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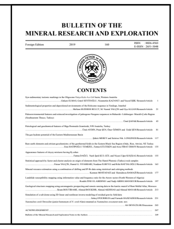
BULLETIN OF THE MINERAL RESEARCH AND EXPLORATION

CONTENTS

Paleoenvironmental features and ostracod investigation of Paleogene-Neogene sequences in Babaeski-Lüleburgaz- Muratlı-Çorlu region (Southeastern Thrace, Turkey)

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Research Article

Keywords:
Thrace Basin, Oligocene, Late Miocene–Pliocene, Ostracoda, Lignite, Paleoenvironment

ABSTRACT

Aim of the study is to evaluate the Paleogene-Neogene sequences of Babaeski- Lüleburgaz-Muratlı-Çorlu (Southeastern Thrace, Turkey) region using the micropaleontological analysis on two borehole samples collected by Mineral Research and Exploration (MTA), measured sections and point samples taken from the neighborhood of Silivri, Türkmenli-Çorlu, Babaeski-Lüleburgaz, Edirne –Babaeski regions and Tekirdağ-Hayrabolu road. There the lignite sandstone, siltstone (Early Oligocene aged Danişmen Formation) and silts (Late Miocene-Pliocene aged Ergene Formation) with well-preserved ostracod fauna obtained from the the upper levels of the sequence along with some micro-Mollusca at some levels. The study results showed that lacustrine and lagoonal ostracods including marine species were generally found in the claystone, siltstone and marl of the lower and upper levels of lignite cuts in borehole. The ostracod assemblages identified in the study were compared with other ostracod studies in the Thrace Basin and other parts of Turkey as well as in the Oligocene in Paris, the Akiten Basin, Belgium. In the Early Oligocene sediments, the presence of the Tethys effect was observed in the investigated area. In addition, the ostracod species defined in the Late Miocene-Pliocene are compared with other ostracod studies carried out in the Thrace Basin and other parts of Turkey as well as in the Western and Eastern Carpathians, Caspian Basin and Baltic Sea. According to obtained fauna, the Paratethys effect was determined more than in Tethys in Late Miocene-Pliocene in the studied region.

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1. Introduction

In the southeast of Thrace Basin, this research, which is mainly used from Tertiary (Paleogene-Neogene) stratigraphy, ostracod assemblage is as follows; the study was conducted in the neighborhood of Çorlu-Muratlı-Lüleburgaz-Babaeski region in southeastern Thrace (Figure 1). The aim of this study is to identify the micropaleontological features and an environmental condition of the Paleogene-Neogene rocks of the Çorlu-Muratlı-Lüleburgaz-Babaeski-Malkara and Silivri regions. For this purpose, a detailed micropaleontological study was accomplished in the regions above. During this study, twenty three of the ostracod samples were taken from the Danişmen Formation and five of them were taken from the Ergene Formation. In this study, species found in the Oligocene include ostracods *Neocyprideis apostolescui*, *N. williamsoniana*, *Cladarocythere apostolescui*, *Cytheromorpha zinndorfi*, *Hemicyprideis elongata*, *H. helvetica*, *H. montosa*, *Cytheridea crassa*, *C. pernota*, *Sphenocytheridea gracilis*, *Serrocytheridea eberti*, *Krithe angusta*, *Cushmanidea scrobiculata*, *Loxoconcha* sp.1, *Loxocorniculum decorata*, *Hirschmannia* sp., *Candona* (*Lineocypris*) sp., *Candona* (*Pseudocandona*) sp., *Candona*

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Figure 1- Location of measured sections from study area (Google earth, 2018).

(*Pseudocandona*) *fertilis, Ilyocypris cranmorensis*, *I. boehli*, *Virgatocypris tenuistriata*, *Novocypris striata*, *Verticypris jacksoni*, *Cypridopsis soyeri* and *Eucypris pechelbronnensis*; gastropods; and micro-pelecypods (*Valvata*, *Viviparus* and *Avimactra*). In addition, *Eucypris dulcifons*, *Heterocypris salina*, *Ilyocypris bradyi,* and *Candona* (*Caspiocypris*) *alta*, they were identified in between Late Miocene–Pliocene.

2. Material and Methods

During the study, measured sections, spot samples and washed cutting samples of the two boreholes completed by the Mineral Research and Exploration General Directorate were taken from the most important unit of the area, the Danişmen Formation and the unconformably overlying Ergene Formation. A total of 22 ostracod genera and 28 ostracod species were identified in the sections, spot samples and drilling samples from 153 washed samples.

The study was conducted on measured sections in Bıyıkali, Beşer Tuğla, Silivri Sahil, Malkara-Tekirdağ and Silivri-Değirmenköy regions selected from 1:25000-scale E19c4, F17b2, F17b4, F18c3, F18c4, F19c4, F20d3, F20d4, G17b1, G18a1, and G18b1 map areas; 2 borehole samples and spot samples from outcrops at different localities (Figure1). During all the sampling, particular attention was given to layers with fossils and lithology types. The washing method was used for a total of 153 samples taken from the measured sections, spot samples and drilling samples for that reason. Samples were disaggregated in the laboratory in order to obtain loose Ostracoda specimens. Hard samples and samples with medium hardness samples were split into 150 g. batches and wrapped with thick paper for being crushed by using a rock hammer. Crushed samples were then placed into 1 L glass beakers and treated with hot water and 15% diluted hydrogen peroxide (H_2O_2) for at least 24 hours. Disaggregated residues were later washed over a mesh of 0.60,0.120, and 0.230 mm sieves, and placed in sample bags upon oven drying. Following the separation of microfossils from grains, Ostracoda were placed on slides for identification of genera and species. Identified Ostracoda genera and species were counted in order to determine their lateral and vertical distribution and abundance**.** Finally, the Ostracoda genera and species contents of each sample were determined (Morkhoven, 1963; Witt, 2003, 2011; Freels, 1980; Esteoulle-Choux et al., 1986; Rückert-Ülkümen et al., 2009; Meisch, 2000) and Hartmann and Puri (1974) systematic has been used.

Plate 1, 2, 3 and 4 were prepared from the selected (Scanning Electron Microscope) SEM images of different Ostracoda genera, species and Mollusca genera.

The paleogeographical environment datas of this study were determined by using the statistical results which identified ostracoda genera and species evaluated in order to determine their lateral and vertical distribution and abundance. The frequency table of ostracode species modified from Sissingh (1972) and correlative interpretation of these data as well as the salinity criteria of Remane, 1958; Morkhoven, 1963; Freels 1980; Athersuch et al., 1989; Witt, 2011; Rückert-Ülkümen et al., 2009. In particular, mollusc genera compatible with lacustrine conditions were described based on the studies of Taner, 1980; Bremer, 1978; Sayar, 1991; Wenz, 1922.

3. Geological Setting

The Thrace Basin is surrounded by the Istranca Massif in the north, the Rhodope massif in the west, and the Menderes Massif in the south (Figure 1). The Istranca massif is composed of gneisses and metamorphosed Paleozoic and Mesozoic sedimentary rocks on the greenschist facies that overlies it (Üşümezsoy, 1982; Taner and Çağatay, 1983). The sedimentary rocks that form the basement of the massif are affected by the Upper Cretaceous granodiorite rocks and are covered by an Upper Cretaceous volcano-sedimentary unit (Perinçek et al., 2015).

The basement in the study area and surroundings (Çorlu-Babaeski-Lüleburgaz-Silivri) is made up of the Istranca metagranite (Figure 2). It is overlain unconformably by cover sediments of the Paleogene (MTA Stratigraphy Committee Lithostratigraphy Unit Series, 2006; Siyako, 2006*b*; Siyako and Huvaz, 2007; Şafak and Güldürek, 2016*a,b*).

Miocene and later units cover the Eocene-Oligocene sequence in the Central and Northern Thrace. Öztunalı and Üşümezsoy (1979) reported that Taner and Çağatay, 1983 had studied granitic rocks in the southern slope of the Istranca Massif. Miocene and later units in Central and Northern Thrace cover the Eocene-Oligocene sequence. Siyako (2006*b*) suggested that the lithostratigraphic roof of the Thrace Basin can be established using the data obtained from southern Thrace, Gökçeada, Bozcaada and Gallipoli Peninsula and the seismic sections and exploration wells in North Thrace. A clear description has yet to be given for the Eocene-Oligocene deposits belonging to the outcrops of the Thrace Basin in the Armutlu Peninsula (Akartuna, 1968), between Mudanya and Trilye in the Biga Peninsula (Siyako et al., 1989) in the south of the Marmara Sea, which shows the southern border of the Thrace Basin.

The basin sedimentation probably started as a transgressive sequence during the Early Eocene (Saner, 1985; Turgut and et al., 1983; Doust and Arıkan, 1974; Keskin, 1974). A metamorphic complex presents the foundation of the basin. The Strandja Mountains are 9,000 meters in thickness, starting from the southern skirts and extending to cover almost all of the Thrace (Figure 1) (Perinçek et al., 2011; Siyako, 2006*a,b*; Siyako, 2005; Görür and Okay, 1996; Turgut and Eseller, 2000; Turgut et al., 1991; Kopp et al., 1969; Perinçek, 1987).

The Paleogene-Neogene units of Thrace are generally composed of clastic rocks but also contain carbonates in the shelf areas and on the ridge and peaks in the middle of the basin. These units were deposited in basins in seven separate time periods, with significant phases of uplift and erosion (Perinçek et al., 2015). The sedimentation in the central part of the basin is partly continuous and in some parts, discontinuities and erosion phases can be observed. The basin floods very quickly and is filled up as it sinks. Turgut et al. (1983) and Keskin (1974) reported that Eocene transgression reached maximum levels in the Early Oligocene as carbonates were deposited at the northern shelf and at the Kuleli - Babaeski elevation, while the deep parts of the basin were filled with turbidity currents in the Middle Eocene - Early Oligocene. Turgut et al. (1983) observed that the Thrace Basin was influenced by delta system formed by a great river, with submarine fans having been formed accordingly.

Keskin (1974), Ediger (1982, 1988), Turgut et al. (1983) and Saner (1985) reported that the regression period of the Eocene transgression occurred in between Middle Oligocene-Lower Miocene stage interval**.** The terrestrial palynofacies of the Late Miocene-Early Pliocene of the Ergene and Kırcasalih formations were reported by Ediger (1982) to have been deposited after a sedimentation in the Middle Miocene. It has also

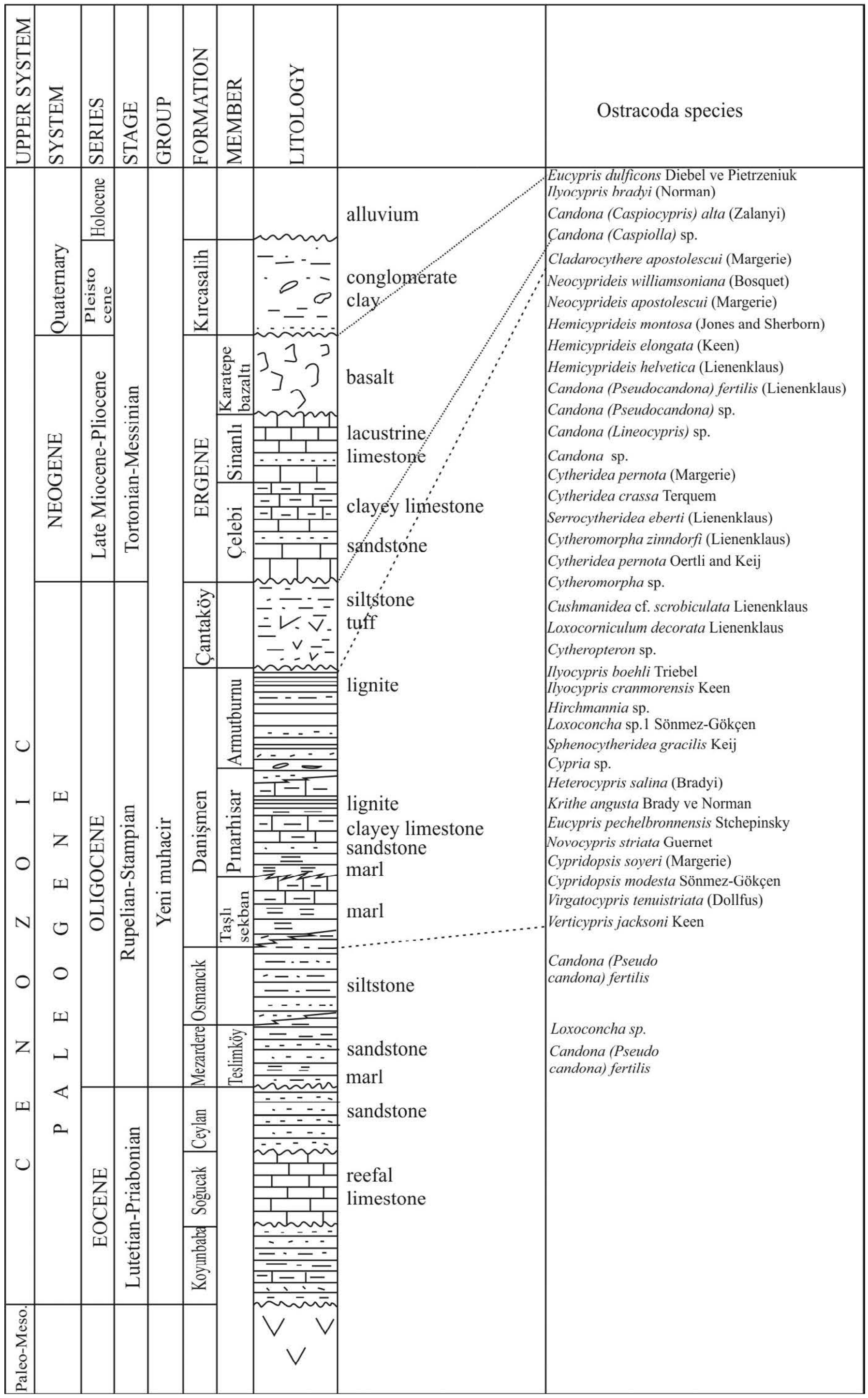

Figure 2- Generalized measured section of the study area.

