DISCOVERY OF THE OLDEST (UPPER LADINIAN TO MIDDLE CARNIAN) RADIOLARIAN ASSEMBLAGES FROM THE BORNOVA FLYSCH ZONE IN WESTERN TURKEY: IMPLICATIONS FOR THE EVOLUTION OF THE NEOTETHYAN IZMIR-ANKARA OCEAN

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ABSTRACT

Diverse upper Ladinian to middle Carnian radiolarian faunas have been obtained from different ribbon cherts blocks and tectonic slices of the Izmir-Ankara Suture Complex and the marginal sediments of the Tauride-Anatolide platform within the Bornova Flysch Zone, western Turkey.

Four isolated samples with late Ladinian, early Carnian, late early Carnian, early middle Carnian ages and one continuous section with late Ladinian to late early Carnian age were considered. As a result of taxonomic studies, sixty-six taxa from different families were defined from these time intervals, definition of sixteen taxa remained in open nomenclature were given and one new species (*Pseudostylosphaera mostleri*) was determined.

The radiolarian ages obtained indicate an upper Ladinian to upper lower Carnian deepening of the Middle Triassic Tauride-Anatolide carbonate platform. Combined with regional geological data this event is interpreted to reflect the initial opening of the Neotethyan Izmir-Ankara oceanic seaway.

INTRODUCTION

The eastern Mediterranean area, including Anatolia, is the site of several Tethyan suture belts (for a recent review see Robertson, 2004). The most prominent and relatively well studied one is the Neotethyan (sensu Sengor and Yılmaz, 1981) Izmir-Ankara Suture Belt (IASB). IASB in NW Anatolia is an almost 200 km wide E-W trending belt between the Sakarya Composite Terrane in the N (Göncüoglu et al., 1996) and the Tauride-Anatolide Platform (TAP) in the S (Fig. 1, inset map). The Sakarya Composite Terrane includes in its pre-Liassic basement the remnants of a Paleotethyan subduction-accretion complex known as the Karakaya Complex (Okay and Göncüoglu, 2004). It is univocally accepted that it represents the remnants of a Triassic oceanic branch (e.g., Stampfli, 2000). In NW Anatolia, the Karakaya Complex locally thrusts over the rock-units of the IASB (Fig. 1).

From top to bottom, IASB is represented by a stack of S-vergent nappes or tectonic slices consisting of intact or dismembered ophiolites, assemblages of the subduction-accretion prism with or without high pressure-low temperature metamorphism (ophiolitic mélanges), olistostromes of the fold-and thrust belt and finally the continental margin units of the TAP (Göncüoglu et al., 1992; 2000; Okay et al., 1996; Göncüoglu, 2000). The mélanges are internally chaotic units mainly including oceanic lithologies (e.g., Haybi Mélange, in Oman, Glennie et al., 1973) and may be of tectonic or sedimentary origin (e.g., Gansser, 1974). The olistostromes, on the other hand, are mainly of sedimentary origin, and commonly include blocks or olistoliths of ophiolites and mélanges. However, they may also comprise pieces of the passive continental margin (NE Oman, e.g., Hauser et al., 2002). The presence of these type of blocks and/or tectonic slivers is not restricted to the mélanges but may also occur in the “flysch basins” that developed on the passive platform margin in front of the advancing ophiolitic nappes (e.g., Lycian nappes in SW Anatolia; Collins and Robertson, 1998). Detail study of these blocks is of crucial importance to decipher the geological evolution of the continental margin as the well as the initial stages of rifting and opening of oceanic sea-ways. This is especially the case in the IASB, where the edge of the platform margin was overridden for several hundred kilometers by the allochthonous mélange complexes (Göncüoglu et al., 2000).

Within the framework of two integrated projects, the authors studied the geochemistry of the volcanic rocks (Yalınız and Göncüoglu, 2005) and the radiolarian biostratigraphy of the blocks or tectonic slices of radiolarian cherts (Tekin et al., 2006), in some cases associated with pillow lavas, in others with platform margin sediments within the Bornova Flysch Zone (BFZ) in NW Anatolia.

In this study, we present the oldest radiolarian data ranging from late Ladinian to early middle Carnian obtained from the ribbon-cherts within the BFZ and we evaluate this data in relation to the opening of the Izmir-Ankara Ocean. The mature stage of oceanic development of the Izmir-Ankara branch of Neotethys was preliminarily interpreted in Göncüoglu et al. (2006a; 2006b). Detailed data, however, related to the Jurassic and Cretaceous radiolarian ages of the oceanic units within the IASB will be presented in further studies.

GEOLOGICAL FRAMEWORK

BFZ is part of the Izmir-Ankara Suture Belt and represents the western extension of the Kutahya-Bolkardag Belt (Ozcan et al., 1989; Göncüoglu et al., 1992), which includes several imbricated tectonic units composed of variably metamorphosed ophiolites and accretionary mélange complexes of the Izmir-Ankara Ocean as well as the TAP margin. Sandwiched between them are olistostromes that formed in front of the ophiolitic nappes during their em-

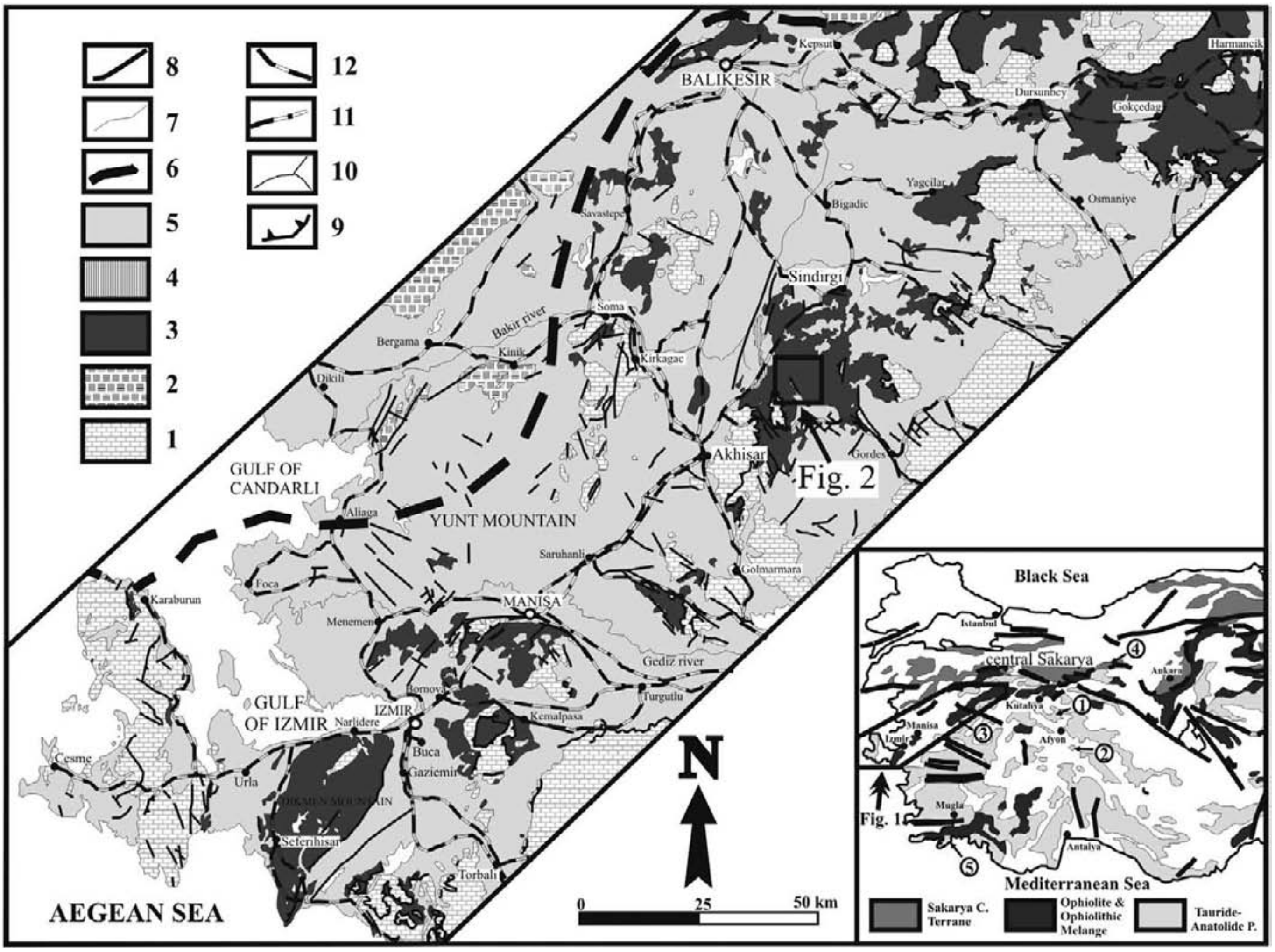

Fig. 1 - Simplified geological map of the Bornova Flysch Zone (simplified after Konak, 2002). 1- Paleozoic-Mesozoic carbonate sequences of the Tauride-Anatolide platform; 2- Karakaya complex; 3- Ophiolite and ophiolitic mélange complexes of the Izmir-Ankara Suture Belt; 4- Eocene carbonate and clastic sequences; 5- Post-Eocene rock units; 6- Boundary between the Sakarya and Tauride-Anatolide units; 7- Stratigraphic contact; 8- Fault; 9- Thrust; 10- Drainage system; 11- Railway; 12- Highway. The inset map (Göncüoglu et al., 1996) shows the distribution of Alpine terranes, the location of the Bornova Flysch Zone and the locations of stratigraphic columnar sections on Fig.7).

placement onto the TAP margin (Göncüoglu et al., 1996; 2003).

BFZ was initially named by Okay and Siyako (1993) to describe a flysch basin, formed along a transform plate boundary (Soma transform fault) within the Izmir-Ankara Ocean. Erdogan et al. (1988), Erdogan (1990a; 1990b) and Erdogan and Gungor (1992) used the name "Bornova Mélange" for this unit and suggested that the rock units in the area represent remnants of a short-lived (Maastrichtian-Danian) oceanic basin within the TAP.

Representatives of the internal TAP occur mainly south of the BFZ as huge allochthonous bodies (Fig. 1) dominated by recrystallized limestones and dolomites (Akdeniz et al., 1980; Konak et al., 1980; Akdeniz, 1985; Konak, 2002). Age data from the relatively less metamorphosed successions to the NE (Ozcan et al., 1989) and SW (Erdogan et al., 1988) suggests that Early Triassic continental clastics rest with an angular unconformity on a Permian and older basement and the Middle Triassic is characterized by shelf type carbonates. Kaya et al. (1995) have shown the presence of pink micritic limestones with intra-formational conglomerates of mass-flow origin above the shelf-carbonates, which have yielded upper Ladinian - lower Carnian conodonts. This succession was interpreted by Göncüoglu et al. (2003) as reflecting the final break-up stage further to the north of the Tauride-Anatolide platform giving way to the opening of the Izmir-Ankara Ocean, as also deduced from the radiolarian ages in the present study. In the internal platform units within the BFZ follows upwards an alternation of dark gray, medium-bedded brecciated algal limestones and dolomites that grade into a very thick sequence of black to dark gray thin to medium-bedded limestones and gray dolomite. The fossil content of this part of the succession indicates a depositional age from Norian to Middle Liassic. This renewed shelf carbonate deposition is ascribed to the restoration of the platform conditions in the internal platform that lasted until Late Cretaceous. From there on the platform was submerged in front of the nappes derived from the Izmir-Ankara accretionary prism and emplaced to the south onto the TAP margin. The bulk of the "flysch" within the BFZ (Figs. 1, 2) formed in peripheral foreland basins and includes blocks/olistoliths of ophiolites, accretionary prism and platform margin rocks, including continental slope and thinned continental crust. The size of the blocks varies from pebble to boulder size to several km (Figs. 3, 4). The age determinations in radiolarian cherts mainly come from this unit.

Towards N in the BFZ, the amount of olistostromal matrix diminishes and coherent blocks of mélange and ophiolites dominate over "flysch" sediments. Moreover, the single lithologies such as pillowed and massive volcanic rocks, radiolarian cherts, pelagic limestones, blueschists, gabbros, serpentinites, recrystallized limestones, all of which were components of the "flysch", are in tectonic contact with each other. The radiolarian cherts in this part are mainly recrystallized or extremely deformed and only yielded ghosts of radiolarians. The northernmost (and uppermost) units of the BFZ (Fig. 1) are huge blocks of serpentinized ultramafic rocks, representing the Izmir-Ankara ophiolites.

The age of the "flysch" is Campanian to Danian according to the fossil findings within the olistostromal sediments (Kaya, 1972; Konuk, 1977). The oldest sediments unconformably overlying the BFZ units are Ilerdian in age. These are lagoonal carbonates and grade into Lower Eocene shallow marine carbonates.

