma and these units and tectonic contact among them are unconformably covered with Liassic deposits (Topuz et al., 2004*b*). Keskin et al. (1989) recognized Devonian-early Carboniferous carbonates and ophiolitic rock slices within the low grade metamorphites of the Pulur massif. Data particularly from the Pulur metamorphites support the idea that late Paleozoic carbonate basement in the area is amalgamated to metamorphites at the north before the Permian.

The low-degree late Permian metamorphism (Topuz et al., 2004*b*), the overlying late Permian unconformity (Yılmaz et al., 1997) and the presence of pebbles of these metamorphites at the base of late Permian (this study) are in contradiction with Early Triassic foraminifera age around Ankara (Akyürek et al., 1984) and Triassic conodont ages from Bursa and Kozak Mountain (Kaya and Mostler, 1992; Kozur et al., 2000). On the one hand, different metamorphic character of these metamorphites, their late Permian (Topuz et al., 2004b) and late Triassic metamorphism ages (Ar/Ar ages of 205-203 Ma, fengite and amphibole from eclogite: Okay and Monie, 1997; metabasites: Okay et al., 2002), geochemistry of metabasites (ocean island/plateau, Okay, 2000; Yalınız and Göncüoğlu, 2002) and the presence of Devonian, Carboniferous and Permian pelagic blocks within the Triassic units can only be explained by active continental margin character of southern Sakarya Zone during the Permo-Triassic.

As a result of this study it is proposed that Silurian-Permian neritic carbonates within the blocky Triassic along the southern margin of the Sakarya Zone represent northern margin of the Tauride-Anatolide Block rather than Eurasia and following the middle Carboniferous they were rapidly deepened, rifted and drifted northerly within the Tethyan ocean and became shallower before the upper Permian and then amalgamated to the active margin at south of Sakarya continent (Figure 9a, b, c). Following a terrestrial period in Murgabian, the region together with Carboniferous Variscan basement was transgressively overlain by late Permian neritic limestones (Figure 9d). During the Triassic period, carbonate and metamorphic exotic blocks must have been transported from rift margins to the basin which was opened on the basement by tectonism (Figure 9e).

According to Adamia et al. (1995), eastern Pontides and Transcaucasus represented the active northern margin of northern Tethys during the Paleozoic-early Cenozoic. Similarly, Okay (2011) also states that upper tectonic slices (Variscan basement) belongs to the active margin of Eurasia whereas the lower slice (Lower Karakaya Complex) belongs to the Paleotethys and amalgamated to the north during the Permo-Triassic.

New fossil data, metamorphic age and geochemical affinity of volcanics in low grade metamorphics (Lower Karakaya Complex) and similar autochthon-carbonate sequences to be found along the Sakarya Zone will greatly contribute to geodynamic evolution of the region.

4. Results

1) In the Sakarya Zone the presence of an autochthon sequence composing of late Paleozoic neritic and pelagic carbonates was described for the first time. Neritic carbonates in lower parts of the late Paleozoic sequence yielded foraminifera ages of Visian-Serpuhovian (Early Carboniferous), Bashkirian- Moskovian (middle Carboniferous),