been observed that the Late Miocene, Early Pliocene - Pleistocene units, which developed after subduction in the Middle Miocene, are a sedimentary products that followed the subduction phase, with a less obvious discrepancy being observed between Late Miocene and Pliocene (Perinçek et al., 2015).

The basin is an area where intensive geological investigations have been carried out on account of the lignite it contains. Some of the major studies that have been conducted on this issue in the Thrace Basin include those by Lebküchner (1974), Perinçek et al. (2011), Sütçü et al. (2009), Rückert-Ülkümen et al. (2009), Şengüler et al. (2000), İslamoğlu et al. (2008), Kara et al. (1996), Şengüler et al. (2003), Şengüler (2008, 2013), Atalay (2002), Perinçek et al. (2015) and Şafak and Güldürek (2016*a,b*), together with the study of a regional geology team, determined the fossil coverage and age of the lignite sandstone formation unit. Furthermore, Kara (1996) reported the general geology of the province and the important coal lands in the Thrace Basin, while Şengüler et al. (2000) conducted a study on the coal deposits and the samples taken from coal mined in Keşan, Malkara and Uzunköprü.

In a separate study by Şengüler (2008), an investigation of the Thrace Basin coals was carried out, and in addition to providing a description of their characteristics, it was determined that coals of the Thrace Basin had been deposited in the delta marshes of the lacustrine environments of the coals. While the rate of the collapse of the product is high, there is excessive sediment thickness, making the correlation of the coal veins difficult. Another study conducted by Şengüler (2013) showed that the environmental conditions of the river were optimal during the settlement of the Danişmen Formation and therefore prevented lignite sedimentation.

4. Paleostratigraphical Results

4.1. Stratigraphy

Units exposed in the study area from base to top are Danişmen Formation, Çantaköy Formation, Ergene Formation, Kırcasalih Formation and alluvium.

The Danişmen Formation is widely exposed in the study area and it is the top unit of the regressive delta system that begins with the Mezardere Formation. The formation consists of Taşlısekban, Pınarhisar and Armutburnu members. The Çantaköy Formation overlies the Danişmen Formation unconformably and it is expressed by siltstone and tuffs.

In this study, the average thickness of the units was measured as 200 m.

In this study the Danişmen Formation contains ostracod species such as *Cytheromorpha zinndorfi* (Lienenklaus) from family Cytheridea; *Cladarocythere apostolescui* (Margerie) from family Limnocytheridae; *N. williamsoniana* (Bosquet), *Neocyprideis apostolescui* (Keij), *Hemicyprideis helvetica* (Lienenklaus), *H. elongata* Keen, *H. montosa* (Jones & Sherborn), *Cytheridea crassa* Ducasse, C. *pernota* Oertli & Keij, *Sphenocytheridea gracilis* Keij and *Serrocytheridea eberti* (Lienenklaus) from family Cytherideidae; *Cushmanidea scrobiculata,* (Lienenklaus) from family Cuchmanideidae; *Krithe angusta* Deltel from family Krithidae; *Loxocorniculum decorata*, *Hirschmannia* sp., and *Loxoconcha* sp.1 Sönmez-Gökçen from family Loxoconchidae; *Candona (Lineocypris)* sp., *Candona (Pseudocandona)* sp., and *Candona (Pseudocandona) fertilis* Triebel from family Candonidae; *Novocypris striata Ilyocypris cranmorensis* Keen, and *I.boehli* Triebel from family Ilyocyprididae; *Verticypris jacksoni* Keen, *Virgatocypris tenuistriata* (Dollfus), and *Eucypris pechelbronnensis* Stchepinsky from family Cyprididae; and *Cypridopsis soyeri* (Margerie) from family Cypridopsidae. In addition, there are pelecypod and gastropod genera such as *Avimactra*, *Viviparus,* and *Valvata* of Oligocene age (Figure 2).

The Ergene Formation is widespread in the study areas, and it also has cross-layered conglomerate, sandstone containing abundant plant material, mudstone, and claystone. The formation is composed of Çelebi and Sinanlı members and is overlied by Karatepe volcanics.The thickness is approximately 50 m as obtained in this study.

The samples from the Ergene Formation contain ostracod assemblages dominated by *Candona (Caspiocypris) alta* Zalanyi from family Candonidae, *Ilyocypris bradyi* Sars from family Ilyocyprididae, *Eucypris dulcifons* Diebel & Pietrzenuik, and *Heterocypris salina* (Brady) from family Cyprididae. These ostracod species indicate Late Miocene–Pliocene age. Kırcasalih Formation contains conglomerate, clay and overlies the Ergene Formation uncomformably.

4.1.1. Measured Stratigraphic Sections, Boreholes And Their Ostracod Contents

Bıyıkali measured section (Tekirdağ-Hayrabolu way): Scale layouts used were taken from the 1:25000 map area F18-c4, beginning with coordinates X_1: 533558.16 E, Y_1: 4541547.36, N Z_1: 226 m and finishing with coordinates X_2: 533561.93 E, Y_2: 4540723.42 N, Z_2: 255 m. From the 35 m thick measured section ten samples were taken for washing. The section consists of yellowish siltstone, sandstone, and claystone. In the section of the Danişmen Formation, following ostracod species *Cytheromorpha zinndorfi* (samples 1, 7, 10); *Neocyprideis apostolescui* (sample 5); *Hemicyprideis montosa* (samples 2, 6, 7); *Cytheridea pernota* (samples 1, 6 ,10); and *Serrocytheridea eberti* (samples 6,7) were identified. In accordance with the identified ostracod fauna, age is determined as Rupelian/Stampian (Figure 3).

Beşer Tuğla measured section: Scale layouts used were taken from the 1:25000 map area G18b1, beginning with coordinates X1:526628.13 E, Y1: 4533404 N, Z_1: 216 m and finishing with coordinates X2:526490.57 E, Y2: 4535116.81 N, Z_2: 115 m. Five washed samples were taken from the measured section, which is 22 m thick. The well-known Mezardere (No.1) clay is at the base of the section and shows concretion and lamination features. There are siltstone beds containing sandstone interbeds in this unit. The succession continues upward with sandstone.

The section is represented by *Loxoconha* sp. and *Candona (Pseudocandona)* sp. (rare) in sample 1; *Cladarocythere apostolescui* and *Neocyprideis williamsoniana* (rare), *Cytheridea pernota* and *Candona (Pseudocandona)* sp. (common), and *Hemicyprideis montosa* and *Ilyocypris boehli* (very common) in sample 2; *Cytheridea pernota* (very rare) in sample 3; and *Loxoconcha* sp.1 Sönmez-Gökçen (common) in sample 4 (Figure 4).

Silivri coast measured section: Scale layouts used were taken from the 1:25000 map area F20-d3, beginning with coordinates X_1:604945.43 E, Y_1: 4547371.95 N, Z_1: 97 m and finishing with coordinates X_2: 604128.86 E, Y_2. 4547360.30 N, Z_2: 122 m. Three samples were taken from the 28 m thick measured section.The section is dominated by yellowish, leaf-tracked, lignite-veined sandstone. Sample 2 taken from the lignite sandstone contains *Cladarocythere apostolescui* (common), *Hemicyprideis montosa* (frequent), *Eucypris pechelbronnensis*, *H. elongata, Candona (Pseudocandona)* sp., *Candona (Pseudocandona) fertilis* Triebel (rare). *Hemicyprideis montosa* (very rare) is both observed in the samples 2, 3 are observed in the study area (Figure 5).

Malkara-Tekirdağ measured section (Malkara Surface Mining): Scale layouts used were taken from the 1:25000 map area G17-b1, beginning with coordinates X_1:458312.02 E, Y_1: 4534233.48 N, Z_1: 134 m and finishing with X_2: 488382.20 E, Y_2. 4534264.20 N, Z_2: 115 m. Eight washed samples were taken from the 70 m thick measured section. The section was measured from beginning to top.

Sample 1, taken from the carbonate, includes abundant silicified wood fossils and contains very rare *Cytheridea pernota, Hemicyprideis montosa, H. elongata,* and rare *Cushmanidea scrobiculata.* Claystone with the sample number 2 contains, contains rare *Cytheromorpha zinndorfi* and very rare *Cushmanidea scrobiculata* and *Krithe angusta*. Sample 3, which was taken from caesious siltstone, contains rare *Cytheridea pernota.* Sample 4, from the claystone, includes very common *Hemicyprideis montosa* and very rare *Hemicyprideis elongata.* Sample 5 contains very rare *Sphenocytheridea gracilis* and rare *Krithe angusta.* Samples 6, 7, and 8, were taken from the bottom of the section, contain rare to common *Cytheromorpha zinndorfi,* very rare to common *Serrocytheridea eberti,* rare to common *Cytheridea pernota,* common *Haplocytheridea helvetica,* very common *Hemicyprideis montosa,* very rare to common *Hemicyprideis elongate* (Figure 6).

Silivri-Değirmenköy measured section (western part of Silivri region): Scale layouts used were taken from the 1:25000 map area F20-d4, beginning with coordinates X_1:584992.95 E, Y_1: 4552551.85 N, Z_1: 157 m and finishing with coordinates X_2: 584952.24 E, Y_2: 4552613.53 N, Z_2: 210 m. Nine washed samples were taken from the measured section, which is 75 m thick. The section contains light-colored siltstone, tuffaceous siltstone, and sandstone. The fauna is composed of frequent to common *Cytheromorpha zinndorfi* in samples 2, 3, 5 and 7; common *Cytheromorpha* sp. in sample 6; frequent *Cytheridea pernota* in samples 4 and 7; very common *Hemicyprideis montosa* in samples 2, 3, 4, 5 and 7; common *Cushmanidea scrobiculata* in samples 2 and 5; common *Loxocorniculum decorata* and *Cytheropteron* sp. in samples 2 and 3; rare *Candona (Caspiocypris) alta*, *Candona (Caspiolla)* sp., and *Heterocypris salina* in sample 9 from the Ergene Formation (Figure 7).