SAMPLE LOCATIONS AND LITHOLOGICAL DESCRIPTIONS

The study area is located along the BFZ, which forms a NE-SW trending corridor between the Aegean Sea and the town of Harmancık (Fig. 1). In this corridor, between the Akhisar and Sindirgi towns, rock units associated to the Upper Cretaceous sedimentary mélange are widely exposed. Four isolated samples from the radiolarian cherts in small blocks included within the mélange, and a succession of 28 samples derived from a mega-block with a continuous siliciclastic succession (Komurcu section) yielded upper Ladinian to middle Carnian radiolarians (Figs. 2, 3). The lithological characteristics of these samples are described below;

1. Sample 04-MAN-112: It comes from a locality situated ca 300 m south of the Sagrakci village, its UTM coordinates are 589^{730} Easting, 328^{125} Northing (Fig. 2). In this area, small blocks of green volcanics, gray limestones, red bedded cherts and gray sandstones are embedded in a highly sheared matrix composed of sandstone and conglomerate. Sample O4-MAN-112 comes from a small block consisting of thin-bedded, red to purple coloured radiolarian chert and mudstone. Radiolarian chert is the dominant lithology.

2. The Komurcu section (samples 04-MAN-126 to O4-MAN-150): At the southeast end of the study area, NW-SE trending tectonic slices of different composition (pillow basalts, cherts, serpentinites and pelagic limestones) are exposed on the road between the Komurcu and Hanpaşa villages (Fig. 2). One of the slices in the mélange includes moderately to well preserved radiolarians and we collected 28 samples from a 29 meter thick section (Figs. 3, 4.1). The name of the section derives from the nearest Komurcu village (Fig. 2). The UTM coordinates of the Komurcu section are (base) 592^{725} Easting, 322^{125} Northing and (top) 592^{800} Easting, 322^{175} Northing.

The basal part of this section is represented by an alternation of thin-bedded, purple-red-brown coloured chert and mudstone (Figs. 3, 4.2). Radiolarian cherts are the dominant lithology in this 11 meter thick section and 18 samples (from samples O4-MAN-136 to O4-MAN-152) were taken from this part.

Overlying strata in the section are characterized by an alternation of green, purple-red, and brown coloured, thin to medium-bedded mudstone and chert (Fig. 3). Compared to the basal part, the amount of angular clasts of volcanic rocks

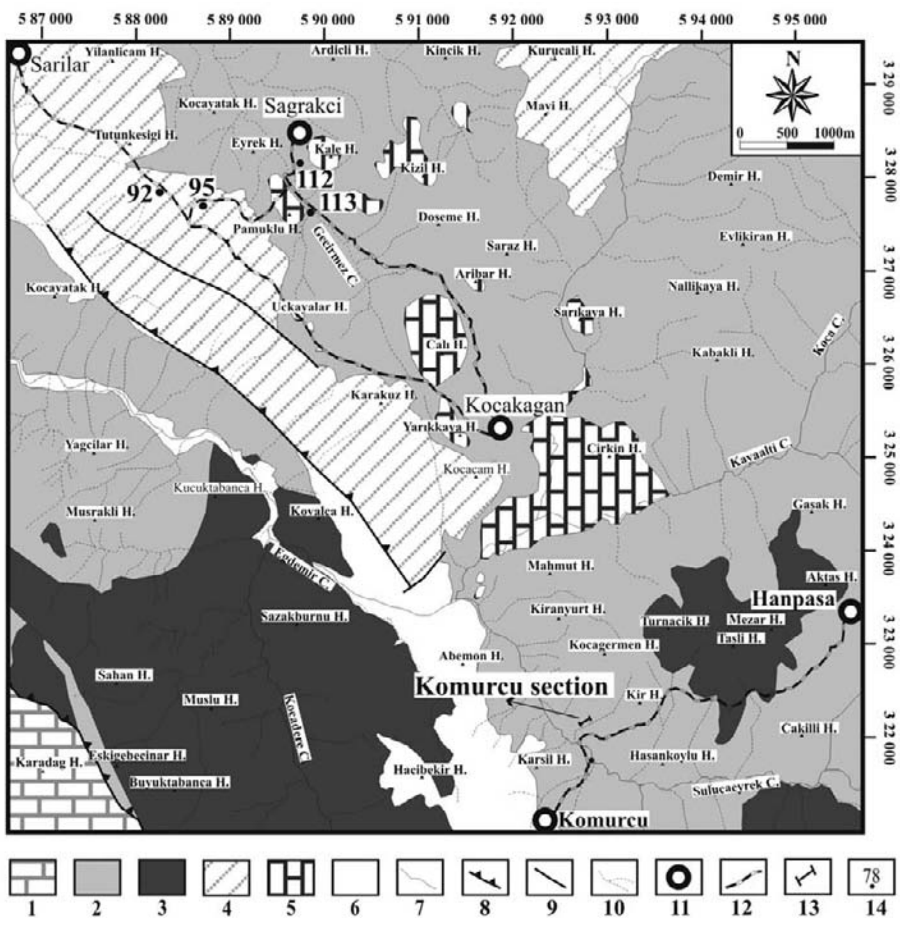

Fig. 2 - Geological map of the study area (after Konak et al., 1980; Akdeniz, 1985). 1- Paleozoic-Mesozoic carbonate sequence of the Tauride-Anatolide platform; 2- Undifferentiated mélange; 3- Mafic and ultramafic slices in mélange; 4- Radiolarite-pelagic limestone slices in mélange; 5- Recrystallized limestone slices in mélange; 6- Post-Mesozoic rock units; 7- Stratigraphic contact; 8- Thrust; 9- Fault; 10- Drainage system; 11- Secondary roads; 12- Main roads; 13- Sections; 14- Locations of the individual samples.

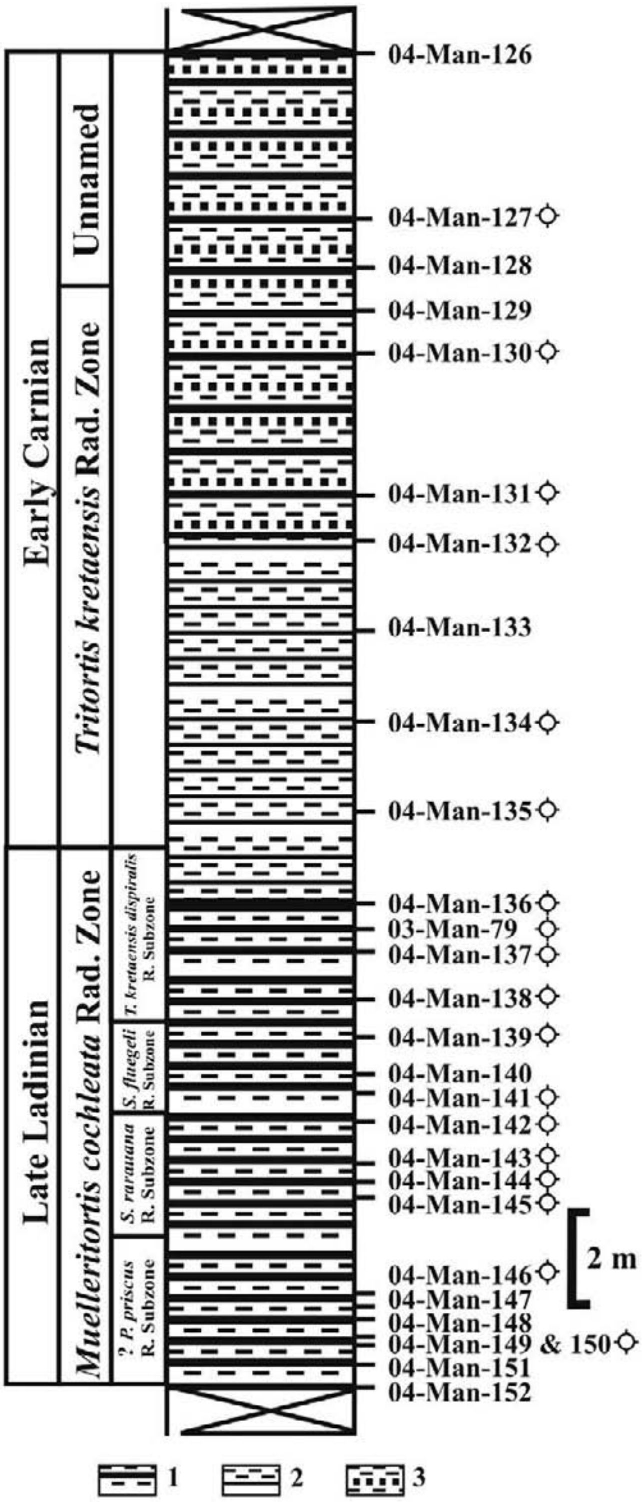

Fig. 3 - Log of the Komurcu section and sampling levels. 1- Alternation of thin-bedded, purple-red-brown coloured chert and mudstone; 2- Alternation of green, purple-red, and brown coloured, thin to medium-bedded mudstone and chert; 3- Alternation of green to brown coloured, thin to medium-bedded sandstone and mudstone with some chert interbeds.

increases in this part, and due to clastic influx, the amount of radiolarians obtained from this part slightly decreases. Three samples (O4-MAN-133, 134 and 135) derive from this 7 meter thick part.

An alternation of green to brown coloured, thin to medium-bedded sandstone and mudstone with some chert interbeds are the characteristics lithology of the upper part of the Komurcu section. Seven samples (from samples O4-MAN-126 to O4-MAN-132) were taken from the rare chert interbeds within the 11 meter thick sandstone and mudstone alternation (Figs. 3, 4.3, 4.4).

3. Sample 04-MAN-113: This sample was taken 700 meters south of the Sagrakcı village on the road between the Sagrakcı and Kocakagan villages (Fig. 2). Its UTM coordinates are 589^{815} Easting, 327^{587} Northing. There are small blocks of volcanics, pelagic limestones and thick-bedded recrystallized limestones within a clastic matrix in this area. Sample 04-MAN-113 was taken from the radiolarian cherts of a block including an alternation of green-gray coloured, thin-bedded cherts and mudstones.

4. Sample 04-MAN-92: This sample was taken two km southeast of the Sarilar village, on the road of Sarilar to Kocakagan villages (Fig. 2). Its UTM coordinates are 588^{435} Easting, 327^{793} Northing. This sample derives from red to green cherts of a small block in the mélange. It is composed of a folded, thin to medium-bedded, red to green coloured alternation of cherts and mudstones (Fig. 4.5).

5. Sample 04-MAN-95: The sampling point is located on the road between the Sarilar and Sagrakcı villages. Its UTM coordinates are 588^{640} Easting, 327^{732} Northing (Fig. 2). This sample was obtained from the green cherts of a block of a green to brown coloured alternation of thin-bedded chert and mudstone (Fig. 4.6).

METHOD AND REPOSITORY

All chert samples from BFZ were processed by techniques suggested by Dumitrica (1970) and Pessagno and Newport (1972) using diluted (5-10%) hydrofluoric acid. Holotype and all materials are stored at the Paleontology Laboratory of the Geological Engineering Department, Hacettepe University, Ankara (Turkey).

RADIOLARIAN BIOSTRATIGRAHY

The following 5 different radiolarian faunas of late Ladinian to middle Carnian ages were obtained;

1. Sample 04-MAN-112: This sample includes characteristic upper Ladinian radiolarians: *Spongostylus tortilis* Kozur and Mostler (Plate 1.3), *Praeorbiculiformella gazipasaensis* (Tekin) (Plate 1.17), *Paurinella latispinosa* Kozur and Mostler (Plate 2.14), *Pseudostylosphaera gracilis* Kozur and Mock (Plate 2.20), *Muelleritortis cochleata* (Nakaseko and Nishimura) s. l. (Plate 3.13), *Annulotriassocampe baldii* Kozur (Plate 3.26), *A. multisegmantatus* Tekin (Plate 4.1), *A. sulovensis* (Kozur and Mock) (Plate 4.2) and *Triassocampe scalaris* Dumitrica, Kozur and Mostler s. l. (Plate 4.8).