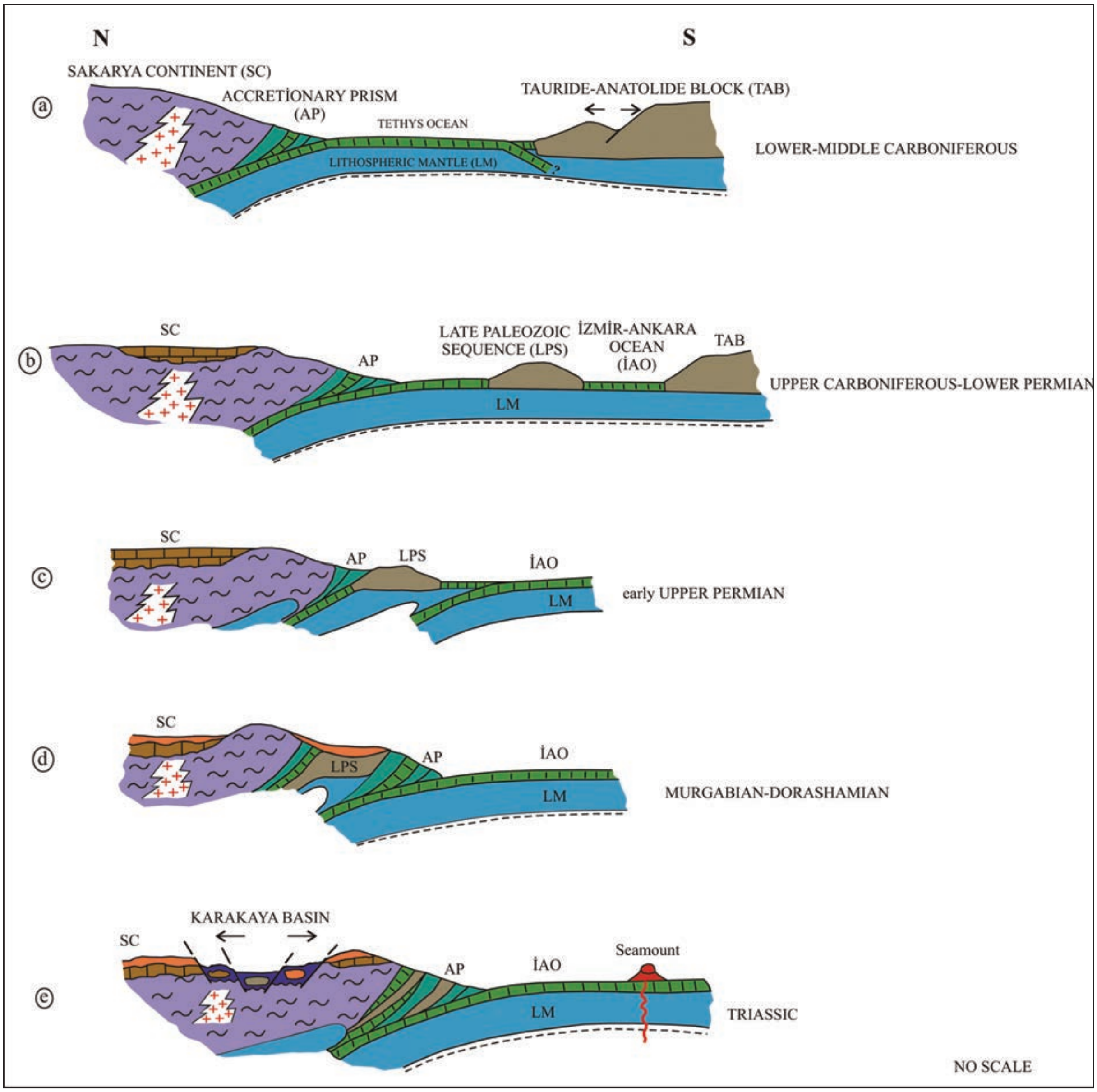

Figure 9- Schematic cross sections showing geologic evolution of the region during the early Carboniferous-Triassic interval.

radiolarites from pelagic micritic limestones comprising the upper parts yielded middle Carboniferous-Permian age and neritic carbonates topmost gave Kubergandian-Murgabian age.

2) Late Carboniferous-early Permian interval in the area is represented by pelagic deposits while carbonates on the Variscan basement along the Sakarya Zone are entirely represented by neritic carbonates.

3) In the Ankara region late Permian unconformity was recognized for the first time. The sequence unconformably overlying the basement rocks is composed of conglomerate, quartzitic sandstone, dolomitic limestones and limestone. Fossils collected from carbonates yielded Murgabian, Midian and Midian-Dorashamian stages of late Permian.

4) The presence of fossiliferous late Paleozoic carbonates indicates that basement was not affected by the Variscan orogeny that is observed along the Sakarya Zone.

5) The presence of middle Carboniferous-Permian

radiolarian-bearing pelagic carbonates within the basement rocks might show that the neritic environment was rapidly deepened and rifted.

6) The presence of rock fragments from the late Paleozoic basement and Emir formation within the late Permian conglomerates necessitates their amalgamation before the late Permian. This might indicate that Emir Formation was formed as early as Permian which is previously accepted as lower Triassic.

7) The presence of late Permian rocks of the Sakarya Zone above the Variscan basement and late Paleozoic sequence explained in this article might imply that fossiliferous late Paleozoic sequence northerly amalgamated to Eurasia margin before the late Permian and the late Paleozoic exotic blocks which are reported to occur as blocks within the Triassic units were derived from this basement which is believed to be originated from Gondwana.

8) The late Paleozoic carbonate basement, late Permian cover and the Paleozoic ophiolites among the tectonic units reported in the literature should be included to pre-Liassic basement of the Sakarya Zone.

9) As a result of Lutetian deformation, the late Permian cover and its basement have a tectonic setting above the İzmir-Ankara oceanic units at the south.

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PLATE I

PLATE I

1, 2. *Pachysphaerina* sp., Sample No: 06MS-22

3. *Mediocris* sp., Sample No: 06MS-22,

4. *Ozawainella* sp., Sample No: 11MS-01,

5. *Eostaffella* sp.**,** Sample No: 11MS-01,

6. *Lasiodiscus* sp., Sample No: 11MS-02,

7. *Neofusulinella* sp., Sample No: 14MS-08,

8. *Minojapanella* sp., Sample No: 14MS-08,

9. *Neoschwagerina* sp., Sample No: 14MS-9B,

10. *Agathammina* sp., Sample No: 14MS-9A,

11. *Tetrataxis* sp., Sample No: 14MS-9A,

12. *Globivalvulina* sp., Sample No: 14MS-10B,

13. *Climacammina* sp., Sample No: 14MS-10A,

14, 15. *Hemigordiopsis* sp., Sample No: 14MS-9A,

16. *Dagmarita chanakchiensis* Reitlinger, Sample No: 06MS-18E,

17-18. *Pachyphloia* sp., Sample No: 11MS-27, 14MS-10A,

19, 20. *Rectostipulina quadrata* Jenny-Deshusses, Sample No: 06MS-18B, 06MS-18B,

21, 22. *Frondina permica* Sellier de Civrieux and Dessauvagie, Sample No: 14MS-12, 06MS-19C,

23. *Charliella* sp., Sample No: 11MS-27,

24. *Multidiscus* sp., Sample No: 06MS-18E


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