TB-57 (Hacısungur) drilling log: This drilling was carried out at coordinates X: 4538398, Y: 501100 and

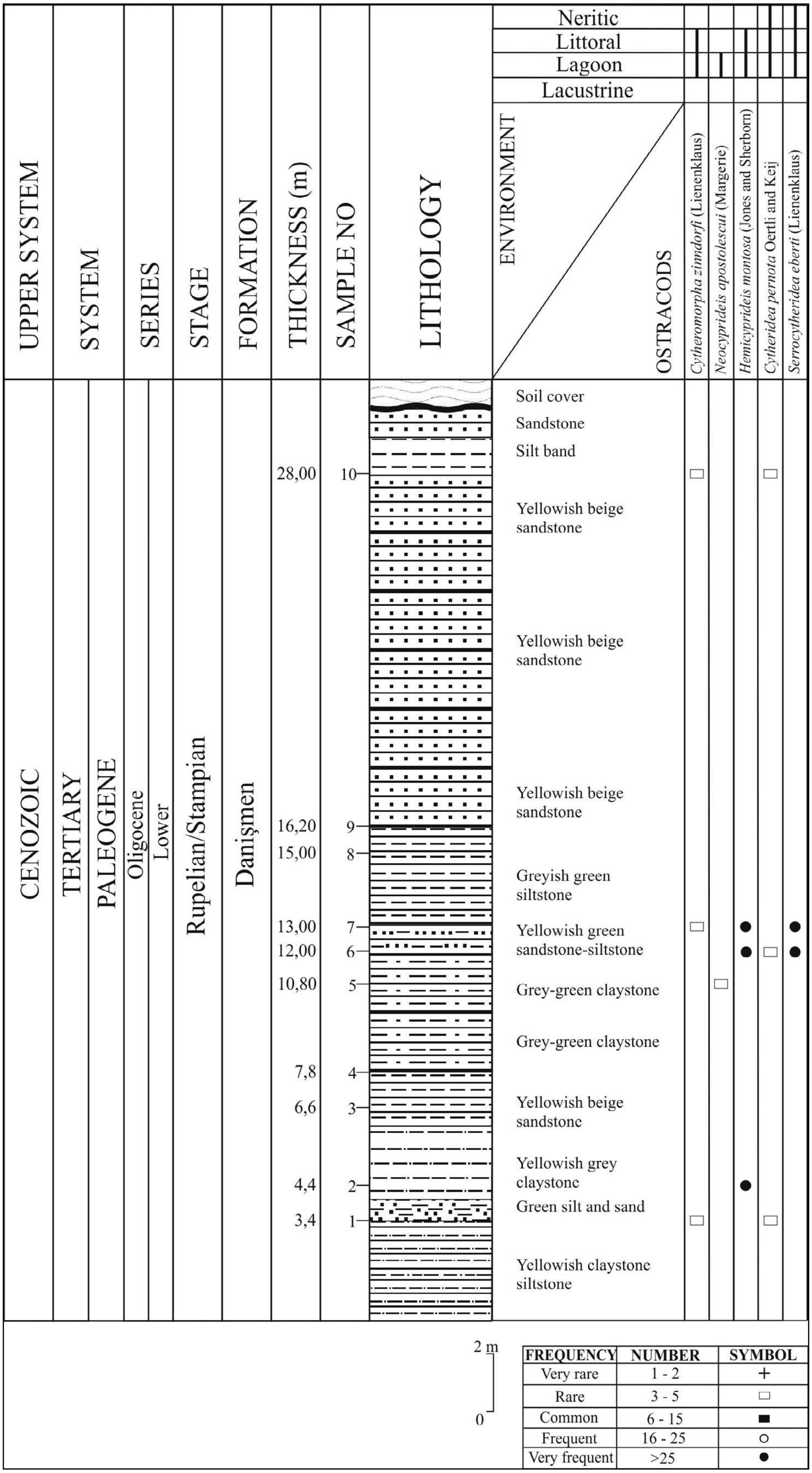

Figure 3- The distribution of ostracod species in Bıyıkali measured section.

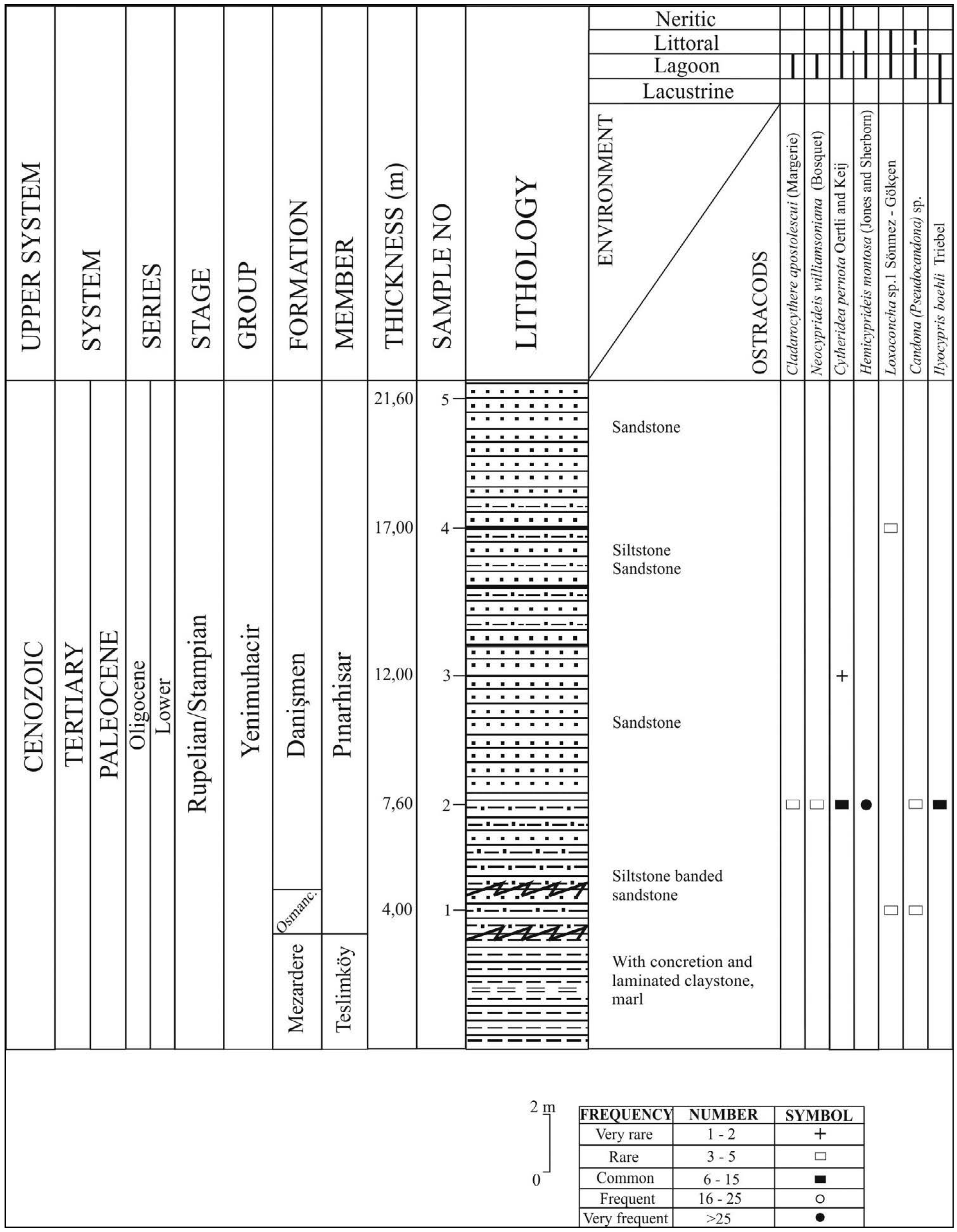

Figure 4- The distribution of ostracod species in Beşer Tuğla measured section.

Z: 134 m of 1:25000 map area G18-a1. Drilling depth is 557 m, and 90 wash samples were taken from the drilling log. The borehole penetrated the Danişmen and Ergene formations. The Danişmen Formation and its Pınarhisar Member were drilled from the depth 557 m. to 11.50m.

Only 11.50 m of the Ergene Formation and Çelebi Member were cut in borehole.

Ostracod species and genera obtained from the Danişmen Formation include *Neocyprideis apostolescui*, *Neocyprideis williamsoniana*, *Hemicyprideis helvetica*, *Hemicyprideis montosa*, *Cytheromorpha zinndorfi*, *Loxocorniculum decorata*, *Hirchmannia* sp., *Candona (Lineocypris)* sp., *Candona (Pseudocandona)* sp., *Candona (Pseudocandona) fertilis*, *Verticypris jacksoni*, *Ilyocypris cranmorensis*, *Ilyocypris boehli*, *Virgatocypris tenuistriata*, *Cypridopsis soyeri*, and *Eucypris pechelbronnensis* (Figure 8).

TD- 58 drilling log: This borehole was located at coordinates X: 4538750, Y: 502300, and Z: 142 m

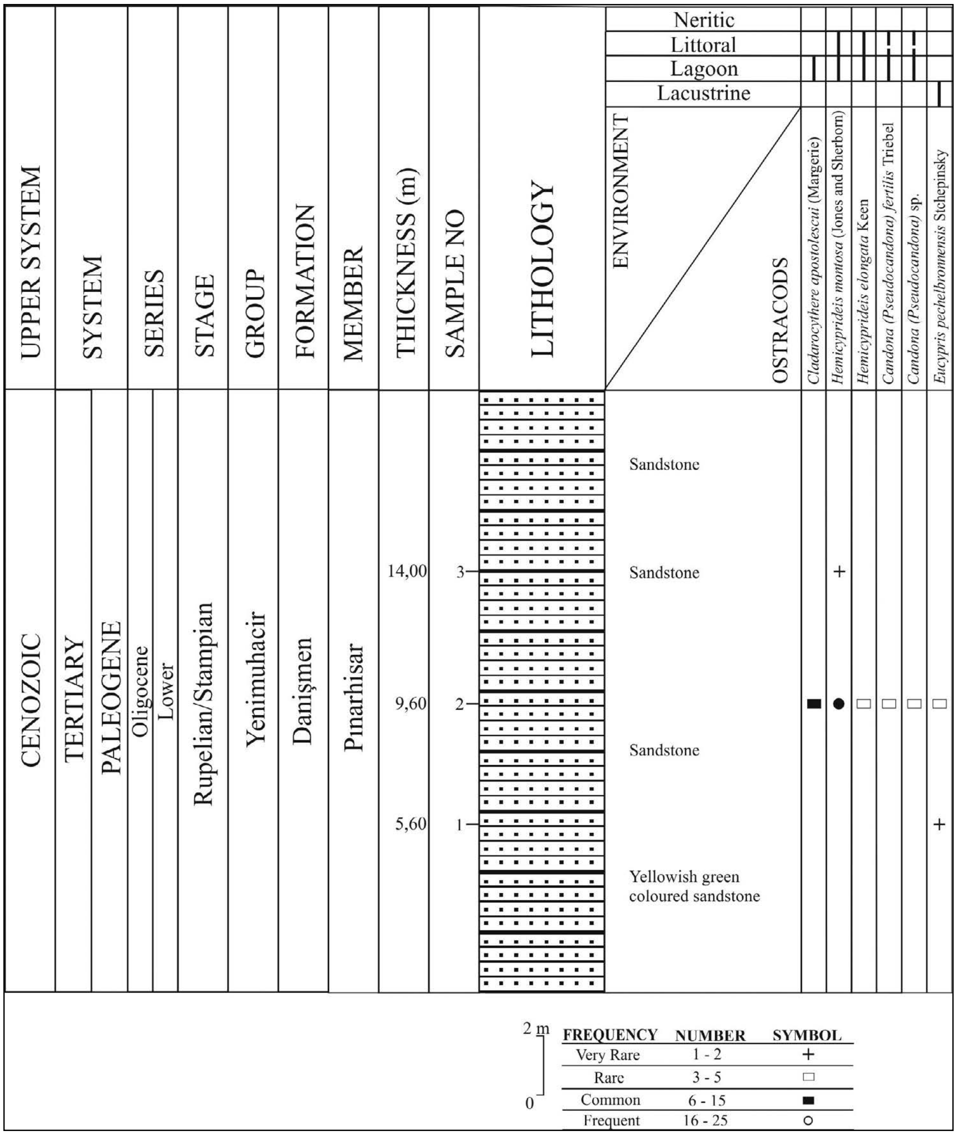

Figure 5- The distribution of ostracod species in Silivri measured section.

of 1:25000 map area G18-a1. Drilling depth was 47 m, and 16 wash samples were taken. In this borehole, the Ergene and Danişmen formations were cut. The upper 24.40 m penetrated the Ergene Formation, with Danişmen Formation from 24.40–46.30 m.

Ostracod genera and species found in this drilled section in the Ergene Formation were *Eucypris dulcifons*, *Ilyocypris bradyi*, and *Heterocypris salina*. Ostracod genera and species in the Danişmen Formation were *Cladarocythere apostolescui*, *Hemicyprideis montosa*, *Cytheridea pernota*, *Neocyprideis* a*postolescui*, *Serrocytheridea eberti*, *Candona (Pseudocandona)* sp., *Candona (Pseudocandona) fertilis*, *Ilyocypris boehli*, and *Cypria* sp (Figure 9).