The radiolarian fauna of this sample corresponds to the "*Muelleritortis cochleata* Zone" suggested by Kozur and Mostler (1994) indicative of the late Ladinian, for the occurrence of nominal species (Fig. 5). According to Kozur (2003), the last subzone of the "*Muelleritortis cochleata* zone" is the *Tritortis kretaensis dispiralis* and the lower boundary of this subzone is marked by the first appearance of the nominal taxon. Due to the absence of *Tritortis kretaensis dispiralis* (Bragin), it possible that the age of this sample does not include the latest Ladinian (Fig. 5). Due to moderate preservation, we could not obtain the associated Oertlispongidae fauna (e. g. *Pterospongus priscus*, *Spon-*

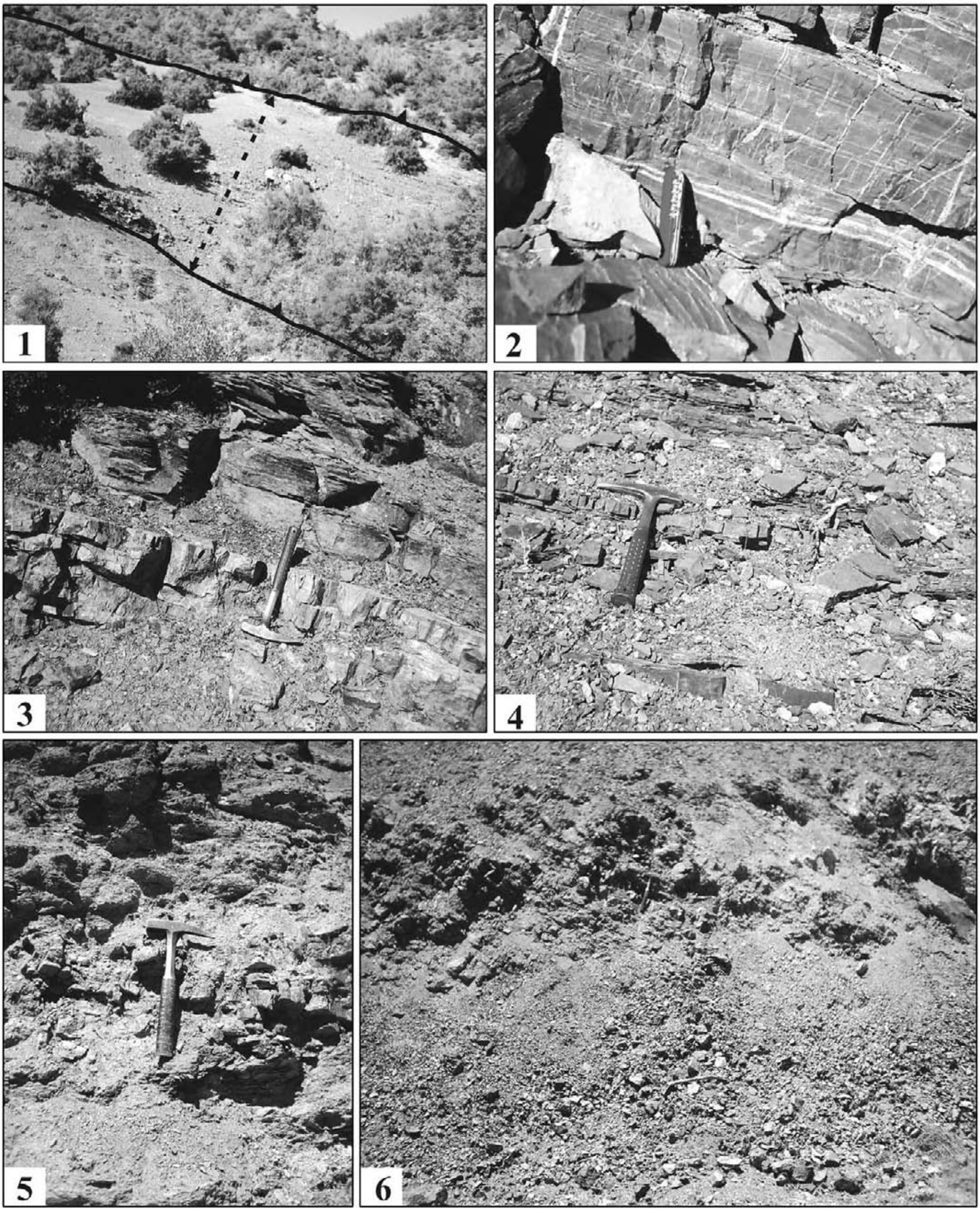

Fig. 4 - Field occurrences of the studied units. 1-4- Photographs from the Komurcu section. 1- General view of the section, dash line indicates its place; 2- Detail photograph showing the alternation of thin-bedded, purple-red-brown coloured chert and mudstone at the base of the section; 3- Detail photograph of the lithologies consisting of green to brown coloured, thin to medium-bedded sandstone and mudstone with some chert interbeds at the top of the section; 4- Photograph showing details of green to brown coloured sandstone and mudstone alternation at the top of the Komurcu section; 5- Photograph showing the folded, thin to medium-bedded, red to green chert and mudstone alternation where sample 04-MAN-92 was collected; 6- Photograph showing the green to brown coloured, thin-bedded chert and mudstone alternation where sample 04-MAN-95 was taken.

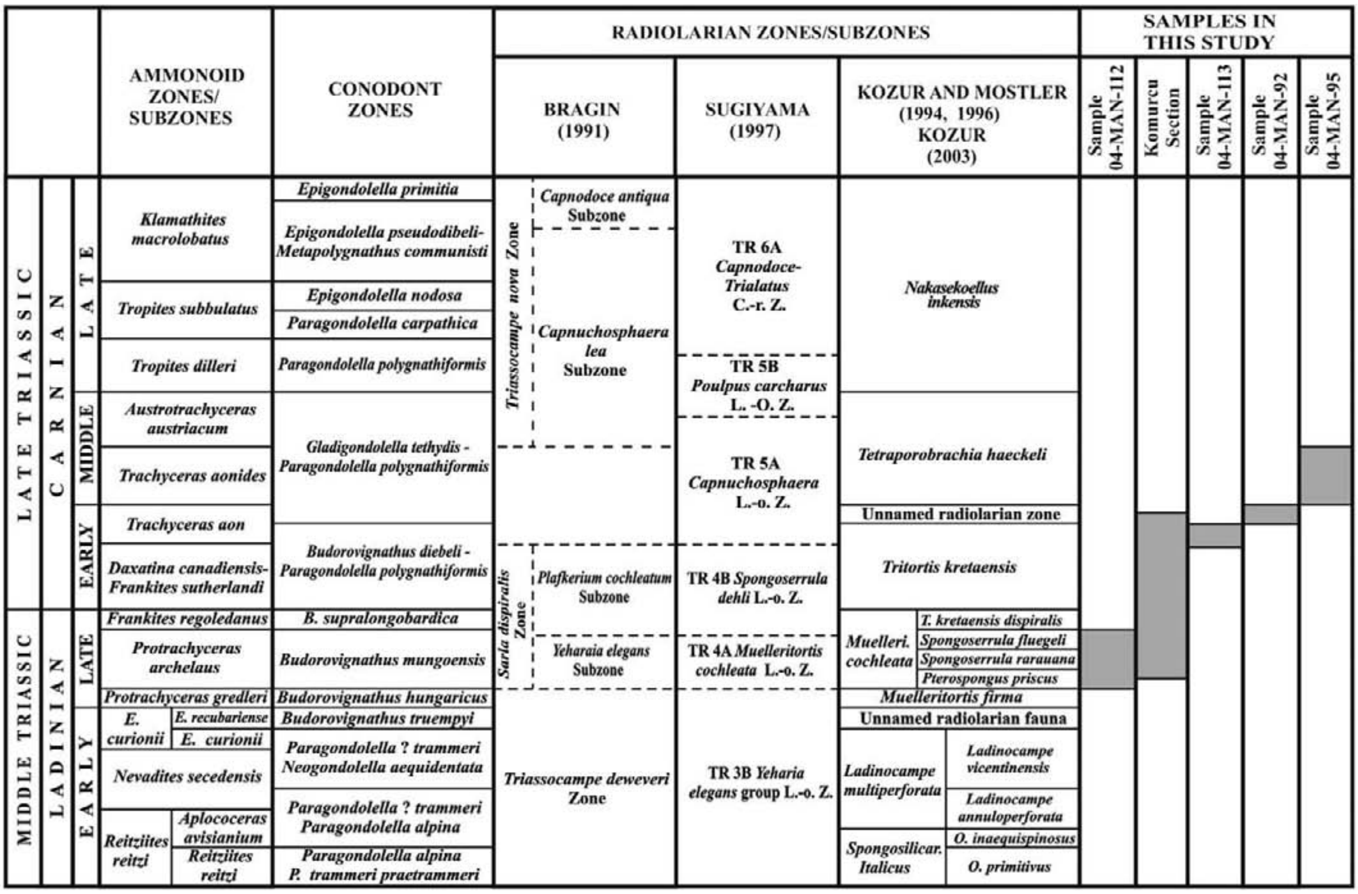

Fig. 5 - Integrated Ammonoid, Conodont (after Kozur, 2003) and radiolarian zonations (after Bragin, 1991; Kozur and Mostler, 1994; 1996; Sugiyama, 1997; Kozur, 2003) of the Ladinian and Carnian. Bars in the figure indicate the stratigraphic positions of samples from this study.

goserrula rarauana, Spongoserrula fluegeli). Accordingly, we could not obtain a more precise age with the comparison of the the zonations of Kozur and Mostler (1994) and Kozur (2003) (Fig. 5).

Most of the taxa in this assemblage are well known from the west Carpathians (Kozur and Mostler, 1981), Hungary (Kozur and Mostler, 1994), central Japan (Sugiyama, 1997) and southern Turkey (Tekin, 1999). Based on the occurrence of *Muelleritortis cochleata* and associated fauna, the age is late Ladinian. This fauna is also completely assigned to the *Muelleritortis cochleata* lowest occurrence zone of Sugiyama (1997) and partly to the "*Yeharia elegans* subzone of *Sarla dispiralis* Zone" by Bragin (1991).

2. The Komurcu section (04-MAN-126 to O4-MAN-150): The occurrence chart of upper Ladinian - lower Carnian radiolarians obtained from the eighteen productive samples of the Komurcu section and their vertical distributions are shown in Fig. 6. SEM images of taxa obtained from this section are also shown in Pl. 1, 2, 3 and 4.

A productive sample (04-MAN-150) from the basal part of the Komurcu section includes *Karnospongella* sp. A, *Hexacatoma* sp. aff. *H. elegantissima*, *Triassocampe scalaris*, *Muelleritortis cochleata* and *Annulotriassocampe sulovensis*. No *Muelleritortis firma* (zone taxon for the basal part of the late Ladinian) nor *Pterospongus priscus* (zone taxon for the lowest subzone of the *Muelleritortis cochleata* zone in late Ladinian) are present in this sample. Higher in the section (3 meters above sample 04-MAN-150), first *Spongoserrula rarauana* (zone taxon of the second subzone of the *Muelleritortis cochleata* Zone) appears in sample 04-MAN-145. Due to these facts, it can be suggested that this part of the section probably corresponds to the *Pterospongus priscus* subzone of the *Muelleritortis cochleata* Zone (Kozur and Mostler, 1994, 1996; Kozur, 2003; Figs. 3, 5, 6).

As it is explained above, *Spongoserrula rarauana* appears for the first time together with *Muelleritortis cochleata, Pseudostylosphaera inaequata* and *P. nazarovi* in sample 04-MAN-145. This assemblage is indicative of the *Spongoserrula rarauana* subzone of the *Muelleritortis cochleata* Zone, as defined by Kozur and Mostler (1996) and Kozur (2003).

Sample 04-MAN-141 has a different fauna with respect to the samples located in the basal part of the section; many taxa from Oertlispongidae, including *Spongoserrula fluegeli* appear for the first time in this sample (Figs. 5, 6). Due to this assemblage, the interval between samples 04-MAN-141 and 04-MAN-139 corresponds to the third subzone (*Spongoserrula fluegeli*) of the *Muelleritortis cochleata* Zone. The basal to central part (from sample 04-MAN-152 to sample 04-MAN-139) of the section corresponds to the "TR4 A *Muelleritortis cochleata* Lowest Occurrence Zone" of Sugiyama (1997) and partly to the "*Yeharaia elegans* Subzone of the *Sarla dispiralis* Zone" of Bragin (1991) (Figs. 5, 6). First appearance of *Nodotetrasphaera cive* in sample 04-MAN-141 also reveals that this level corresponds to the *Spongoserrula fluegeli* Subzone of the *Muelleritortis cochleata* Zone (Kozur and Mostler, 2006).

FAD of *Tritortis kretaensis dispiralis* is at sample 04-MAN-138 together with *Canoptum* ? sp. A, *Paurinella latispinosa* and *Canoptum cucurbita* (Sugiyama). Together with the associated fauna, the interval between samples 04-MAN-138 to 04-MAN-136 corresponds to the fourth subzone (*Tritortis kretaensis dispiralis*) of the *Muelleritortis cochleata* Zone indicating a latest Ladinian age (Kozur and Mostler, 1994; 1996; Kozur, 2003).