Lithological descriptions and fossil contents of spot samples: Two spot samples were taken from the clay unit along the Lüleburgaz–Babaeski road at map area F18-a_1 with coordinates X: 4586180, Y: 508038 and X: 4586074, Y: 516298. They contain *Candona (Caspiocypris) alta* and *Heterocypris salina* (Ergene Formation).

One spot sample was taken from the claystone unit along the Babaeski–Edirne road at F18-a_1 with coordinates X: 4593295, Y: 497759, Z: 101 m. It also contains *Candona* (*Caspiocypris*) *alta* and *Heterocypris salina* (Ergene Formation).

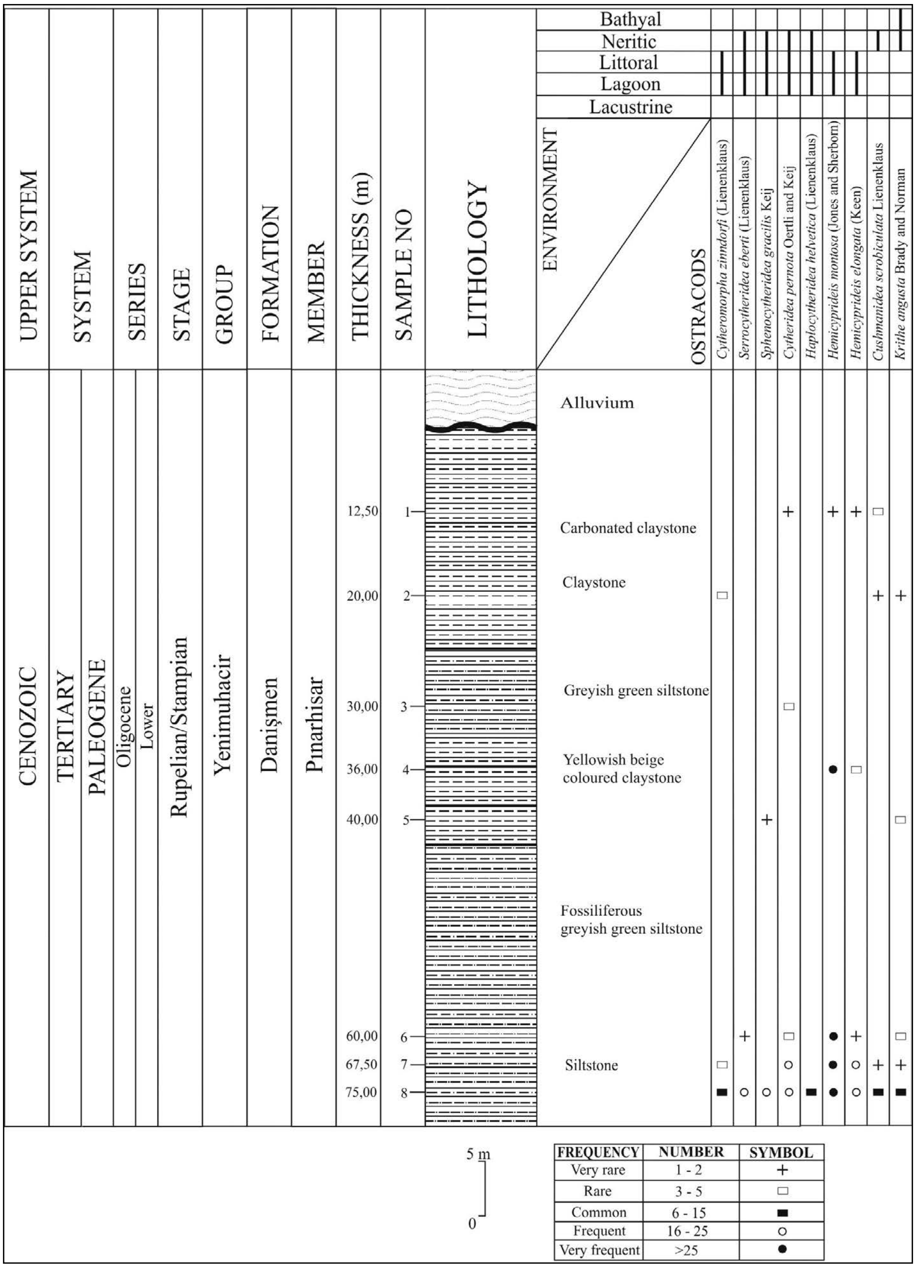

Figure 6- The distribution of ostracod species in Malkara-Tekirdağ measured section.

Two spot samples were taken from the claystone and clay-silt unit along the Babaeski–Edirne road at F17-b_2 with coordinates X: 4590755, Y: 502277, Z: 79 m. They contain *Eucypris dulcifons* and *Ilyocypris bradyi* (Ergene Formation).

Three spot samples were taken from the claystone unit along the Babaeski–Lüleburgaz road at F18-a_2 with coordinates X: 4585760, Y: 519085, Z: 77 m. The *Cyprideis* sp., *Candona* (*Caspiocypris*) *alta*, and *Cypridopsis* sp. were observed in the samples (from the Ergene Formation).

One spot sample was taken from the sandstone-siltstone unit along the Tekirdağ–Hayrabolu road at F18-c_3 with coordinates X: 4540670, Y: 539937, Z: 200 m. The sample contains *Hemicyprideis montosa, Cytheridea pernota,* and *Cypria* sp. (from the Danişmen Formation).

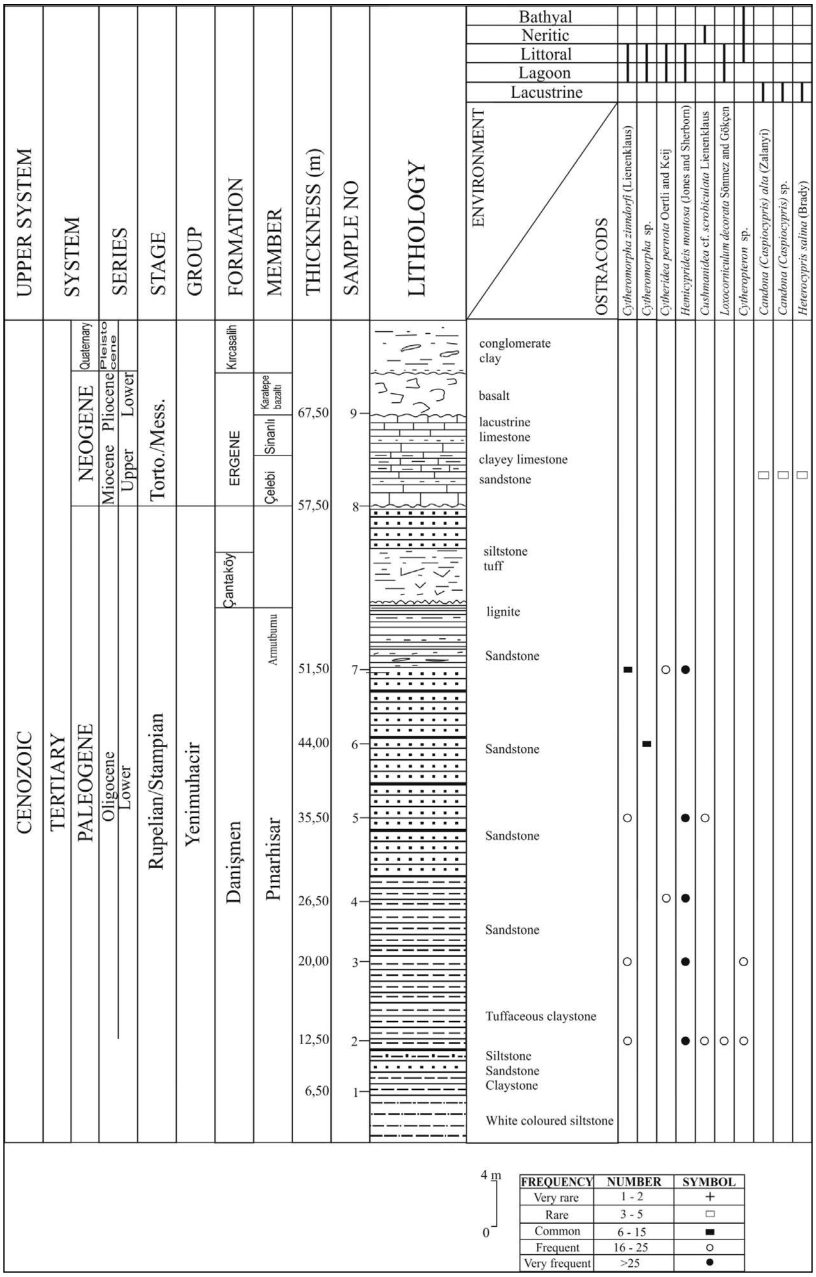

Figure 7- The distribution of ostracod species in Silivri-Değirmenköy measured section.

One spot sample was taken at Türkmenli Village, F18-c_4 with coordinates X: 4543542, Y: 570530, Z: 125 m. It contains *Hemicyprideis montosa* and *Candona (Pseudocandona) fertilis* (from the Danişmen Formation).

One spot sample was taken from the sandy pebble unit at Çiftlikköy at F20-d_4 with coordinates X: 4553023, Y: 589258, Z: 228 m. It contains *Heterocypris* sp. (from the Ergene Formation).

One spot sample was taken from the sandstone at İbribey, G18-a_2 with coordinates X: 4534500, y: 510640, Z: 206 m. It was barren.

Two spot samples were collected from conchoidal hard siltstone and claystone from the Barbaros-Nayip area at G18-b_2 with coordinates X1: 4525479, Y1: 534791/X2: 4525235, Y2: 534327 *Cladarocythere apostolescui* and *Cytheromorpha* sp. (from the Danişmen Formation) (Figure 10).

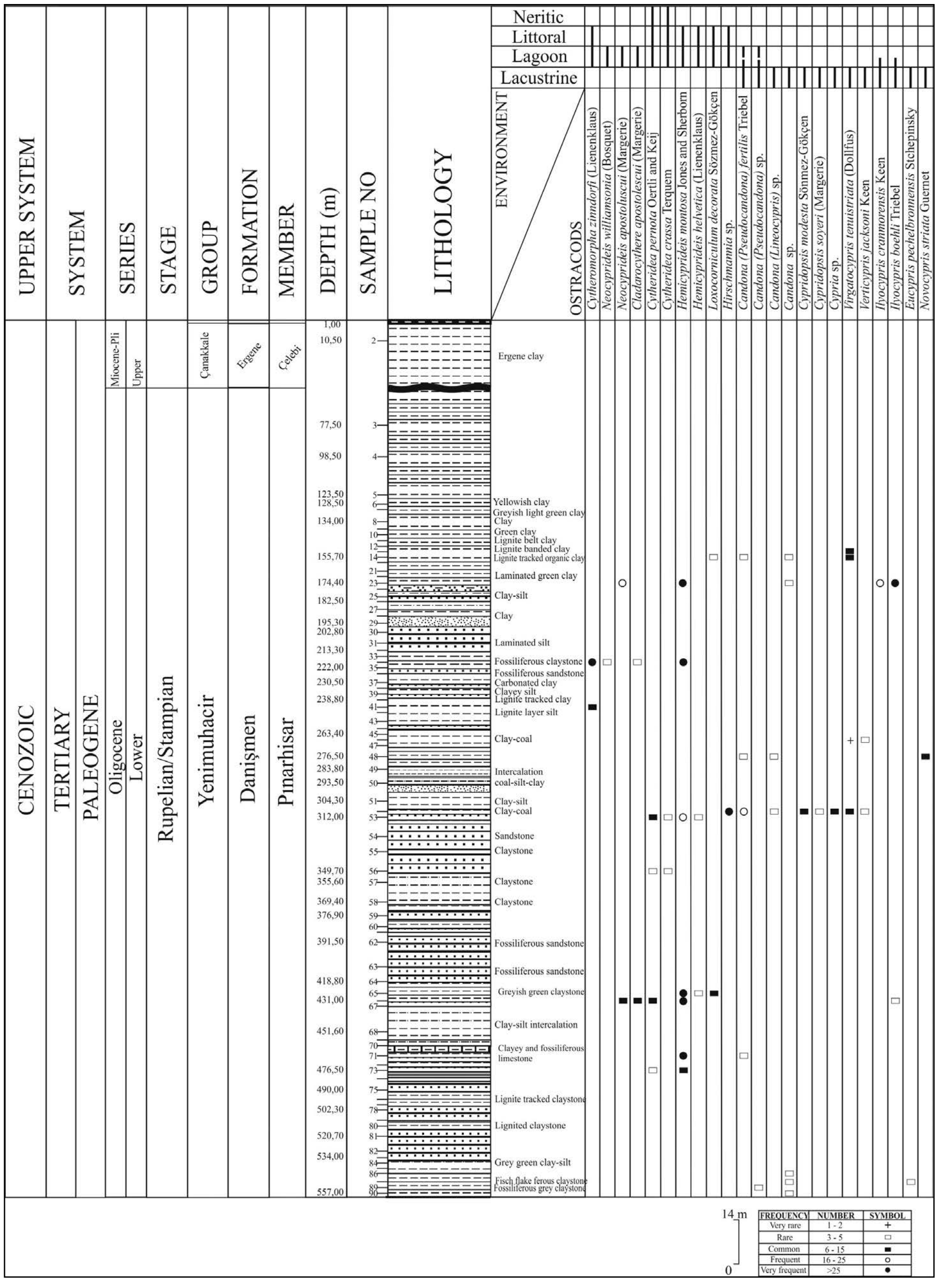

Figure 8-The distribution of ostracod species in Hacısungur (TB-57) drilling log.

5. Chronostratigraphical and Paleogeographical Distributions of Ostracoda

The ranges of the fossils observed in this study are as follows (Table 1)**:** *Cytheromorpha zinndorfi* in Germany at the Rupelian–Aquitanian (Lienenklaus, 1905; Keij 1957); in Belgium at the Eocene (Keij, 1957); in France and Turkey at the Early Oligocene (Sönmez-Gökçen, 1973; Apostolescu, 1964; Gökçen, 1975; Estéoule et al., 1986; Şafak, 1997; Şafak and Güldürek, 2016*a*; Şafak, 2008; Şafak, 2016; Şafak, 2010*a*; Şafak et al., 2015; and Şafak and Güldürek, 2016*b*; and in Switzerland at the Oligocene (Oertli, 1956).

Neocyprideis apostolescui in England, France, and Turkey at the Middle Eocene (Şafak, 1990; Şafak, 2008; Şafak, 2010*b*; Şafak and Güldürek, 2016*a,b*; Şafak et al., 2015; Oertli, 1985; Haskins, 1969; Nazik, 1993; Şafak, 2010*a*; Şafak, 2016).

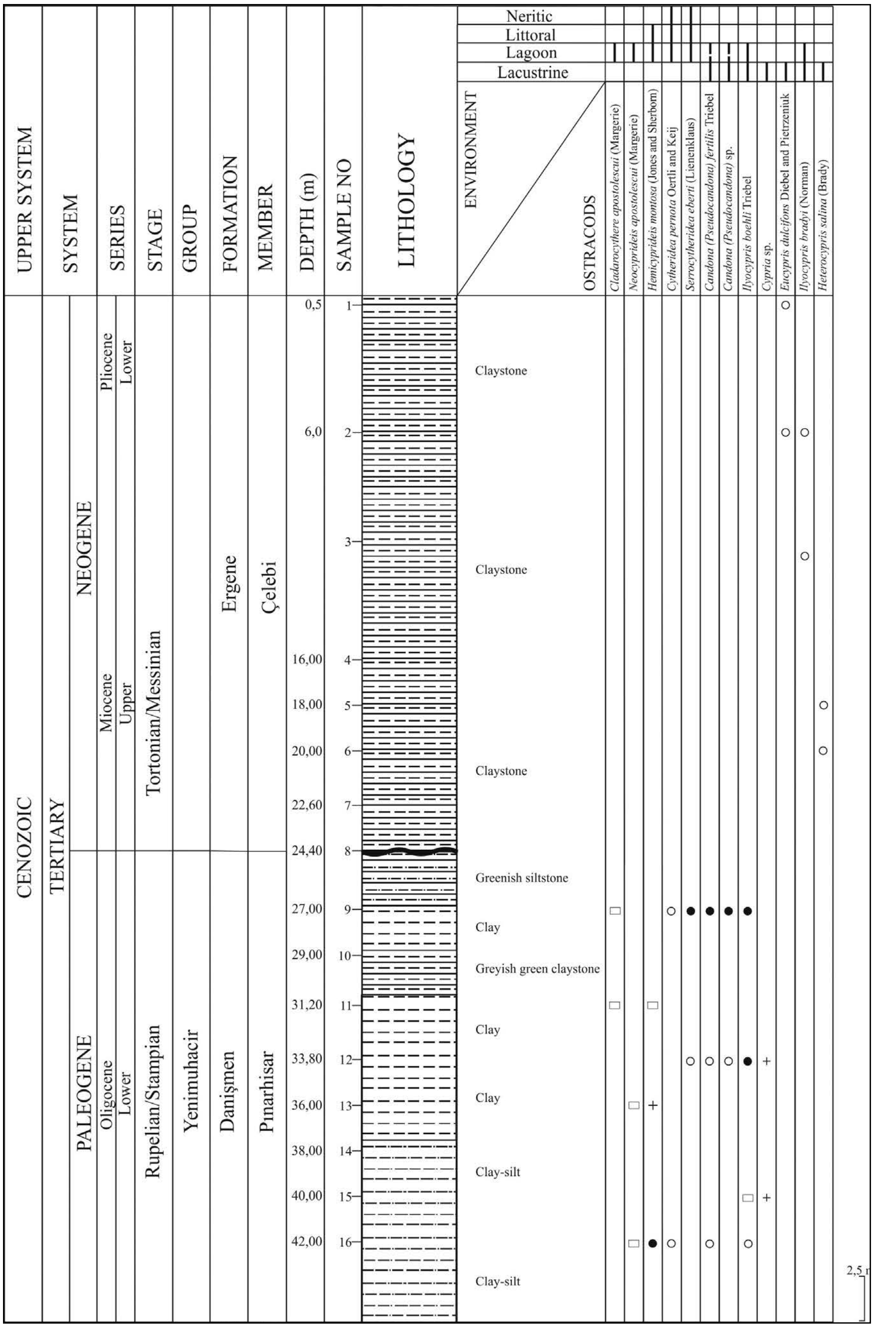

Figure 9- The distribution of ostracod species in TD-58 drilling log.

Neocyprideis williamsoniana in England and France at the Early Oligocene (Keen, 1972; Haskins, 1969; Oertli, 1985; Şafak, 1993; Şafak, 2008; Şafak, 2010*a*; Şafak, 2010*b*; Şafak et al., 2015; Şafak and Güldürek, 2016*a,b*; Şafak, 2016).

Cladarocythere apostolescui in England and Turkey at the Early Oligocene (Keen, 1972; Şafak and Güldürek, 2016*a*; Şafak et al., 2015; Şafak and Güldürek, 2016*b*; Şafak, 2016).

Cytheridea pernota in Romania, Hungary, France, England and Turkey at the Late Eocene–Early Oligocene (Jiricek, 1983; Monostori, 1983; Oertli, 1985; Keen, 1972; Şafak, 2010*a*; Şafak, 2008; Şafak et al., 2015; Şafak and Güldürek, 2016*a,b*; Şafak, 2016).

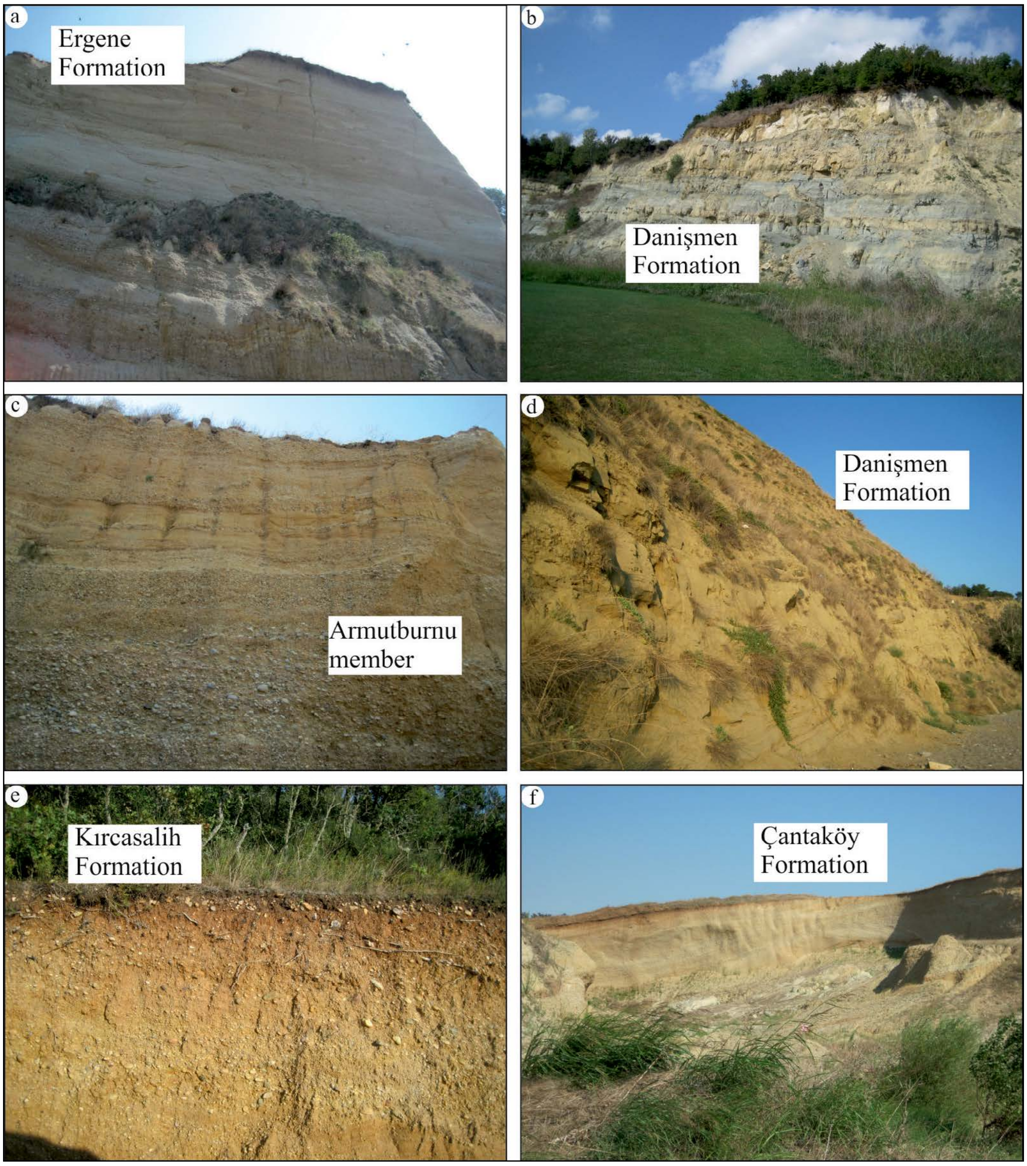

Figure 10- Outcrops of the studied formation.a. Çiftlikköy, Ergene; b. Bıyıkali village, Danişmen; c. Barbaros-Nayip area, Armutburnu-Danişmen; d. Silivri coast, Danişmen; e: Çorlu-Türkmenli village, Kırcasalih; f: Silivri-Değirmenköy-Çantaköy village, Çantaköy.

Cytheridea crassa in Turkey/Malatya at the Middle Eocene (Şafak, 1990) and in France/Aquitaine Basin at the Eocene (Oertli, 1985).

Serrocytheridea eberti in Germany at the late Oligocene (Colin and Carbonnel, 1992), at the Rupelian (Lienenklaus, 1894; Uffenorde and Radtke, 2008); in the Paris Basin at the Stampian (Oertli, 1985); and in France at the Aquitanian (Colin and Carbonnel, 1992); in Switzerland at the Rupelian-Chattian (Oertli, 1956); in Turkey/Thrace at the Sannoisian, at the Oligocene (Sönmez-Gökçen, 1973; Witt, 2011)

Sphenocytheridea gracilis in the Paris Basin at the Lutetian (Keij, 1957, Oertli, 1985)

Haplocytheridea helvetica in Switzerland at the Rupelian–Chattian (Oertli, 1956); in Germany at the Chattian (Goerlich, 1953); in western Europe at the Oligocene (Oertli and Key, 1955); in Belgium at the Tongrian–Rupelian (Keij, 1957); in Holland at the Tongrian (Keij, 1957); in China/Tarim Basin at the Late Eocene (Bosboom et al., 2011); in Turkey/Thrace at the Sannoisian (Sönmez-Gökçen, 1973);

Table 1- The correlation of ostracod species span in Eocene-Oligocene-Pliocene sediments in Turkey with other European basins.