Dominance of *Tritortis kretaensis* against *Muelleritortis cochleata* appears for the first time in sample 04-MAN-135 and this is the baseline of the *Tritortis kretaensis* Zone corresponding to the base of Carnian time according to Kozur and Mostler (1994). Both *Tritortis kretaensis dispiralis* and *Tritortis kretaensis kretaensis* were found for the last time in sample 04-MAN-130, therefore, we can conclude that the

SERIES	MIDDLE TRIASSIC												LATE TRIASSIC					
STAGES	late Ladinian												early Carnian					
RADIOLARIAN ZONES	*Muelleritortis cochleata* R. Z.												*T. kretaensis* R. Z.					Un.
RADIOLARIAN SUBZONES	? *P. p.* R. S.		*S. rarauana* Rad. Subz.				*S. fluegeli* R. S.		*T. kretaensis dispiralis* R. S.									
	04-MAN-150	04-MAN-146	04-MAN-145	04-MAN-144	04-MAN-143	04-MAN-142	04-MAN-141	04-MAN-139	04-MAN-138	04-MAN-137	03-MAN-79	04-MAN-136	04-MAN-135	04-MAN-134	04-MAN-132	04-MAN-131	04-MAN-130	04-MAN-127
***Karnospongella* sp. A**	+																	
***Hexacatoma* sp. aff. *H. elegantissima* Tekin and Mostler**	+																	
***Triassocampe scalaris* Dumitrica, Kozur and Mostler s. l.**	+		+			+			+									
***Muelleritortis cochleata* (Nakaseko and Nishimura) s. l.**	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			
***Annulotriassocampe sulovensis* (Kozur and Mock)**	+		+	+	+	+		+	+					+	+	+	+	+
***Pseudostylosphaera inaequata* (Bragin)**			+					+										
***Spongoserrula rarauana rarauana* Dumitrica**			+				+	+	+									
***Pseudostylosphaera nazarovi* (Kozur and Mostler)**			+					+			+			+				+
***Steigerispongus subsymmetricus* Kozur and Mostler**				+														
***Muelleritortis expansa* Kozur and Mostler**				+														
***Spongopallium crassum* Tekin and Mostler**					+													
***Canoptum inornatum* Tekin**					+			+			+		+			+	+	+
***Gibberospongus* sp. A**							+											
***Scutispongus bogdani ancoraeformis* Kozur and Mostler**							+											
***Steigerispongus brevipediculus* Kozur and Mostler**							+											
***Cryptostephanidium goncuoglui* Tekin**							+											
***Paurinella acutispinosa* Kozur and Mostler**							+											
***Pentaspongodiscus discoides* Tekin**							+	+		+	+							
***Spongoserrula fluegeli* Kozur and Mostler**							+	+			+							
***Paronaella claviformis* (Kozur and Mostler)**							+				+			+	+			+
***Nodotetrasphaera cive* (Sugiyama)**							+	+							+			+
***Annulotriassocampe baldii* Kozur**							+			+			+		+	+	+	+
***Pterospongus* sp. A**								+										
***Scutispongus ploechingeri* Kozur and Mostler**								+										
***Scutispongus sagittaeformis* Kozur and Mostler**								+										
***S. longispinosus longispinosus* (Kozur and Mostler)**								+										
***Canoptum* ? sp. A**									+									
***Paurinella latispinosa* Kozur and Mostler**									+						+			
***Tritortis kretaensis dispiralis* (Bragin)**									+	+	+	+	+	+	+	+	+	
***Canoptum cucurbita* (Sugiyama)**									+	+	+	+		+			+	+
***Pseudostylosphaera gracilis* Kozur and Mock**										+	+			+		+		+
***Ditortis* sp. A**											+							
***Tritortis kretaensis kretaensis* (Kozur and Krahl)**											+	+	+	+	+	+	+	
***Paronaella glaber* (Kozur and Mostler)**											+						+	+
***Paronaella* sp. A**														+				
***Karnospongella* sp. cf. *K. bispinosa* Kozur and Mostler**														+				
***Pseudostylosphaera* sp. aff. *P. mostleri* Tekin n. sp.**																		+
***Whalenella* sp. A**																		+
***Multimonilis* sp. B**																		+

Fig. 6 - Occurrence chart of taxa from the Komurcu section.

interval between 04-MAN-135 to 04-MAN-130 corresponds to the "*Tritortis kretaensis* Zone" by Kozur and Mostler (1994, 1996) and Kozur (2003) (Figs. 5, 6). This part of the section corresponds also partly to the "TR 4B *Spongoserrula dehli* Lowest Occurrence Zone" of Sugiyama (1997) and to the "*Yeharaia elegans* subzone of the *Sarla dispiralis* Zone" of Bragin (1991).

Radiolarian fauna from the upper part of the section (sample 04-MAN-127) is represented by *Paronaella claviformis, P. glaber, Nodotetrasphaera cive, Pseudostylosphaera gracilis, P.* sp. aff. *P. mostleri, P. nazarovi, C. cucurbita, Canoptum inornatum, Annulotriassocampe baldii, A. sulovensis, Whalenella* sp. A and *Multimonilis* sp. B. Neither *Tritortis kretaensis* nor *Tetraporobrachia haeckeli* (zone taxon of the middle Carnian by Kozur and Mostler, 1994) are present in sample 04-MAN-127. Based on this fauna, it can be assumed that this part of the section corresponds to the "unnamed radiolarian zone" by Kozur and Mostler (1994) and Kozur (2003), indicating a late early Carnian. This part of the section possibly corresponds to the basal part of the "TR5A *Capnuchosphaera* Lowest Occurrence Zone" by Sugiyama (1997). Taxa with many individuals such as *Nodotetrasphaera cive, Pseudostylosphaera gracilis, C. cucurbita, Canoptum inornatum, Annulotriassocampe baldii* and *A. sulovensis* defined from this sample were also well known from the same radiolarian zone in the Sugozu section, southern Turkey (Tekin, 1999).

3. Sample 04-MAN-113: Moderately preserved radiolarians as *Vinassaspongus subsphaericus* Kozur and Mostler (Plate 1.5), *Praeorbiculiformella gazipasaensis* (Tekin) (Plate 1.18), *Tritortis kretaensis dispiralis* (Bragin) (Plate 3.18), *T. kretaensis kretaensis* (Kozur and Krahl) (Plate 3.21), *Canoptum cucurbita* (Sugiyama) (Plate 4.9) and *Castrum blomei* Tekin and Mostler (Plate 4.20) were obtained from this sample. Based on the co-occurrence of abundant *Tritortis kretaensis dispiralis* and *T. kretaensis kretaensis* and the absence of *Muelleritortis cochleata,* the age of this sample should be early Carnian corresponding to the upper part of the "*Tritortis kretaensis* Zone" by Kozur and Mostler (1994) and Kozur (2003). According to Kozur and Mostler (1994) and Tekin (1999), *Muelleritortis cochleata* is present at the basal part of the *"Tritortis kretaensis* Zone". Therefore, the absence of this taxon in the assemblage reveals the upper part of this zone. Sugiyama (1997) also suggested that *Muelleritortis cochleata* last appears at the end of "TR 4B *Spongoserrula dehli* Lowest Occurrence Zone" and that the absence of this taxon indicates that the basal part of the "TR 5A *Capnuchosphaera* Lowest Occurrence Zone" corresponding to the upper part of "*Tritortis kretaensis* Zone" by Kozur and Mostler (1994) (Fig. 5).

4. Sample 04-MAN-92: Rare radiolarians as possible spines of *Nodotetrasphaera cive* (Sugiyama) (Plate 3.10), *Canoptum inornatum* Tekin (Plate 4.14) and *Canoptum levis* Tekin (Plate 4.15) are present in this sample. According to Sugiyama (1997), *Nodotetrasphaera cive* first appears in the central part of the "TR 4B *Spongoserrula dehli* Lowest Occurrence Zone" corresponding to the basal part of the Carnian and it disappears close to the top of the "TR 5A *Capnuchosphaera* Lowest Occurrence Zone" corresponding mainly to the middle Carnian. This sample does not contain zone taxa as *Muelleritortis cochleata* (late late Ladinian - earliest Carnian), *Tritortis kretaensis* (latest Ladinian - early early Carnian) and *Tetraporobrachia haeckeli* (middle Carnian) of Kozur and Mostler (1994). Based especially on the presence of possible spines of *Nodotetrasphaera cive*, together with the absence of two characteristic taxa (*T. kretaensis* and *Tetraporobrachia haeckeli*), the age of this sample can be assigned as late early Carnian, corresponding to the "unnamed radiolarian zone" by Kozur and Mostler (1994) and the basal part of the "TR 5A *Capnuchosphaera* Lowest Occurrence Zone" by Sugiyama (1997) (Fig. 5). Similarly to this fauna, Tekin (1999) claimed that the presence of abundant *Nodotetrasphaera cive, Canoptum inornatum* and *C. levis* within the strata corresponds to the "unnamed radiolarian zone" of Kozur and Mostler (1994) from the Sugozu section, southern Turkey.

5. Sample 04-MAN-95: This sample yielded very diverse, well-preserved and abundant radiolarians: *Dumitricasphaera goestlingensis* Kozur and Mostler (Plate 1.2), *Vinassaspongus* sp. aff. *V. erendili* Tekin (Plate 1.4), *V. subsphaericus* Kozur and Mostler (Plate 1.6), *Zhamojdasphaera* sp. A (Plate 1.7), *Bistarkum* ? sp. A (Plate 1.8-9), *B.* sp. B (Plate 1.10-11), *Paronaella claviformis* (Kozur and Mostler) (Plate 1.13), *Triassocrucella triassica* (Kozur and Mostler) (Plate 1.16), *Praeorbiculiformella* sp. cf. *P. karnica* Kozur and Mostler (Plate 1.19), *P.* sp. A (Plate 1.20), *P.* ? sp. B (Plate 1.21), *Tetraporobrachia haeckeli* Kozur and Mostler (Plate 1.22), *Veghicyclia haeckeli* Kozur and Mostler (Plate 1.23), *Capnuchosphaera triassica* De Wever (Plate 2.15), ? *C. triassica* De Wever (Plate 2.16), *Pseudostylosphaera gracilis* Kozur and Mock (Plate 2.21), *P.* sp. aff. *P. hellenica* (De Wever) (Plate 2.22), *P. longispinosa* Kozur and Mostler (Plate 2.25), *P. mostleri* Tekin n. sp. (Plate 3.1-5), *P.* sp. aff. *P. mostleri* Tekin n. sp. (Plate 3.6), possible spines of *Nodotetrasphaera cive* (Sugiyama) (Plate 3.12), *Praeheliostaurus multidentatus* Lahm (Plate 3.23), *Palaeosaturnalis triassicus* (Kozur and Mostler) (Plate 3.24), *Annulotriassocampe* sp. A (Plate 4.5-6), *Canoptum cucurbita* (Sugiyama) (Plate 4.10-11), *C. inornatum* Tekin (Plate 4.14), *Castrum blomei* Tekin and Mostler (Plate 4.19), *C.* sp. aff. *C. perornatum* Blome (Plate 4.21) and *Multimonilis* sp. A (Plate 4.22). This radiolarian fauna corresponds to the "*Tetraporobrachia haeckeli* Zone" of Kozur and Mostler (1994) due to co-occurrence of nominal species and associated fauna (Fig. 5). Some taxa as *Paronaella claviformis*, *Tetraporobrachia haeckeli* and *Praeheliostaurus multidentatus* from this fauna previously were only known from middle Carnian strata (Kozur and Mostler, 1979; 1981)

According to the zonation by Sugiyama (1997), the radiolarian fauna of sample 04-MAN-95 can be assigned to the basal part of the TR 5A "*Capnuchosphaera* Lowest Occurrence Zone" (Fig. 5). Although the radiolarian fauna of sample 04-MAN-95 includes *Capnuchosphaera triassica*, characteristic *Capnuchosphaera* such as *C. deweveri* Kozur and Mostler and *C. silviensis* Blome that first appear at the top of TR 5A "*Capnuchosphaera* Lowest Occurrence Zone" and *C. lea* De Wever, *C. theloides* De Wever and *C. tricornis* De Wever that first appear at the base of TR 5B "*Poulpus carcharus* Lowest Occurrence Zone" corresponding to late middle to late Carnian are not present in this sample. It means that the age of the sample could not be late Middle Carnian. Similar radiolarian faunas from this time interval have been previously reported from many localities as Gostling and Grossreifling (northern Calcareous Alps) in Austria (Kozur and Mostler, 1972; 1978; 1979; 1981; Lahm, 1984), central Japan (Sugiyama, 1997) and southern Turkey (Tekin, 1999; Tekin and Göncüoglu, 2002; Tekin and Bedi, 2007a and 2007b). Based on this data, the age of this sample is assigned to the early middle Carnian

DISCUSSION

Investigation on the ages of radiolarian cherts along the IASB is still in preliminary stage. However, the data obtained from several hundreds samples from the BFZ (Göncüoglu et al., 2006b and this study), central Sakarya (Tekin et al., 2002; Göncüoglu et al., 2006a) and Ankara (Bragin and Tekin, 1996; Tekin, 1999) may shed light on the important events such as the opening, oceanic crust formation and oceanic decoupling within the Izmir-Ankara Ocean.

The oldest age obtained from radiolarian cherts in the BFZ is late Ladinian and early Carnian. Within the IASB, Late Middle - Late Triassic ages occur in different depositional settings, including platform margin, base of slope and oceanic crust.

Kaya et al. (1995) and Göncüoglu et al. (2003) showed that the Middle-Upper Triassic Tauride-Anatolide shallow platform carbonates of the Kutahya-Bolkardag Belt, SE of Kütahya and Afyon (Fig. 1, inset map localities 1 and 2 and Fig. 7, sections 1 and 2) bear evidence of a very rapid deepening during the late Ladinian - early Carnian period, represented by olistostromal conglomerates and calciturbidites, followed by pelagic limestones. In both localities the open internal platform-type limestones (Ozcan et al. 1989) make up the basement of the succession. Moreover, the succession SW of Afyon (locality 2 in Fig. 1, inset map) includes lava flows (Akal et al. 2003). The formation of these successions within the platform series is attributed to the initial rifting of the Izmir-Ankara oceanic basin to the north of the Tauride-Anatolide Platform (Göncüoglu et al. 2003).

The new upper Ladinian radiolarian data in the BFZ from the Sagrakcı locality and from the basal part of the Komurcu section (Fig. 1, inset map, location 3, and Fig. 7, column 3) are yet the oldest fauna obtained from the IASB. The Komurcu outcrop is of special interest because of its depositional features and stratigraphic continuity into the Carnian. In contrast to the radiolarian cherts elsewhere, this section is characterized by the presence of terrigenous detritus (metamorphic quartz, white mica next to volcanic clasts) within the associated sediments, especially in the lowest part of the succession (Figs. 3 and 4.3, 4.4). The alternation of thin-bedded, purple-red-brown coloured chert and the mudstone facies at the bottom, indicate the periodic deposition of radiolarian tests from blooms, alternating with continuous deposition of terrigenous clays in a well-oxidized deep-sea and the absence of bottom currents. The red chert facies in the middle part of the succession is interpreted as formed mainly by biogenic debris. Some weak lamination and alternation with very thin-bedded red mudstones may suggest reworking by bottom currents in a deep-sea pelagic environment below the CCD. The upper part of the succession is dominated by the green mudstones and sandstones with chert interbeds (Figs. 4.3, 4.4). The green mudstones and sandstones with chert interbeds may probably reflect a source of organic material from a nearby platform or alternatively restricted circulation. The first interpretation is supported by the presence of terrigenous clasts in the coarser grained interlayers. Clasts of chloritized volcanic rocks in this part may derive from a coeval or slightly older basic volcanism that may correspond to the basaltic lavas SE of Afyon (column 2 in Fig. 7). Overall, the Komurcu section provides evidence that during the late Ladinian a proximal base-of-slope setting with accumulation of terrigenous as well as volcanic detritus was dominating the edge of the Tauride-Anatolide platform margin.

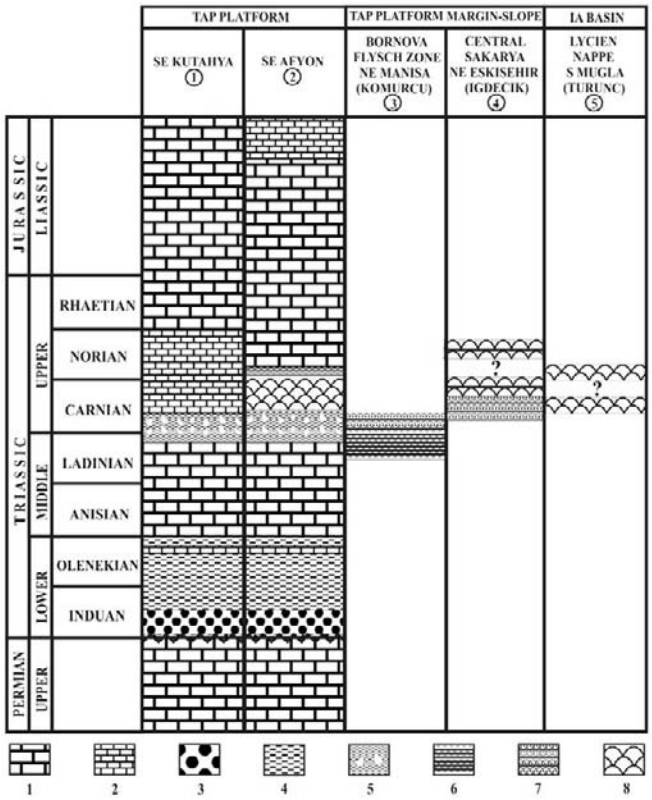

Fig. 7 - Generalized columnar sections of successions evaluated in the text. The locations of the sections (1 - 5) are shown in the inset map of Fig. 1. 1- Platform carbonates; 2- Pelagic carbonates; 3- Coarse clastics; 4- Mudstone; 5- Olistostromal units; 6- Chert-mudstone alternation; 7- Sandstone-mudstone alternation with chert interbeds; 8- Basic volcanics.

The first data on the development of Mid-Ocean-Ridge (MORB) volcanism comes from the radiolarian cherts/mudstones directly in depositional contact with lava-flows in the IASB. Within the Gulbahar Nappe (Turunc) of the Lycien Nappes in SW Anatolia (location 5 in Fig. 1, inset map), unanimously accepted to represent the northern margin sequences of the Tauride Anatolide platform and the adjacent oceanic lithologies of the Izmir-Ankara Ocean (Sengor et al., 1984; Collins and Robertson, 1998), middle Carnian (corresponding to the *Tetraporobrachia haeckeli* zone, Tekin and Göncüoglu, 2002) radiolarian mudstones are associated with pillow-basalts (Fig.7, column 5). Geochemically, they represent within-plate to transitional-MORB basaltic volcanism (Yalınız et al., in prep.) and they are attributed to the initial spreading of the Izmir-Ankara Ocean. On the other hand, late Carnian ages were reported from radiolarian cherts in the central Sakarya area (location 4 in Fig. 1, inset map and Fig.7, column 4), associated with pillow lavas, geochemically indicating an evolving MORB-type oceanic crust (Göncüoglu et al., 2001; Tekin et al., 2002; Göncüoglu et al., 2006a; 2006b). In this locality, cherts are underlain by coarse clastics resembling the Komurcu section. However, the dominance of pillow lavas with radiolarian cherts and mudstones and the absence of continent-derived clastics in the upper part of the succession were interpreted to reflect a basinal deposition and spreading of the Izmir-Ankara oceanic crust between the Sakarya composite terrane and the Tauride-Anatolide platform (Göncüoglu et al., 2006a). Hence, using the depositional features and radiolarian age of the cherts and associated sediments, together with the geochemical discrimination of coeval volcanism a reconstruction of the southern margin of the Neotethyan Izmir-Ankara Ocean in NW Anatolia can be hypotesized. In this reconstruction the upper Ladinan - middle Carnian radiolarian cherts can be placed at the proximal base-of-slope, whereas the middle and upper Carnian chert-pillow lava associations represent an oceanic crust sequence.

In the previous studies the only data on Carnian radiolarian cherts in the IASB were from central Sakarya (Göncüoglu et al., 2001; Tekin et al., 2002) and on late Norian were from the Ankara Mélange (Bragin and Tekin, 1996; Tekin, 1999). The indication of this data for an early Upper Triassic Neotethyan oceanization (Göncüoglu et al. 2000; 2003) was disputed by some authors (e.g., Beccaletto et al., 2005) and the presence of these cherts was attributed to tectonic interleaving of slices of the Triassic (Paleotethyan) Karakaya Complex within the accretionary complex of the Late Cretaceous IASB. Hence, our new finding of several chert blocks with upper Ladinian to lower middle Carnian radiolarians within the BFZ and the proposed succession of events can be used as a clue in favour of the independent evolution of the Paleotethyan Karakaya and Neotethyan Izmir-Ankara oceans during the Triassic.

Middle and Upper Triassic radiolarian ages were already reported from various Tethyan oceanic basins in the Aegean; e. g., in the Vardar Zone, highly condensed Ammonitico Rosso pelagic limestones supposedly accumulated on a volcanic seamount during the mid - Late Triassic (Clift and Robertson, 1990). In the Pindos, Degnan and Robertson (1998) report Ladinan - lower Carnian pelagic successions with radiolarians similar to the Komurcu section.

Further west - northwest, Middle and Late Triassic ages have been reported in previous studies. These include the Carnian-Norian ages from radiolarian cherts in the Avdella Mélange beneath the Pindos ophiolite (Jones et al., 1992), Carnian-Norian ages from radiolarites from the overlying ophiolitic gabbros in the southern Peloponnese (Agelona ophiolite) (Danelian et al., 2000), late Ladinian-Norian ages from radiolarites in the Pagondas Mélange (Danelian and Robertson, 2001) and Triassic ages from the Pelagonian - Subpelagonian Domain in the Argolis Peninsula (Bortolotti et al., 2001; 2002; 2003) in Greece, Carnian - Norian ages from a chert block in the mélange of the Dinaride ophiolite belt, Serbia (Gorican et al., 1999) and Middle and Late Triassic ages from cherts in a mélange in the Mirdita zone, Albania (Kellici et al., 1994; Kellici and De Wever, 1994; Marcucci et al., 1994; Chiari et al., 1996; Bortolotti et al., 2004; 2006).

The new evidence of Middle and Upper Triassic Neotethyan oceanic lithologies in NW Anatolia suggests coexistence of the Paleotethyan and Neotethyan oceanic branches and should be carefully considered in the correlations across the Aegean Sea.

CONCLUSIONS

The BFZ in NW Anatolia comprises imbricated tectonic slices of the Izmir-Ankara ophiolite, mélanges representing the subduction-accretion complexes, the slope and continental margin sediments of the Tauride-Anatolide platform, upon which the oceanic assemblages was emplaced from N to S. Between these slices, there are also olistostromal sediments formed in small peripheral foreland basins during the emplacement of the slices. Radiolarian chert fragments of pebble to mega-olistolith size are common constituents of the mélanges and yielded radiolarians of a wide range of ages: from late Ladinian to early Turonian (Tekin et al., 2006; Göncüoglu et al., 2006b).

The oldest ages obtained from the BFZ together with the previous data from other parts of the Izmir-Ankara Suture Belt indicate that deposition of radiolarian cherts north of the Tauride-Anatolide platform margin commenced not later than late Ladinian. These data together with the geochemical evaluation of the associated volcanic rocks support our former suggestion (Göncüoglu et al., 1996; 2000; 2001; 2003; Tekin et al., 2002; 2006) that the Izmir-Ankara oceanic branch of Neotethys opened during the late Middle - early Late Triassic.

The new data from BFZ also implies that during the mid - Late Triassic the Paleotethyan Karakaya and the Neotethyan Izmir-Ankara oceans were coexisting in NW Anatolia.

TAXONOMIC NOTES

Subclass **Radiolaria**
Order **Polycystina**
Suborder **Spumellariina** Ehrenberg, 1838
Superfamily **Actinommacea** Haeckel, 1862
Family **Stylosphaeridae** Haeckel, 1882
Genus ***Vinassaspongus*** Kozur and Mostler, 1979
Type species: Vinassaspongus subsphaericus Kozur and Mostler, 1979.

Vinassaspongus* sp. aff. *V. erendili Tekin, 1999 (Plate 1.4)

aff. *Vinassaspongus erendili* Tekin, 1999, pp. 67-68, pl. 2, figs. 9-10.

Remarks: This specimen differs from holotype by having a smaller cortical shell, shorter main spines with proximal longer straight part and loosely twisted distal ends.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Genus ***Zhamojdasphaera*** Kozur and Mostler, 1979
Type species: Zhamojdasphaera latispinosa Kozur and Mostler, 1979.

***Zhamojdasphaera* sp. A** (Plate 1.7)

Description: Cortical shell subsphaerical, spongy. Three main spines situated at right angles. Primary spines thin, plate like, straight, basally wide gradually decreasing in width distally. Length of primary spine always shorter than the diameter of cortical shell.

Remarks: It differs from *Z. latispinosa* Kozur and Mostler (1979, p. 67, pl. 7, figs. 7-9; pl. 12, fig. 5) by having a smaller cortical shell and basally very wide and distally tapering, shorter, straight, triangular main spines.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Superfamily **Pyloniacea** Haeckel, 1881, emend. Dumitrica in De Wever et al., 2001
Family **Angulobracchiidae** Baumgartner, 1980, emend. Dumitrica in De Wever et al., 2001
Genus ***Bistarkum*** Yeh, 1987
Type species: Bistarkum rigidum Yeh, 1987.

***Bistarkum* ? sp. A** (Plate 1.8-9)

Description: Test cylindrical, gradually increasing in width towards the one side. Test surface covered by spongy meshwork and no auxiliary spines present at the tips.

Remarks: It is differentiated from the other *Bistarkum* by having a uniform test gradually increasing in width and absence of two equal rays. It is tentatively assigned to *Bistarkum* due to absence of two rays.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

***Bistarkum* sp. B** (Plate 1.10-11)

Description: Test subcylindrical with two nearly equal sized spongy rays. Test slightly medially decreasing in width and no auxiliary spines present at the tips.

Remarks: It can be differentiated from *Bistarkum rhaeticum* Tekin (2002, pp. 422-423, pl. 1, figs. 16-17) in possessing a longer and medially contracting test.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Genus ***Paronaella*** Pessagno, 1971 emend. Baumgartner, 1980.

Type species: Paronaella solanoensis Pessagno, 1971.

***Paronaella* sp. A** (Plate 1.15)

Description: Test with three, spongy rays. Rays long, circular in cross section at the base and distally widened and flattened.

Remarks: It can be differentiated from *Paronaella glaber* (Kozur and Mostler, 1978, p. 148, pl. 3, fig. 15) by having distally widened and flattened arms.

Range and occurrence: Late Triassic, early early Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Genus ***Praeorbiculiformella*** Kozur and Mostler, 1978

Type species: Praeorbiculiformella plana Kozur and Mostler, 1978.

Praeorbiculiformella* sp. cf. *P. karnica Kozur and Mostler, 1978 (Plate 1.19)

cf. *Praeorbiculiformella karnica* Kozur and Mostler, 1978, p. 165, pl. 1, fig. 14.

Remarks: Although the general shape of the specimen is similar to holotype, exact definition is not carried out due to poor preservation.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

***Praeorbiculiformella* sp. A** (Plate 1.20)

Description: Test large, roughly circular in outline. Rim of the test slightly elevated and possessing mainly tetragonal to pentagonal pore frames. Short, thin, basally tricarinate and distally needle-like four equatorial spines disposed in a right angle.

Remarks: It is differentiated from the other *Praeorbiculiformella* in possessing basally tricarinate and distally needle-like four equatorial spines.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

***Praeorbiculiformella* ? sp. B** (Plate 1.21)

Description: Test very large with ten short, porous arms radiating in the same plane from periphery of central disc. Central cavity well defined and gentle slope present between central cavity and rim. Peripheral arms short, tube-like, tapering distally with row of pores and needle-like spines at the tips.