OSTRACOD SPECIES	EOCENE			OLIGOCENE		MIOCENE			PL.	QUA.
	LOWER	MIDDLE	UPPER	LOWER	UPPER	LOWER	MIDDLE	UPPER		
Cytheromorpha zinndorfi (Lienenklaus)			€€€	+++ *** ### $$$	$$$					
Neocyprideis apostolescui (Margerie)		ééé *** ###								
Neocyprideis williamsoniana (Bosquet)				ééé ***						
Cladarocythere apostolescui (Bosquet)			ééé ###	ééé ###						
Cytheridea pernota Oertli and Keij			ééé *** <<< >>> ###	ééé *** <<< >>> ###						
Cytheridea crassa Terquem	***	*** ###	***							
Serrocytheridea eberti (Lienenklaus)				+++ $$$ ###	+++ $$$ ###					
Sphenocytheridea gracilis Keij		***								
Haplocytheridea helvetica (Lienenklaus)			^^^	OOO €€€ !!! $$$ ###	+++ OOO $$$ ###					
Hemicyprideis montosa (Jones and Sherborn)				ééé *** ###						
Hemicyprideis elongata (Keen)				ééé *** ###						
Hemicyprideis helvetica (Lienenklaus)				ééé *** ###	### >>>					
Loxocorniculum decorata Sönmez-Gökçen				###						
Ilyocypris boehli Triebel				ééé ###	###					
Ilyocypris bradyi (Norman)						QQQ ??? AAA JJJ	QQQ ??? AAA JJJ	QQQ ??? AAA JJJ ###	###	###
Ilyocypris cranmorensis Keen				ééé						
Novocypris striata Guernet	***	***	***	###	###					

Germany +++ Lienenklaus, 1896, 1905; Goerlich, 1953; Keij, 1957; Carbonel ve Ritzkovski, 1969
France *** Apostolescu, 1964; Estéoulle et al., 1986
Belgium €€€ Keij, 1957
England ééé Haskins, 1969; Keen, 1972
Sweden $$$ Oertli, 1956; Carbonel, Weidmann ve Berger, 1985
Turkey ### Sönmez-Gökçen, 1973; Gökçen, 1975; Şafak, 1990, 1997, 2003, 2008, 2010, 2010 a,b, 2013; Şafak et al., 1999, 2005, 2013; Şafak ve Güldürek, 2014; Nazik, 1993; Tanar ve Gökçen, 1990; Ünlügenç ve diğ., 1991; Witt, 2003, 2011; Freels, 1980; Şafak ve diğ., 1992, 1999, 2015; Nazik et al., 1992, 1999, 2008; Avşar ve diğ., 2006; Matzke-Karasz&Witt, 2005
Hungary <<< Monostori, 1983
Romania >>> Jiricek, 1983; Vasiliev et al., 2005
Europe OOO Triebel, 1963; Oertli et al., 1955)
Netherlands !!! Keij, 1957
China ^^^ Bosbom et al., 2011, Xiangzhong et al., 2010; Mischke et al., 2003
Serbia === Krstic, 1972
Slovakiaa &&& Pipik, 2001
Baltic Sea \\\ Meisch, 2000; Annette and Strahl, 2011
Kaspik Basin /// Zalanyi, 1929
Urals DDD Danukalova et al., 2007
Africa QQQ
Asia ???
USA AAA
Middle East JJJ

Hemicyprideis montosa and *H. elongata* in France, England, and Turkey at the Early Oligocene (Oertli, 1985; Keen, 1972; Şafak et al., 2005; Şafak, 1993; Şafak, 2010*a*; Şafak, 2008; Şafak, 2010*b*; Şafak et al., 2015; Şafak and Güldürek, 2016*a,b*; Şafak, 2016);

H. helvetica in Paris and England at the Early Oligocene (Oertli, 1985; Keen, 1972); in Romania at the Late Oligocene (Jiricek, 1983); and in Turkey (in the Mut Basin, Karsanti Basin, Tekirdag, Denizli and Thrace) at the Oligocene (Tanar and Gökçen, 1990; Şafak et al., 2005; Şafak, 1993; Şafak, 2008; Şafak, 2010*a*; Şafak and Güldürek, 2016*a,b*; Şafak, 2016);

Loxocorniculum decorata in Turkey/Thrace SE at the Sannoisian (Sönmez-Gökçen, 1973; Şafak, 2016; Şafak et al., 2015)

Candona (Pseudocandona) fertilis in Germany at the Early and Late Oligocene (Carbonnel and Ritzkovski, 1969); in Switzerland and France at the Late Oligocene (Carbonnel and Ritzkovski, 1969); in Europe at the Oligocene (Triebel, 1963); and in Turkey (Karsantı Basin, İstanbul, Thrace Basin) at the Early-Late Oligocene (Şafak, 1997; Şafak et al., 2015; Şafak and Güldürek, 2016*a,b*; Şafak, 2016; Şafak, 2010*a*; Ünlügenç et al., 1991)

Cypridopsis modesta in Turkey/Thrace SE at the Sannoisian (Sönmez-Gökçen, 1973).

Virgatocypris tenuistriata in France/Paris Basin at the Late Eocene (Oertli, 1985); in England at the Sannoisian (Keen, 1972); and in Turkey at the Rupelian/Stampian (Şafak et al., 2015; Şafak, 2016).

Verticypris jacksoni and *Ilyocypris cranmorensis* in Turkey (İstanbul and Thrace Basin) at the Rupelian/Stampian (Şafak, 2016; Şafak et al., 2015); in England at the Sannoisian (Oertli, 1985)

Cypridopsis soyeri in Turkey (NW Thrace Basin and İstanbul) at the Oligocene (Şafak et al., 2015; Şafak and Güldürek, 2016*a*; Şafak, 2016); in England at the Sannoisian (Keen, 1972);

Ilyocypris boehli in Turkey (Thrace Basin, İstanbul, Mut Basin, Karsantı Basin) at the Early and Late Oligocene (Sönmez-Gökçen, 1973; Şafak et al., 2015; Şafak and Güldürek, 2016*a;* Şafak, 2016; Tanar and Gökçen, 1990; Şafak et al., 2005; Şafak, 1993; Ünlügenç et al., 1991); in England at the Early Oligocene (Keen, 1972)

Eucypris pechelbronnensis in Turkey (Thrace Basin and İstanbul) at the Rupelian/Stampian (Şafak et al., 2015; Şafak, 2016); England and France at the Sannoisian (Stchepinsky, 1960; Keen, 1972)

Novocypris striata in the Aquitaine Basin at the Eocene; in the Paris Basin at the Stampian–Early Eocene (Oertli, 1985); and in Turkey/Thrace NW and İstanbul at the Oligocene (Şafak et al., 2015; Şafak and Güldürek, 2016*a,b*; Şafak, 2016).

Eucypris dulcifons in NW China Recent and in China at the Pleistocene (Li et al., 2010) in the Baltic Sea at the Pleistocene–Holocene (Kossler and Strahl, 2011); in NW China at Recent (Mischke et al., 2003); in the South of the Ural Mountains at the Late–Middle Pleistocene (Danukalova et al., 2007); in Turkey (İstanbul, Kayseri) at the Late Miocene, Tortonian, and Pliocene (Şafak, 1997; Şafak et al., 1999*a,b*; Nazik et al., 1992) and in Akyatan Lagoon the Recent (Nazik et al., 1999).

Heterocypris salina in the North and Baltic Seas at the Late Miocene–Recent (Meisch, 2000); in Serbia at the Middle Miocene (Krstic, 1972); in Slovakia at the Late Miocene (Pipik, 2001); in W Anatolia at the Late Miocene–Pliocene (Witt, 2003); in SW Anatolia at the Late Miocene (Freels, 1980); in NW Anatolia at the Pannonian–Pleistocene (Matzke-Karasz and Witt, 2005); in Turkey/Malatya at the Upper Miocene (Nazik et al., 2008); in the Bakırköy Basin at the Tortonian (Şafak, 1997); in W Istanbul at the Pliocene (Şafak et al., 1999*a*), (Şafak et al., 1999*b*); and in Denizli at the Late Miocene (Şafak, 2010*a*); in Thrace at the Late Miocene –Pliocene (Şafak and Güldürek, 2016*b*).

Ilyocypris bradyi in Middle East, South America, Middle Asia, North Africa, and Europe at the Miocene–Recent (Meisch, 2000); in Turkey (İstanbul, Kayseri, Thrace Basin) at the Pliocene (Şafak et al., 1999*a,b*); in the Bakırköy Basin at the Tortonian (Şafak, 1997); in Kayseri at the Pliocene (Şafak et al., 1992; Nazik et al., 1992); in the west of Istanbul at the Pliocene (Şafak et al., 1999*a,b*) and in Yumurtalık Bay the Recent (Şafak, 2003); in Thrace at the Late Miocene –Pliocene (Şafak and Güldürek, 2016*b*).

Candona (Caspiocypris) alta in the Caspian Basin at the Late Miocene (Zalanyi, 1929); in the south of the Carpathian Mountains at the Miocene–Pliocene (Vasiliev et al., 2005); in Romania at the Sarmatian (Hanganu, 1974); in Turkey (Sivas and

Şebinkarahisar) at the Upper Miocene (Freel, 1980); in Sarız and Tufanbeyli at the Pliocene (Şafak et al., 1992; Nazik et al., 1992); in Hınıs/Erzurum at the Pliocene–Early Pleistocene (Şafak, 2013).

It was stated by Islamoğlu et al. (2008) that Paratethys sea, a branch of the Tethys, dominated Thrace during Eocene epoch in the form shallow marine carbonate platforms, and the three-stage isolation process started later during Oligocene Epoch. Some ostracods, such as *Neocyprideis apostolescui*, *Cytheridea crassa*, *C. pernota*, *Haplocytheridea helvetica*, were the samples observed within the Tethys ocean in different parts of the UK and Turkey. Ostracod fauna, which were also described in this study, were found in the shallow marine carbonate platforms during Middle and Late Eocene (Lutetian-Priabonian) and considered remarkable to investigate Eocene-Oligocene transition. It is stated that during the early Rupelian period Thrace Region still contained the seas of Western Tethys, then the isolation from Tethys began and finally the eastern Paratetis endemic fauna and the third stage developed in the form of an increasing continent. The ostracods species, namely *Cytheromorpha zinndorfi*, *Cladarocythere apostolescui*, *Serrocytheridea eberti*, *Hemicypreidis montosa*, *H. helvetica*, *Candona (Pseudocandona) fertilis*, *Ilyocypris boehli*, are the samples observed in the UK, Switzerland, Romania, Hungary and Turkey to showing the characteristics of the Tethys- Paratethys. These species are the examples defined in this study in the Eastern Paratethys section, where the isolation of the early Oligocene (Rupelian) was stated to initiate.

The Late Oligocene period is explained to be observed in the formation of pure freshwater marshes and coastal marshes by the stream. The ostracod species of *Haplocytheridea helvetica*, *Hemicyprideis helvetica*, *Candona (Pseudocandona) fertilis*, *Ilyocypris boehli*, which show Paratethys properties, are observed in Hungary, Caspian basin and in various parts of Turkey. These species are the examples identified in the Late Oligocene by the authors, indicating the formation of fresh water marshes and the coastal marshes by the stream. It is stated that a sedimentary basin system originating from the changing tectonic regimes extended from the Western Mediterranean coasts, which lied in front of the Alps, to the areas including the Carpathians, and from there to the Caucasus, Caspian Sea and the Pontides in the East. These sedimentary strata are told to be firstly called as Paratethys by Laskarev (1924) (Kovac et al., 2017). It is stated that the Paratethys emerged in the early Oligocene and associated with the complete isolation of internal-continental Seas (Kovac et al., 2017), and low-organic carbon deposits were mentioned for the north of Central Paratethys.