Remarks: It is differentiated from the other *Praeorbiculiformella* in possessing a tube-like, peripheral arms and it is tentatively assigned to this genus due to presence of these arms.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Superfamily **Sponguracea** Haeckel, 1862 emend. Kozur and Mostler, 1981

Family **Gomberellidae** Kozur and Mostler, 1981

Genus ***Karnospongella*** Kozur and Mostler, 1981

Type species: Karnospongella bispinosa Kozur and Mostler, 1981.

Karnospongella* sp. cf. *K. bispinosa Kozur and Mostler, 1981 (Plate 1.25)

cf. *Karnospongella bispinosa* Kozur and Mostler, 1981, p. 42, pl. 50, figs. 1, 2.

Remarks: Although the specimen is incomplete, general shape of the shell is similar to those of *Karnospongella bispinosa* Kozur and Mostler, 1981.

Range and occurrence: Late Triassic, early early Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

***Karnospongella* sp. A** (Plate 1.26)

Description: Shell spongy, subcylindrical, slightly widened distally. Two main spines thick, twisted, strongly dextrally tricarinate with very thin ridges and wide and deep grooves

Remarks: It can be differentiated from *Karnospongella bispinosa* Kozur and Mostler (1981, p. 42, pl. 50, figs. 1, 2) by having a slightly smaller, distally widened subcylindrical test instead of ellipsoidal one and thicker main spines.

Range and occurrence: Middle Triassic, late Ladinian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Family **Oertlispongidae** Kozur and Mostler in Dumitrica et al., 1980

Subfamily **Oertlisponginae** Kozur and Mostler in Dumitrica et al., 1980, emend. Dumitrica, 1982

Genus ***Gibberospongus*** Kozur and Mostler, 1996

Type species: Gibberospongus spinosus Kozur and Mostler, 1996.

***Gibberospongus* sp. A** (Plate 2.1)

Description: Polar spine long with straight stem, stem possess recurved part distally. One triangular, straight spine present at the outer distal end of blade. A second very small spine also present at the transition between and blade.

Remarks: It differs from *G. bispinosus* Kozur and Mostler (1996, p. 128, pl. 9, fig. 8) in having a straight, triangular first spine at the outer distal end of blade instead of a recurved one and a very small, second spine at the transition between and blade instead of long, recurved one.

Range and occurrence: Middle Triassic, late Ladinian;

NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Genus ***Pterospongus*** Dumitrica, 1982
Type species: Pterospongus patrulii Dumitrica, 1982.

***Pterospongus* sp. A** (Plate 2.2)
Description: Spine broad with long recurved spines at corner. Outer margin with deep axial sinus and regularly arranged, six teeth on each side of the test.
Remarks: It differs from *Pterospongus patrulii* Dumitrica (1982, p. 68, pl. 7, figs. 5, 6; pl. 8, figs. 4-6; pl. 9, figs. 1, 2) by possessing a regularly arranged six teeth on each side of the test instead of a irregularly arranged, three to four teeth.
Range and occurrence: Middle Triassic, late Ladinian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Suborder **Entactinaria** Kozur and Mostler, 1982
? Family **Capnuchosphaeridae** De Wever in De Wever et al., 1979 emend Pessagno in Pessagno et al., 1979 emend Blome, 1983
Subfamily **Capnuchosphaerinae** De Wever, 1982
Genus ***Hexacatoma*** Tekin and Mostler, 2005
Type species: Hexacatoma elegantissima Tekin and Mostler, 2005.

Hexacatoma* sp. aff. *H. elegantissima Tekin and Mostler, 2005 (Plate 2.17)
aff. *Hexacatoma elegantissima* Tekin and Mostler, 2005, p. 36, pl. 5, figs. 3-8.
Remarks: This specimen differs from the holotype in possessing a more sphaerical shell with tubes which are not in the same plane.
Range and occurrence: Middle Triassic, late Ladinian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Family **Hindeosphaeridae** Kozur and Mostler, 1981
Genus ***Pseudostylosphaera*** Kozur and Mostler, 1981
Type species: Pseudostylosphaera gracilis Kozur and Mock in Kozur and Mostler, 1981.

Pseudostylosphaera* sp. aff. *P. hellenica (De Wever in De Wever et al., 1979) (Plate 2.22)
aff. *Archaeospongoprunum ? hellenicum* De Wever in De Wever, Sanfilippo, Riedel and Gruber, 1979, p. 78, pl. 1, fig. 8.
Remarks: This specimen differs from the holotype by having a subcylindrical cortical shell and main spines with loosely twisted distal ends.
Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Pseudostylosphaera mostleri Tekin n. sp. (Plate 3.1-5)
Pseudostylosphaera sp. A Yeh, 1989, p. 64, pl. 1, figs. 3, 12.
Description: Cortical shell large, subellipsoidal to subspherical with double-layered pore frame structures. Outer layer of meshwork consisting of large, elevated, polygonal (tetragonal to hexagonal, mainly hexagonal) pore frames with highly elevated nodes at pore frame vertices. Inner layer of meshwork consisting of polygonal (mainly trigonal and teragonal) pore frames with small, subcircular pores. Two polar spines unequal and tricarinate with wide ridges and deep, wide grooves. Short polar spine straight and long polar spine slightly, dextrally twisted. Polar spines gradually decreasing in width to the distal ends.
Remarks: It can be distinguished from *P. inaequata* (Bragin, 1986, p. 71, pl. 2, fig. 7) in possessing a smaller, more globular cortical shell and shorter polar spines decreasing in width gradually distally and straight, shorter polar spine instead of slightly sinistrially twisted one. It differs also from *P. tenuis* (Nakaseko and Nishimura, 1979, pp. 68-69, pl. 1, figs. 8, 10) in having a thicker, shorter polar spines and dextrally twisted longer polar spine instead of straight one.
Etymology: This species is dedicated to Prof. Dr. Helfried Mostler (Innsbruck University, Innsbruck, Austria) honoring his contributions to the knowledge of Radiolaria, Sponge and Holuthurian biostratigraphy.
Measurements: Based on the five type specimens (in μm)

	HT	Min.	Max.	Av.
Length of cortical shell perpendicular to the polar spines	100	95	115	101
Max. length of the shorter polar spine	72	55	100	70.5
Max. length of thelonger polar spine	122	100	161	125.7
Width of longer polar spine 6at base	39	31	39	34.4

Deposition of type: Holotype (Plate 3.1, sample O4-MAN-95) = HU.JMB.0091 deposited at (Geological Engineering Department of Hacettepe University).
Type locality: Fields Creek formation, east-central Oregon, USA; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.
Range: Late Triassic; middle Carnian.

Pseudostylosphaera* sp. aff. *P. mostleri Tekin **n. sp.** (Plate 3.6-7)
Remarks: This taxon is distinguished from holotype in having a slightly, sinistrially twisted, shorter polar spine instead of straight one.
Range and occurrence: Late Triassic, late early Carnian - middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Genus ***Ditortis*** Kozur, 1988
Type species: *Ditortis recskensis* Kozur, 1988.

***Ditortis* sp. A** (Plate 3.8)
Description: Shell thick walled with double layered shell structure. Two main spines disposed opposite to each other. One of the main spine, short, tricarinate, strongly dextrally twisted and the other long, straight with extra grooves on the ridges. Distal ends of main spines tapering.
Remarks: It is differentiated from *Ditortis recskensis* Kozur (1988, pp. 96-97, pl. 3, fig. 6) in having a more globular shell and shorter twisted and straight main spines.
Range and occurrence: Middle Triassic, late Ladinian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Suborder Nassellaria Ehrenberg, 1875
Family **Reusticyrtiidae** Kozur and Mostler, 1979

Genus ***Annulotriassocampe*** Kozur in Kozur and Mostler, 1994
Type species: Annulotriassocampe baldii Kozur in Kozur and Mostler, 1994.

***Annulotriassocampe* sp. A** (Plate 4.5-6)

Description: Test long, slender, slightly, medially inflated with eight post-abdominal segments. Cephalis dome-shaped, smooth and poreless. Thorax, abdomen and rest of the segments inverse subtrapezoidal in outline and these segments display one ring of pores bordered by only upper ring. Lower ring mainly reduced on all segments. Pores mainly small and circular, ten of them visible at one side of the test, laterally.

Remarks: This taxon is differentiated from *Annulotriassocampe multisegmantatus* Tekin (1999, p. 169, pl. 41, figs. 3-6) by having a more slender test, lesser segments, wide circumferential ridges on segments and lesser pores on segments.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Superfamily **Amphipyndacea** Riedel, 1967
Family **Canoptidae** Pessagno in Pessagno et al., 1979
Genus ***Canoptum*** Pessagno in Pessagno et al., 1979
Type species: Canoptum poissoni Pessagno in Pessagno et al., 1979.

***Canoptum* ? sp. A** (Plate 4.16-17)

Description: Test possibly includes three segments, conical and completely covered by microgranular silica. Cephalis dome shaped with needle-like, inclined apical horn. Collar and lumbar strictures less distinct. Thorax trapezoidal in outline and abdomen hoop-like, slightly decreasing in width at the distal end.

Remarks: This taxon is differentiated from the other *Canoptum* by having a apical horn and due to presence of apical horn, it is tentatively assigned to this genus.

Range and occurrence: Middle Triassic, late Ladinian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Superfamily **Eucyrtidiaceae** Ehrenberg, 1847
Family **Pseudodictyomitridae** Pessagno, 1977
Genus ***Whalenella*** Kozur, 1984
Type species: Dictyomitra arrecta Hinde, 1908.

***Whalenella* sp. A** (Plate 4.18)

Description: Test long, mainly conical with seven post-abdominal segments. Cephalis triangular, thorax to last segments subtrapezoidal in outline. Cephalis and thorax poreless, covered by microgranular silica. Abdomen to last segment include discontinues costae, and many small pores between costae.

Remarks: It can be differentiated from *Whalenella kraineri* (Tekin, 1999, pp. 152-153, pl. 35, figs. 7-9) by having more slender and shorter test and lesser and more discontinous costae on the medial to distal parts of the test.

Range and occurrence: Late Triassic; late early Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

NASSELLERIA INCERTAE SEDIS

Genus ***Castrum*** Blome, 1984
Type species: Castrum perornatum Blome, 1984.

Castrum* sp. aff. *C. perornatum Blome, 1984 (Plate 4.21)

aff. *Castrum perornatum* Blome, 1984, p. 54, pl. 14, figs. 4, 9, 12, 14, 18; pl. 17, fig. 14.

Remarks: This specimen differs from the holotype by having irregular pore frames between circumferential ridges.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

Genus ***Multimonilis*** Yeh, 1989
Type species: Multimonilis pulcher Yeh, 1989.

***Multimonilis* sp. A** (Plate 4.22)

Description: Test multicyrtoid, slender, subconical in shape. Cephalis hemispherical to dome-shaped, imperforate without horn. Thorax to last post-abdominal segments increasing in width slowly and subtrapezoidal in outline. Surface of thorax and abdomen smooth, post-abdominal segments possess irregular, small nodes. Nodes connected to each other with rods.

Remarks: This taxon differs from *Multimonilis pulcher* Yeh (1989, p. 73, pl. 9, figs. 9, 19) by having a more slender test, less distinct constrictions between segments and irregular, smaller nodes on post-abdominal segments.

Range and occurrence: Late Triassic, middle Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

***Multimonilis* sp. B** (Plate 4.23)

Description: Test multicyrtoid, slender, subconical in shape. Cephalothorax triangular, imperforate with rudimentary horn. After cephalothorax, width of test abruptly decreasing. Abdomen to last post-abdominal segments increasing in width slowly and subtrapezoidal in outline. Surface of abdomen to last post-abdominal segments possess irregular, small pores.

Remarks: This specimen differs from the other *Multimonilis* by having a bulbous cephalothorax.

Range and occurrence: Late Triassic, late early Carnian; NE Akhisar town and Manisa city, Bornova Flysch Zone, western Turkey.