In Neogene, the connection between the Mediterranean and the individual basins was very unstable, and the partial or total isolation of these basins must have led to the emergence of endemic fauna in each watershed system, and that the division of these internal seas were in three regions: Western (Alpine), Central (Carpathian, Balkan) and Eastern (Crimean-Caucasian) Paratethys. During the Late Miocene, the Central Paratethys sedimentary environment gradually changed into bitter and fresh water due to the isolation of Lake Pannon (Kovac et al., 2017). The area was filled with a large amount of deltaic sediment from the edges of the basin, thus the deep water lake environment gradually turned into shallow water (Kovac et al., 2017). At the end of this period, in the Mediterranean, the impact of Messinian salinity crisis and sea level on the Mediterranean was tectonically effective in the closed lake system, and alluvial plains began to develop (Kovac et al., 2017). Ostracod species such as *Ilyocypris bradyi*, *Heterocypris salina*, *Candona* (*Caspiocypris*) *alta* are the examples observed in Tethys-Paratethys during the studies carried out in the different parts of England and Turkey. These species are also described in this study as indicators of the development water fauna, which were transformed into shallow water due to the unstable and Pannonian insulations.

6. Lithostratigraphy and Paleoenvironmental Interpretation

The General Directorate of Mineral Research and Exploration Stratigraphy Committee published a book in 2006 entitled Thrace Lithostratigraphy Units within Lithostratigraphy Units Series-2.

Tertiary units in this basin were studied in detail by Kasar et al. (1983), Siyako (2002), Türkecan and Yurtsever (2002) and Siyako (2006*b*). The results of these studies show that the age of the Danişmen Formation is Middle Eocene–Lower Miocene (Yenimuhacir Group) and the age of the Ergene Formation (Çanakkale Group) is Late Miocene–

Pliocene. This study examined the Danişmen and Ergene formations (Figure 2).

The Danişmen Formation forms top unit in the Yenimuhacir Group (Siyako, 2002, 2006*b*). The Yenimuhacir Group was firstly named as a formation (Esso Standard, 1960; Holmes, 1961), then redefined by Ünal (1967) and Kasar et al. (1983) as a group.

The Yenimuhacir Group consists of the Mezardere, Osmancık, and Danişmen formations. The Mezardere Formation is composed of shale and marl facies of the delta front, and the Ceylan-Keşan formations underlie the Istranca metagranite. The Osmancık Formation lies above and is gradational with the underlying Yenimuhacir Group; it was first identified by Ünal (1967). The formation contains interbedded tuffs and sandstones. Teslimköy member is formed by sandstone and marl. The Osmancık Formation, observed from the north of Keşan to Tekirdağ, was aged as Late Eocene–Early Oligocene by Sümengen et al. (1987), Alişan and Gerhard (1987), and Batı et al. (1993, 2002). The Osmancık Formation was described by Ünal (1967) and Holmes (1961) as the Osmancık Sandstone, which lies above the Mezardere Formation, transitional with the Danişmen Formation. The Osmancık Formation was deposited as a progressive delta front facies, which has been aged as Oligocene by Akyol and Akgün (1995), Batı et al. (1993, 2002), Gerhard and Alişan (1987, 1985).

The Danişmen Formation was defined by Boer (1954) and decribed by Beer and Right (1960) and used as a formation by Kasar et al. (1983) and Ünal (1967). It is transitional and lies above the Osmancık Formation and is covered by younger units (Atalay, 2002; Siyako, 2006*b*).

The formation consists of claystone, sandstone, lignite, and marl beds of Early Eocene age (Kemper, 1961; Ozansoy, 1962; Lebküchner, 1974; Saraç,1987; Şafak, 2008, Şafak and Güldürek, 2016*a*); Middle Oligocene (Umut et al., 1983, Sümengen et al., 1987); Late Oligocene by (Kasar and Eren, 1986; Batı et al., 2002); and Late Oligocene–Early Miocene (Alişan, 1985; Gerhard and Alişan, 1987; Batı et al., 1993; Şenol 1980; Bear and Wright 1960; Şafak, 2008) determining the thickness of the unit reach up to 200-250-670-150 m.

The Ergene Formation was defined by Boer (1954). Sediments of this formation is transitional with the overlying Çantaköy Formation and is unconformable with the older underlying units (Siyako, 2006*b*). The unit was described as the Ergene Group by Ünal, 1967; Turgut et al., 1983; Kasar et al., 1983; Şentürk et al., 1988*b*; Şentürk et al., 1988*a*; Sümengen et al., 1987 and as the Velimeşe Formation by Umut et al. (1983).

Among the ostracod genera, the genus *Cushmanidea* represents epineritic; *Cytheridea* represents lagoonal-epineritic; such as *Krithe* represents the infraneritic-bathyal range while others represent different ranges; *Hirschmannia, Hemicyprideis, Loxoconcha*, and *Cytheromorpha* represent lagoonal-littoral; *Neocyprideis* and *Cladarocythere* represent lagoonal; *Ilyocypris* lacustrine-lagoonal; *Virgatocypris*, *Candona* (*Lineocypris*), *Heterocypris*, *Cypridopsis*, *Eucypri*s, *Novocypris*, *Candona (Pseudocandona)*, and *Verticypris* represent lacustrine. Furthermore, three genera (*Valvata, Viviparus,* and *Avimactra*) that belong to the gastropod and pelecypod classes represent lagoonal and lacustrine environments, respectively.

Ambient conditions required for the distribution of ostracods found in the measured sections of the study area are as follows:

In the Bıyıkali section, the ostracod taxa represent the following environments *Hemicyprideis* represents lagoonal-littoral, *Neocyprideis* represents lagoonal, and *Cytheridea* represents lagoonal-epineritic. The section indicates lagoonal environment.

In the Beşer Tuğla section, the genera of ostracods represent the following environments: and *Ilyocypris* and *Candona* (*Pseudocandona*) represent lacustrine, *Neocyprideis* and *Cladarocythere* represent lagoonal, *Loxoconcha* and *Hemicyprideis* represent lagoonal-littoral, and *Cytheridea* represents lagoonal-epineritic. The section indicates lagoon environment.

In the Silivri section, identified ostracods represent the following environments: *Eucypris* represents lacustrine, *Candona (Pseudocandona)* represents lacustrine-lagoonal, *Cladarocythere* represents lagoonal, and *Hemicyprideis* represents lagoonal-littoral. This section indicates deposition dominated by freshwater up to lagoonal conditions.

The ostracods of the Malkara-Tekirdağ section represent the following environments: *Cytheromorpha*, *Cytheridea*, and *Hemicyprideis* represent lagoonal-littoral; *Sphenocytheridea*, *Serrocytheridea*, and *Cytheridea* represent lagoonal-neritic; *Cushmanidea* represents neritic; and *Krithe* represents neritic-bathyal. This section reflects the conditions of a shallow marine environment generally.

In the Silivri-Değirmenköy section, the ostracod taxa represent the following environments: *Candona* (*Caspiocypris*), *Candona* (*Caspiolla*), and *Heterocypris* represent lacustrine; *Cytheromorpha*, *Hemicyprideis*, and *Loxocorniculum* represent lagoonal-littoral; *Cytheridea* represents lagoonal-neritic; *Cushmanidea* represents neritic; and *Cytheropteron* represents neritic-bathyal. The transition from lagoonal condition to marine environment was observed in this section.

In the TB-57 drilling log, the ostracods represent the following environments: *Candona* (*Lineocypris*), *Cypridopsis, Eucypris, Verticypris Candona, Cypria, Novocypris* and *Virgatocypris* represent lacustrine; *Neocyprideis* and *Cladarocythere* represent lagoonal; *Cytheromorpha, Hemicyprideis, Loxocorniculum,* and *Hirschmannia* represent lagoonal-littoral; and *Cytheridea* represents lagoonal-neritic. The sequence developed under closed-basin brackish water conditions, which are indicative of a rare shallow marine environment.

In the TB-58 borehole, the ostracod genera represent the following environments:

Cypria, Eucypris, and *Heterocypris* represent lacustrine; *Candona* (*Pseudocandona*)*, Ilyocypris* represent lacustrine-lagoonal; *Cladarocythere, Neocyprideis* represent lagoonal; *Hemicyprideis* represents lagoonal-littoral; and *Cytheridea* and *Serrocytheridea* represent lagoonal-neritic. The sequence indicates a shallow marine condition and together with lake to lagoon conditions.

7. Discussion

The Istranca massif and the massif of the Tertiary Thrace basins, which constitute the southern slope of the deposition (Okay and Yurtsever, 2006) are composed of two main units in the north-east of the Black Sea. The Istranca massif is represented by gneiss and metamorphosed Paleozoic and Mesozoic sedimentary rocks that overlie the greenschist facies (Taner and Çağatay, 1983; Üşümezsoy, 1982). Starting from the southern Istranca Mountains, Tertiary deposits reach 9000 meters of thickness, covering all of Trakya and outcropping (Şengüler et al., 2000; 2003; Turgut et al., 1983; 1991; Kopp et al., 1969). Paleocene-Early Eocene sediments in the region have been observed in a very narrow area of Southwestern Thrace, but they were incompatible with the Middle Eocene limestones. The Middle Eocene-Early Miocene sediments were part of the Koyunbaba and Soğucak formations that had developed transgressively. The Ceylan Formation precipitated in places where the basin deepened, while the delta system that developed later is included in the Yenimuhacir Group and consists of Mezardere, Osmancık and Danişmen Formations from top to bottom. The Çantaköy Formation is another unit that had been deposited within this age range. Miocene units have been studied as part of the Çanakkale and Çekmece groups and the Ergene Formation. The uppermost Miocene-Pliocene is represented by the Kırcasalih Formation, which spreads widely throughout Northern Thrace (Siyako, 2006*b*).

Siyako (2006*b*) reported that Paleocene-Pleistocene sediments in the Thrace Basin had separated from each other by angular unconformities, and that Paleocene-Lower Eocene sediments were present in a very narrow area in southwest Thrace and the Gelibolu Peninsula.

Additionally, Siyako (2006*a,b*) stated that this stack was covered unconformably by the Middle Eocene limestone.

Various units in the basin that had collapsed in the early-Middle Eocene period in terrestrial and marine environments have been observed to be vertically and laterally transitional to each other (Siyako, 2006*a*, Siyako, 2005).

In the Late Eocene, the Keşan Formation and the Ceylan Formation corresponding to the upper levels of this unit were deposited, and thereafter, the sediment referred to the Yenimuhacir Group started to deposit – with lithological differences observed between them in a shallow environment during the latter part of the Late Eocene-early Oligocene period (Kopp et al., 1969, Kasar et al., 1983; Atalık, 1992; Sümengen and Terlemez, 1991; Siyako, 2006*b*, 2005).

The Mezardere, Osmancık and Danişmen formations were deposited in this shallow system up to the Early Miocene (Siyako, 2005; Ünal, 1967; Kasar et al., 1983). Siyako (2006*b*) stated that at the end of this phase, the region became completely filled and ascended to land, with the sedimentation of young Miocene-Pliocene units beginning as a result of erosion.

Volcanic outcrops observed by Siyako (2006*b*) in the Hisarlıdağ Formation in Southwestern Thrace deposited in the Early-Middle Miocene and also outcrops observed in Çanakkale and Çekmece groups and the Ergene Formation deposited in the Upper Miocene; outcrops observed in Karatepe Basalt deposited in the Miocene; and outcrops observed in the Kırcasalih Formation, with wide expanses in Northern Thrace, deposited in the Pliocene. The Marmara Formation formed by the marine terraces defined around the Marmara Sea deposited in the Pleistocene.

Studies by Maravelis et al. (2007) and Maravelis and Zelilidis (2012) on the paleoclimatology and paleoecology of the Eocene / Oligocene border in the Thrace Basin and Northeastern Aegean Sea, showed that the Eocene sediments orginated in deeper marine conditions than the Oligocene sediments.

Siyako and Huvaz (2007) performed a study on the Eocene stratigraphy and evolution of the Thrace Basin, while İslamoğlu et al. (2008) studied the storage environment in the Oligocene sediments in the Thrace Basin, from Tethys up to the Eastern Paratethys, researching their paleoclimatology and palaeogeography.

Rückert-Ülkümen et al. (2009) described the palaeobiogeographical properties of the Eastern Paratethys in the Ergene Basin (NW Turkey) and reported on the Neogene biostratigraphy of the Ergene Basin (Eastern Paratethys) coastal zone.

Witt (2011) presented systematics of ostracod faunas of marine Oligocene and terrestrial Miocene formations in the study of the Thrace-Pınarhisar sediments.

It was revealed that an ostracod community, which was explored by Şafak and Güldürek (2016*a*), and significant consolidation in Oligocene compared to the previously identified Eocene in the west of Thrace, as determined by Maravelis et al. (2007) and Maravelis and Zelilidis (2012), could be observed in the south-eastern part of the area.