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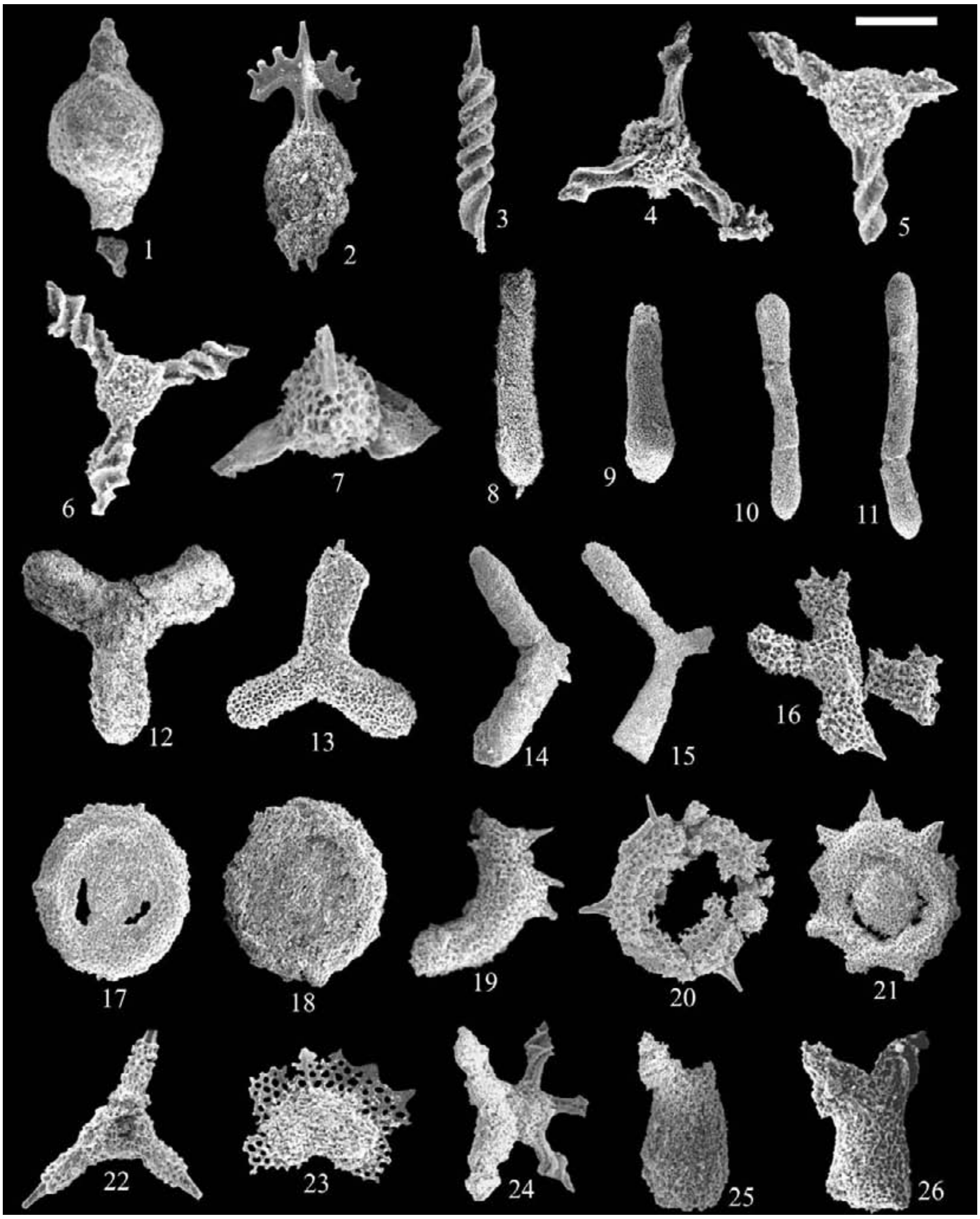

Plate 1 - Scanning electron micrographs of the upper Ladinian to middle Carnian radiolarians from the Bornova Flysch Zone, western Turkey. Scale- number of microns for each figure. 1) *Spongopallium crassum* Tekin and Mostler, sample no. O4-MAN-143, Komurcu section, late Ladinian, scale bar- 105μm; 2) *Dumitricasphaera goestlingensis* Kozur and Mostler, sample no. O4-MAN-95, middle Carnian, scale bar- 105μm; 3) *Spongostylus tortilis* Kozur and Mostler, sample no. O4-MAN-112, late Ladinian, scale bar- 105μm; 4) *Vinassaspongus* sp. aff. *V. erendili* Tekin, sample no. O4-MAN-95, middle Carnian, scale bar- 75μm; 5-6) *Vinassaspongus subsphaericus* Kozur and Mostler, 5) Sample no. O4-MAN-113, early early Carnian; 6) Sample no. O4-MAN-95, middle Carnian, scale bar for both figures- 70μm; 7) *Zhamojdasphaera* sp. A, sample no. O4-MAN-95, middle Carnian, scale bar- 65μm; 8-9) *Bistarkum* ? sp. A, both specimens are from sample no. O4-MAN-95, middle Carnian, scale bar for both figures- 175μm; 10-11) *Bistarkum* sp. B, sample no. O4-MAN-95, middle Carnian, scale bar for both figures- 250μm; 12-13) *Paronaella claviformis* (Kozur and Mostler), 12) Sample no. O4-MAN-141, Komurcu section, late Ladinian; 13) Sample no. O4-MAN-95, middle Carnian, scale bar- 180 and 150 μm; 14) *Paronaella glaber* (Kozur and Mostler), sample no. O4-MAN-130, Komurcu section, early early Carnian, scale bar- 270μm; 15) *Paronaella* sp. A, sample no. O4-MAN-134, Komurcu section, early early Carnian, scale bar- 250μm; 16) *Triassocrucella triassica* (Kozur and Mostler), sample no. O4-MAN-95, middle Carnian, scale bar- 150μm; 17-18) *Praeorbiculiformella gazipasaensis* (Tekin), 17) Sample no. O4-MAN-112, late Ladinian, 18) Sample no. O4-MAN-113, early early Carnian, scale bar for both figures- 200μm; 19) *Praeorbiculiformella* sp. cf. *P. karnica* Kozur and Mostler, sample no. O4-MAN-95, middle Carnian, scale bar- 110; 20) *Praeorbiculiformella* sp. A, sample no. O4-MAN-95, middle Carnian, scale bar- 125μm; 21) *Praeorbiculiformella* ? sp. B, sample no. O4-MAN-95, middle Carnian, scale bar- 160μm; 22) *Tetraporobrachia haeckeli* Kozur and Mostler, sample no. O4-MAN-95, middle Carnian, scale bar- 140μm; 23) *Veghicyclia haeckeli* Kozur and Mostler, sample no. O4-MAN-95, middle Carnian, scale bar- 105μm; 24) *Pentaspongodiscus discoides* Tekin, sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar- 130μm; 25) *Karnospongella* sp. cf. *K. bispinosa* Kozur and Mostler, sample no. O4-MAN-134, Komurcu section, early early Carnian, scale bar- 120μm; 26) *Karnospongella* sp. A, sample no. O4-MAN-150, Komurcu section, late Ladinian, scale bar- 110μm.

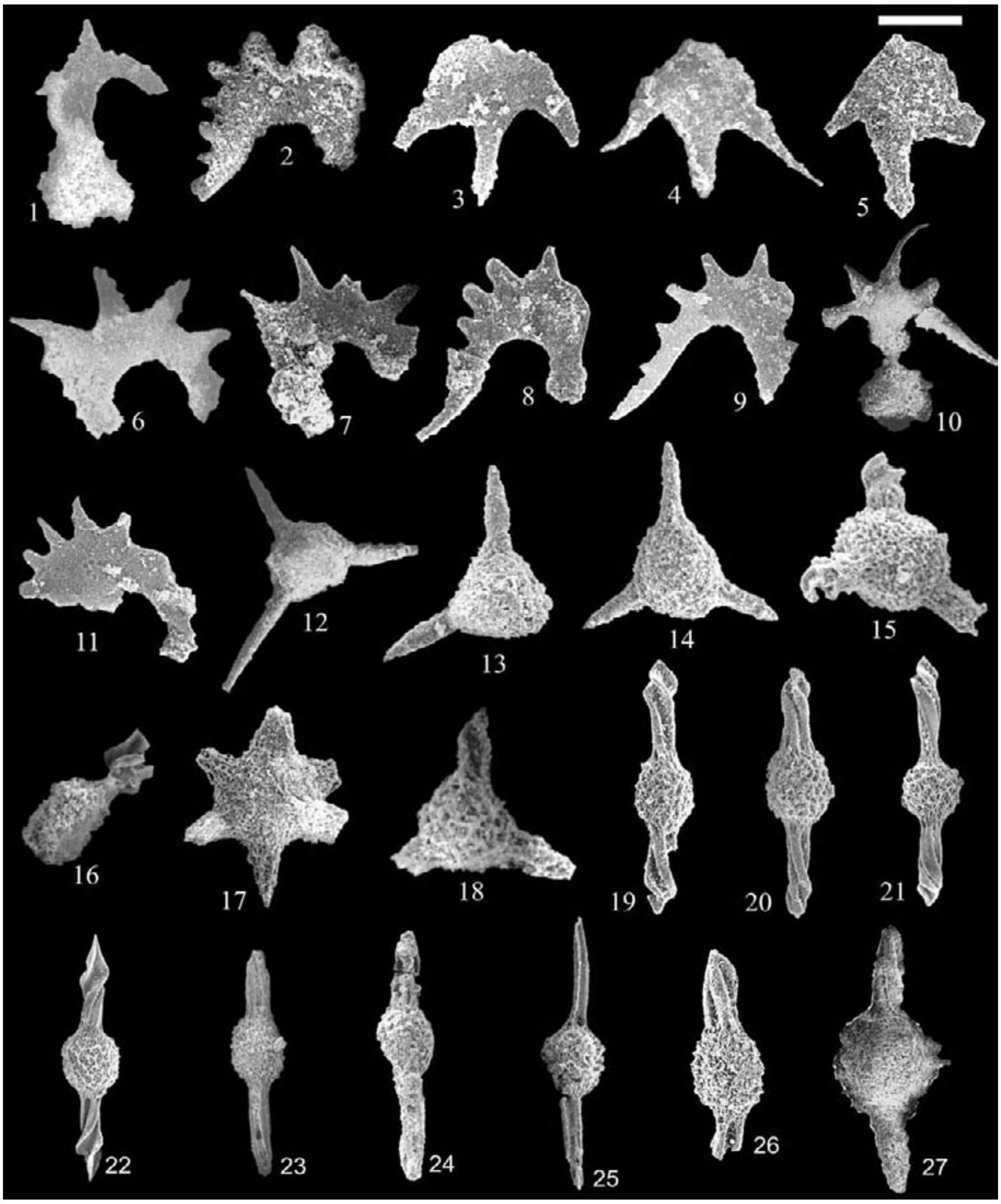

Plate 2 - Scanning electron micrographs of the upper Ladinian to middle Carnian radiolarians from the Bornova Flysch Zone, western Turkey. Scale- number of microns for each figure. 1) *Gibberospongus* sp. A, sample no. O4-MAN-141, Komurcu section, late Ladinian, scale bar- 130μm; 2) *Pterospongus* sp. A, sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar- 160μm; 3) *Scutispongus bogdani ancoraeformis* Kozur and Mostler, sample no. O4-MAN-141, Komurcu section, late Ladinian, scale bar- 125μm; 4) *Scutispongus ploechingeri* Kozur and Mostler, sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar- 170μm; 5) *Scutispongus sagittaeformis* Kozur and Mostler, sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar- 150μm; 6-7) *Spongoserrula fluegeli* Kozur and Mostler, 6) Sample no. O4-MAN-141, Komurcu section, late Ladinian, 7) Sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar for both specimens- 125μm; 8-9) *Spongoserrula rarauana* Dumitrica, 8) Sample no. O4-MAN-139, Komurcu section, late Ladinian, 9) Sample no. O4-MAN-141, late Ladinian, Komurcu section, scale bar for both figures- 170μm; 10) *Steigerispongus brevipediculus* Kozur and Mostler, sample no. O4-MAN-141, Komurcu section, late Ladinian, scale bar- 200μm; 11) *Steigerispongus subsymmetricus* Kozur and Mostler, sample no. O4-MAN-144, Komurcu section, late Ladinian, scale bar- 120μm; 12) *Paurinella acutispinosa* Kozur and Mostler, sample no. O4-MAN-141, Komurcu section, late Ladinian, scale bar- 130μm; 13-14) *Paurinella latispinosa* Kozur and Mostler, 13) Sample no. O4-MAN-138, Komurcu section, late Ladinian, 14) Sample no. O4-MAN-112, late Ladinian, scale bar for both specimens- 80μm; 15) *Capnuchosphaera triassica* De Wever, Sample no. O4-MAN-95, middle Carnian, scale bar- 90μm; 16) ?*Capnuchosphaera triassica* De Wever, scale bar- 105μm; 17) *Hexacatoma* sp. aff. *H. elegantissima* Tekin and Mostler, sample no. O4-MAN-150, Komurcu section, late Ladinian, scale bar- 120μm; 18) *Cryptostephanidium goncuoglui* Tekin, sample no. O4-MAN-141, Komurcu section, late Ladinian, scale bar- 70μm; 19-21) *Pseudostylosphaera gracilis* Kozur and Mock, 19) Sample no. O3-MAN-79, Komurcu section, late Ladinian, 20) Sample no. O4-MAN-112, late Ladinian, 21) Sample no. O4-MAN-95, middle Carnian, scale bar for all specimens- 170μm; 22) *Pseudostylosphaera* sp. aff. *P. hellenica* (De Wever), sample no. O4-MAN-95, middle Carnian, scale bar- 130μm; 23-24) *Pseudostylosphaera inaequata* (Bragin), 23) Sample no. O4-MAN-145, Komurcu section, late Ladinian, 24) Sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar for both specimens- 260μm; 25) *Pseudostylosphaera longispinosa* Kozur and Mostler, sample no. O4-MAN-95, middle Carnian, scale bar- 170μm; 26-27) *Pseudostylosphaera nazarovi* (Kozur and Mostler), 26) Sample no. O3-MAN-79, Komurcu section, late Ladinian, 27) Sample no. O4-MAN-134, Komurcu section, late Ladinian, scale bar- 240 and 280μm, respectively.

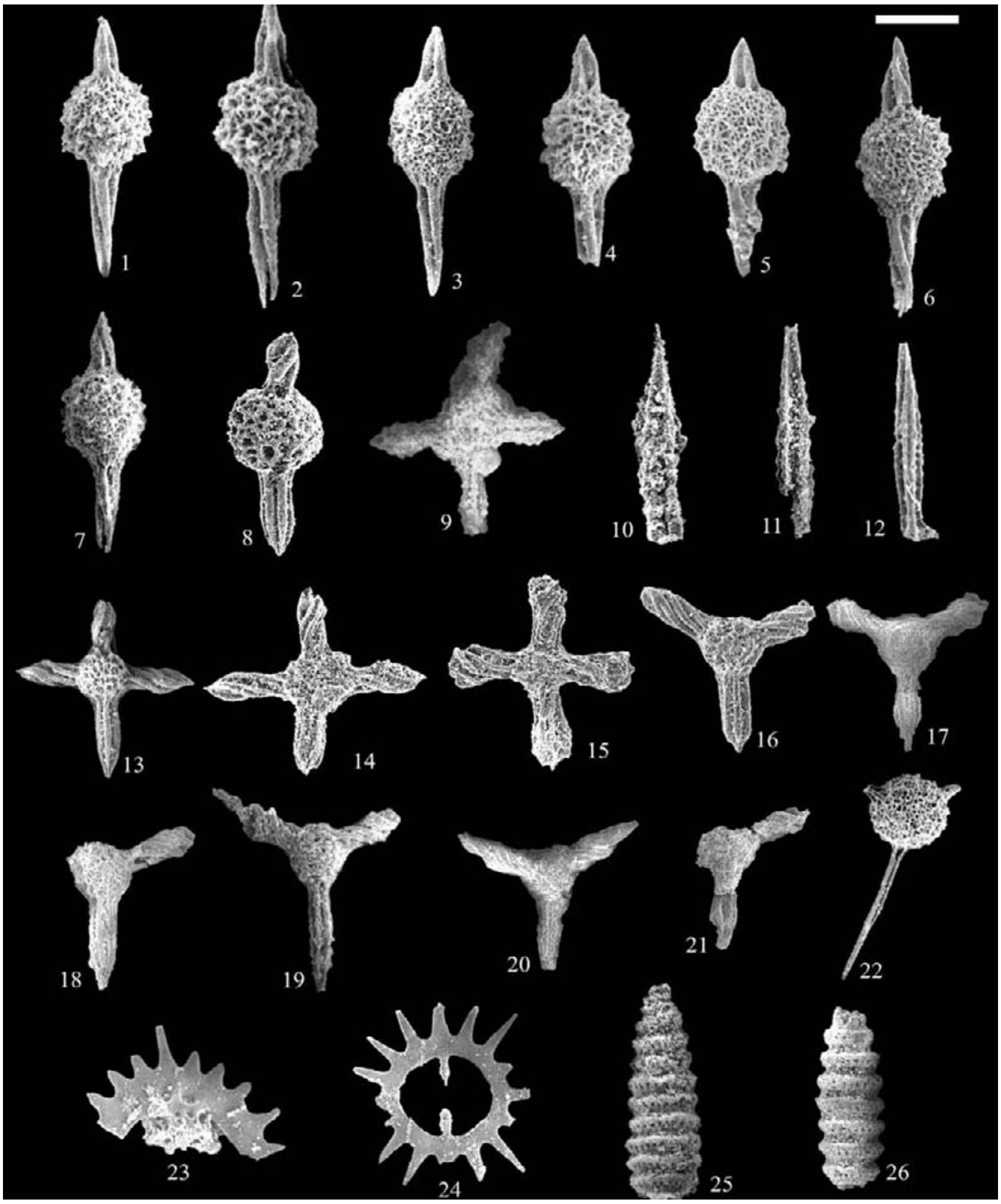

Plate 3 - Scanning electron micrographs of the upper Ladinian to middle Carnian radiolarians from the Bornova Flysch Zone, western Turkey. Scale- number of microns for each figure. 1-5) *Pseudostylosphaera mostleri* Tekin n. sp., 1) Holotype, 2-5) Paratypes, all specimens are from sample O4-MAN-95, middle Carnian, scale bar for all specimens- 90μm; 6-7) *Pseudostylosphaera* sp. aff. *P. mostleri* Tekin n. sp., 6) sample no. O4-MAN-95, middle Carnian, 7) Sample no. O4-MAN-127, Komurcu section, late early Carnian, scale bar- 110 and 90μm, respectively; 8) *Ditortis* sp. A, sample no. O3-MAN-79, Komurcu section, late Ladinian, scale bar- 200μm; 9) *Nodotetrasphaera cive* (Sugiyama), sample no. O4-MAN-141, Komurcu section, late Ladinian, scale bar- 110μm; 10-12) Possible spines of *Nodotetrasphaera cive* (Sugiyama), 10) Sample no. O4-MAN-92, late early Carnian, 11) Sample no. O4-MAN-127, Komurcu section, late early Carnian, 12) Sample no. O4-MAN-95, middle Carnian, scale bar- 85, 90 and 125μm, respectively; 13-14) *Muelleritortis cochleata* (Nakaseko and Nishimura) s. l., 13) Sample no. O4-MAN-112, late Ladinian, 14) Sample no. O3-MAN-79, Komurcu section, late Ladinian, scale bar- 170 and 210μm, respectively; 15) *Muelleritortis expansa* Kozur and Mostler, sample no. O4-MAN-144, Komurcu section, late Ladinian, scale bar- 210μm; 16-18) *Tritortis kretaensis dispiralis* (Bragin), 16) Sample no. O3-MAN-79, Komurcu section, late Ladinian, 17) Sample no. O4-MAN-132, Komurcu section, early early Carnian, 18) Sample no. O4-MAN-113, early early Carnian; scale bar- 220, 220 and 180μm, respectively; 19-21) *Tritortis kretaensis kretaensis* (Kozur and Krahl), 19) Sample no. O4-MAN-134, Komurcu section, early early Carnian, 20) Sample no. O4-MAN-132, Komurcu section, early early Carnian, 21) Sample no. O4-MAN-113, early early Carnian; scale bar- 260, 250 and 230μm, respectively; 22) *Sepsagon longispinosus longispinosus* (Kozur and Mostler), sample no. O4-MAN-139, Komurcu section, late Ladinian, scale bar- 160μm; 23) *Praeheliostaurus multidentatus* Lahm, sample no. O4-MAN-95, middle Carnian, scale bar- 100μm; 24) *Palaeosaturnalis triassicus* (Kozur and Mostler), sample no. O4-MAN-95, middle Carnian, scale bar- 175μm; 25-26) *Annulotriassocampe baldii* Kozur, 25) Sample no. O4-MAN-112, late Ladinian, 26) Sample no. O4-MAN-127, Komurcu section, late early Carnian, scale bar for both specimens- 100μm.

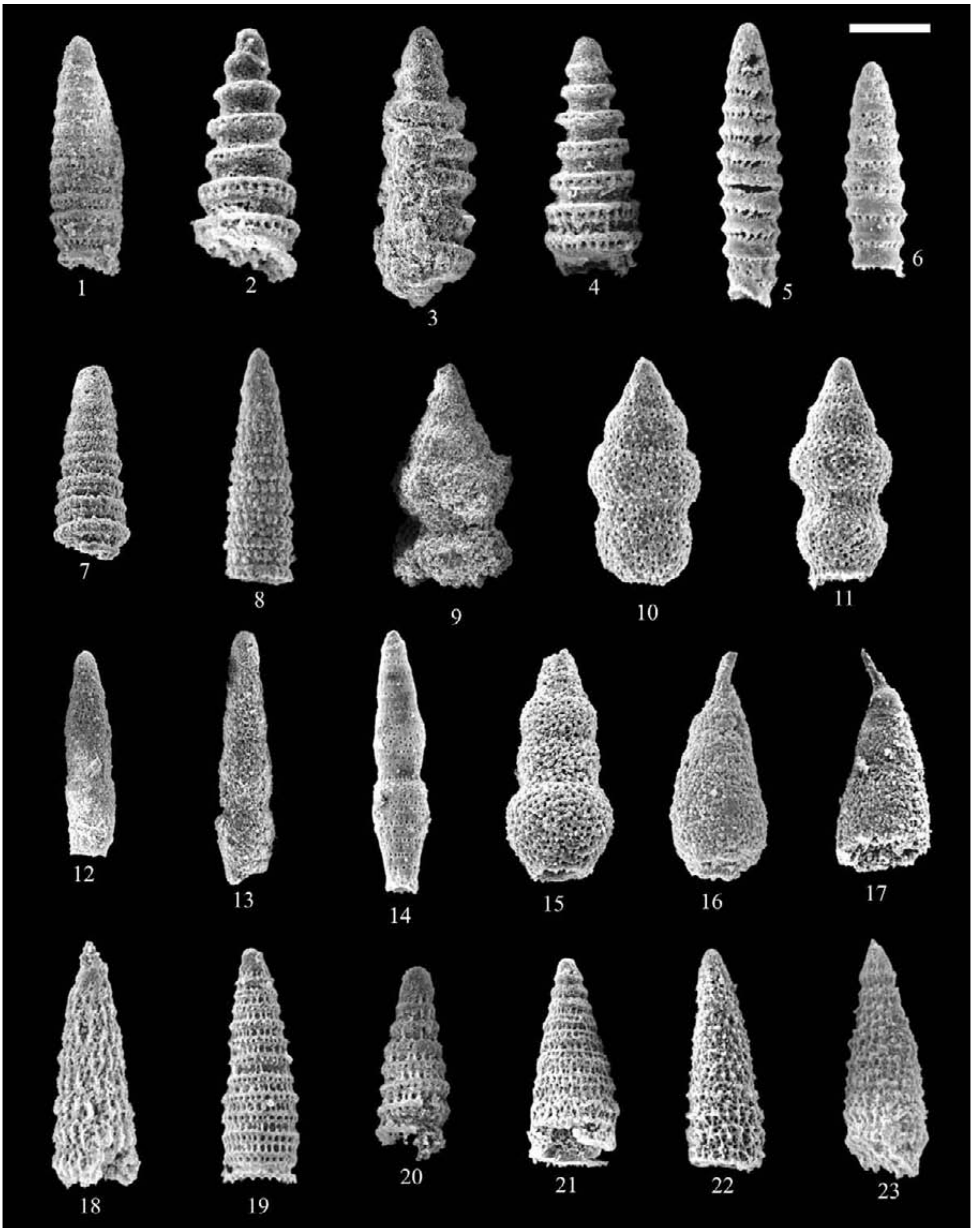

Plate 4 - Scanning electron micrographs of the upper Ladinian to middle Carnian radiolarians from the Bornova Flysch Zone, western Turkey. Scale- number of microns for each figure. 1) *Annulotriassocampe multisegmantatus* Tekin, sample no. O4-MAN-112, late Ladinian, scale bar- 100μm; 2-4) *Annulotriassocampe sulovensis* (Kozur and Mock), 2) Sample no. O4-MAN-112, late Ladinian, 3) Sample no. O4-MAN-127, Komurcu section, late early Carnian, 4) Sample no. O4-MAN-143, Komurcu section, late Ladinian, scale bar for all specimens- 70μm; 5-6) *Annulotriassocampe* sp. A, both specimens are from sample no. O4-MAN-95, middle Carnian, scale bar for both specimens- 100μm; 7-8) *Triassocampe scalaris* Dumitrica, Kozur and Mostler s. l., 7) Sample no. O4-MAN-138, Komurcu section, late Ladinian, 8) Sample no. O4-MAN-112, late Ladinian, scale bar- 90 and 125μm, respectively; 9-11) *Canoptum cucurbita* (Sugiyama), 9) Sample no. O4-MAN-113, early early Carnian, 10-11) Both specimens are from sample no. O4-MAN-95, middle Carnian, scale bar- 90, 80 and 80μm, respectively; 12-14) *Canoptum inornatum* Tekin, 12) Sample no. O4-MAN-143, Komurcu section, late Ladinian, 13) Sample no. O4-MAN-92, late early Carnian, 14) Sample no. O4-MAN-95, middle Carnian, scale bar for all specimens- 120μm; 15) *Canoptum levis* Tekin, sample no. O4-MAN-92, late early Carnian, scale bar- 65μm; 16-17) *Canoptum* ? sp. A, both specimens are from sample no. O4-MAN-138, Komurcu section, late Ladinian, scale bar for both specimens- 90μm; 18) *Whalenella* sp. A, sample no. O4-MAN-127, Komurcu section, late early Carnian, scale bar- 80μm; 19-20) *Castrum blomei* Tekin and Mostler, 19) Sample no. O4-MAN-95, middle Carnian, 20) Sample no. O4-MAN-113, early early Carnian, scale bar- 100 and 85μm, respectively; 21) *Castrum* sp. aff. *C. perornatum* Blome, sample no. O4-MAN-95, middle Carnian, scale bar- 110μm; 22) *Multimonilis* sp. A, sample no. O4-MAN-95, middle Carnian, scale bar- 110μm; 23) *Multimonilis* sp. B, sample no. O4-MAN-127, Komurcu section, late early Carnian, scale bar- 100μm.