Akgün et al. (2013) studied the vegetation structure and composition during the Oligocene period in the south and west of the Thrace Basin, and the Basin's climate characteristics as well. The first palynomorph and mollusc assemblages were identified during the Rupelian and Chattian. The annual average temperature of palynomorphs was investigated to explain the transition during the Rupelian and Chattian, which revealed climatic cooling, vegetation and pollen changes of the pollen assemblages in coastal deposits.

Demirtaş et al. (2015) studied the late Oligocene palynomorphs from the Middle Miocene coals of the Gelibolu Peninsula. Samples were taken from coal zones in two different regions; coal petrography was used to examine the storage conditions of the two coal zones along with their organic petrography, compositions, maceral ratios and palynological characteristics. The maceral compositions of the Oligocene coals were similar to those of the Miocene; the two different communities were distinguished by the percentages of palynomorphs. The first assemblage was found in the late Oligocene sediments, and the second one was found in the sediments of the Middle Miocene period**.**

In this study, a micropaleontological evaluation of the Paleogene-Neogene sediments of Babaeski-Muratlı-Çorlu-Lüleburgaz (Southeastern Thrace) region was carried out.

This study was carried out on drilled sections taken from Silivri, Türkmenli-Çorlu, Babaeski- Lüleburgaz, Edirne –Babaeski, Tekirdağ-Hayrabolu road, and two drilling washing samples, prepared by MTA, of which the drilling procedure was carried out with point samples. In addition to well-preserved ostracod fauna, obtained from greenish, yellowish claystone, , leafy, lignite sandstone, yellowish beige colored sandstone, organic colored clay, and silt (Early Oligocene Danişmen Formation), and the clays (Late Miocene-Pliocene Ergene Formation), all of which are widely found in the area, micro-molluscs were also observed in some levels. The clay lithology of the Yenimuhacir Group under the Danişmen Formation and lenticular sandstone of the Teslimköy Member feature siltstone intercalated sandstone (Osmancık Formation) above it. In the study area, the Danişmen Formation of the Taşlısekban and Armutburnu Member were very small, while the Pinarhisar Member was fossilized and thicker.

The ostracod community within the Danişmen Formation and its members, and their location in the stack, which was indicated to belong to the Rupelian / Stampian, Late Oligocene (Chattian) according to Şafak and Güldürek, 2016*a,b*, were not included in this study.

The stack is unconformably overlain by the Ergene Formation. The unit in the area of investigation, particularly the top layer of the stack, is well-known, and in addition to well-preserved ostracod fauna, micro-mollusks were found in some levels.

It was observed that the Çelebi Formation of the study was fossilized, and Sinanlı Member and Karatepe Basalt were found to have very little thickness. With this study, it was found that the Ergene Formation was Late Miocene-Pliocene. The Kırcasalih Formation that developed over this unit was Pleistocene. The Danişmen Formation was determined to have collapsed in Early Oligocene, while the Miocene fauna mentioned in the literature was not found.

The Ergene Basin in Neogene described by Rückert-Ülkümen et al. (2009) did not have a *Congeria ornithopsis* location that was similar to that of the basins in Bulgaria, North Yugoslavia and Vienna, and the examined Ergene site contained clayey levels as well as scarce fossiliferous levels in both measured sections according to drilling data.

The ostracod species identified in the study were compared with other ostracods in the Thrace Basin and other parts of Turkey, as well as with other ostracods in the Oligocene in Europe, Northwest and Paris-Aquitain Basin, Belgium, England, Romania and Switzerland. Based on this fauna, the Early Oligocene region was shown to have been influenced by the Tethys effect.

The ostracod species identified in the study area in the Late Miocene-Pliocene were compared against other ostracod studies in the Thrace Basin and other parts of Turkey, as well as in the Baltic Sea, Caspian Basin, Romania and Carpathians. According to these fauna assemblages, the Paratethys effect was determined to be much more higher than the effect of Tethys in the Late Miocene-Pliocene period.

8. Conclusions

A micropaleontological analysis of the Tertiary sediments from the Çorlu-Muratlı-Lüleburgaz-Babaeski region (Southeast Thrace) was completed in this study. The dominant conditions of depositional environment were identified.

Yellow-green claystone, yellow-beige sandstone, leaf-imprinted lignite bearing sandstone, organic colored clay, silt, and clay of the Danişmen and Ergene formations are widespread throughout the area, constituting the upper layers of the sediments. They provided well-preserved ostracod fauna, with micro-molluscs observed in some layers. According to the microfauna content of all samples, the age of the sedimentation was identified as the early Oligocene-Pliocene.

Species of Oligocene age include ostracods *Cytheromorpha zinndorfi*, *Cladarocythere apostolescui*, *Neocyprideis apostolescui*, *N. williamsoniana*, *Hemicyprideis montosa*, *H. elongata, H. helvetica*, *Serrocytheridea eberti*, *Sphenocytheridea gracilis*, *Cytheridea pernota*, *C. crassa*, *Cushmanidea scrobiculata*, *Krithe angusta*, *Loxocorniculum decorata*, *Hirschmannia* sp., *Loxoconcha* sp.1, *Candona* (*Pseudocandona*) *fertilis, Candona* (*Pseudocandona*) sp., *Candona* (*Lineocypris*) sp., *Ilyocypris boehli*, *I. cranmorensis*, *Novocypris striata*, *Eucypris pechelbronnensis, Virgatocypris tenuistriata*, *Verticypris jacksoni* and *Cypridopsis soyeri*; micro-pelecypods and gastropods such as *Avimactra*, *Viviparus*, and *Valvata*. Meanwhile, ostracods *Candona* (*Caspiocypris*) *alta*, *I. bradyi*, *E. dulcifons*, and *H. salina* were identified to be from the Late Miocene–Pliocene. Among the ostracod genera, the genus *Krithe* represents the infraneritic-bathyal range, whereas others represent different ranges, specifically: *Cushmanidea* epineritic; *Cytheridea* lagoonal-epineritic; *Cytheromorpha*, *Hemicyprideis, Hirschmannia, and Loxoconcha* lagoonal-littoral; *Cladarocythere* and *Neocyprideis* lagoonal; *Ilyocypris* lacustrine-lagoonal; and *Novocypris*, *Eucypris*, *Virgatocypris*, *Verticypris*, *Heterocypris*, *Candona (Pseudocandona)*, *Candona* (*Lineocypris*), and *Cypridopsis* lacustrine. In addition, three genera (*Avimactra, Viviparus,* and *Valvata*) of pelecypods and gastropods represent lagoonal and lacustrine environments, respectively.

The faunal study showed that the measured sections used in the study and the marl, siltstone, and claystone in the upper and lower layers of lignite intersected by the boreholes containing lagoonal and lake ostracods generally.

This study showed a similar age–environment relationship when compared with other studies conducted in the Thrace Basin, northwestern Europe, the Paris/Aquitaine Basins, Belgium, England, Romania, and Sweden.

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PLATES

PLATE - I

1-3. *Cytheromorpha zinndorfi* (Lienenklaus)

1. Carapace, left side view, Hacısungurlu Borehole, 34th sample
2. Carapace, left side view, Malkara-Tekirdağ Measured Section, 8th sample
3. Carapace, right side view, Bıyıkali Measured Section, 7th sample

4. *Cytheromorpha* sp.

4. Carapace, right side view, Silivri-Değirmenköy Measured Section, 6th sample

5. *Cladarocythere apostolescui* (Margerie)

5. Left valve, side view, Hacısungurlu Borehole, 34th sample

6. *Neocyprideis apostolescui* (Keij)

6. Left valve, outside view, Hacısungurlu Borehole, 23rd sample

7. *Neocyprideis williamsoniana* (Bosquet)

7. Left valve, outside view, Hacısungurlu Borehole, 66th sample

8-9. *Cytheridea pernota* (Oertli and Keij)

8. Right valve, outside view, Hacısungurlu Borehole, 53rd sample
9. Left valve, outside view, Hacısungurlu Borehole, 53rd sample

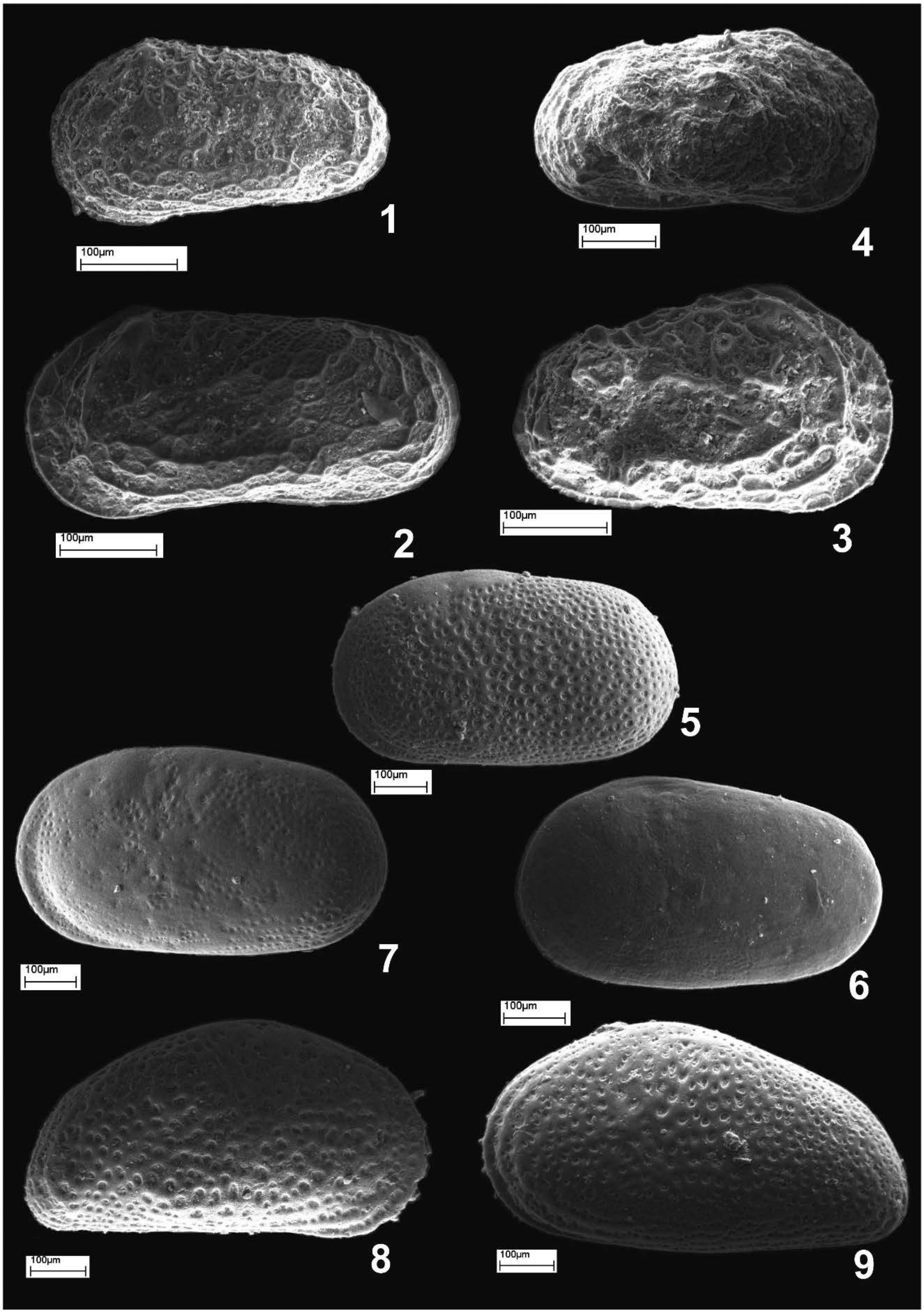
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PLATE - 2

1. *Cytheridea crassa* Terquem
    1. Carapace, right side view, Hacısungurlu Borehole, 56th sample

2-4. *Hemicyprideis montosa* (Jones and Sherborn)
    2. Left valve, outside view, Hacısungurlu Borehole, 65th sample
    3. Right valve, outside view, Silivri Measured Section, 2nd sample
    4. Carapace, left side view, Hacısungurlu Borehole, 53rd sample

5. *Hemicyprideis elongata* Keen
    5. Carapace, right side view, Silivri Measured Section, 2nd sample

6-8. *Serrocytheridea eberti* (Lienenklaus)
    6. Carapace, left side view, Malkara-Tekirdağ Measured Section, 8th sample
    7. Carapace, right side view, TD-58 Borehole, 9th sample
    8. Carapace, left side view, Malkara-Tekirdağ Measured Section, 6th sample

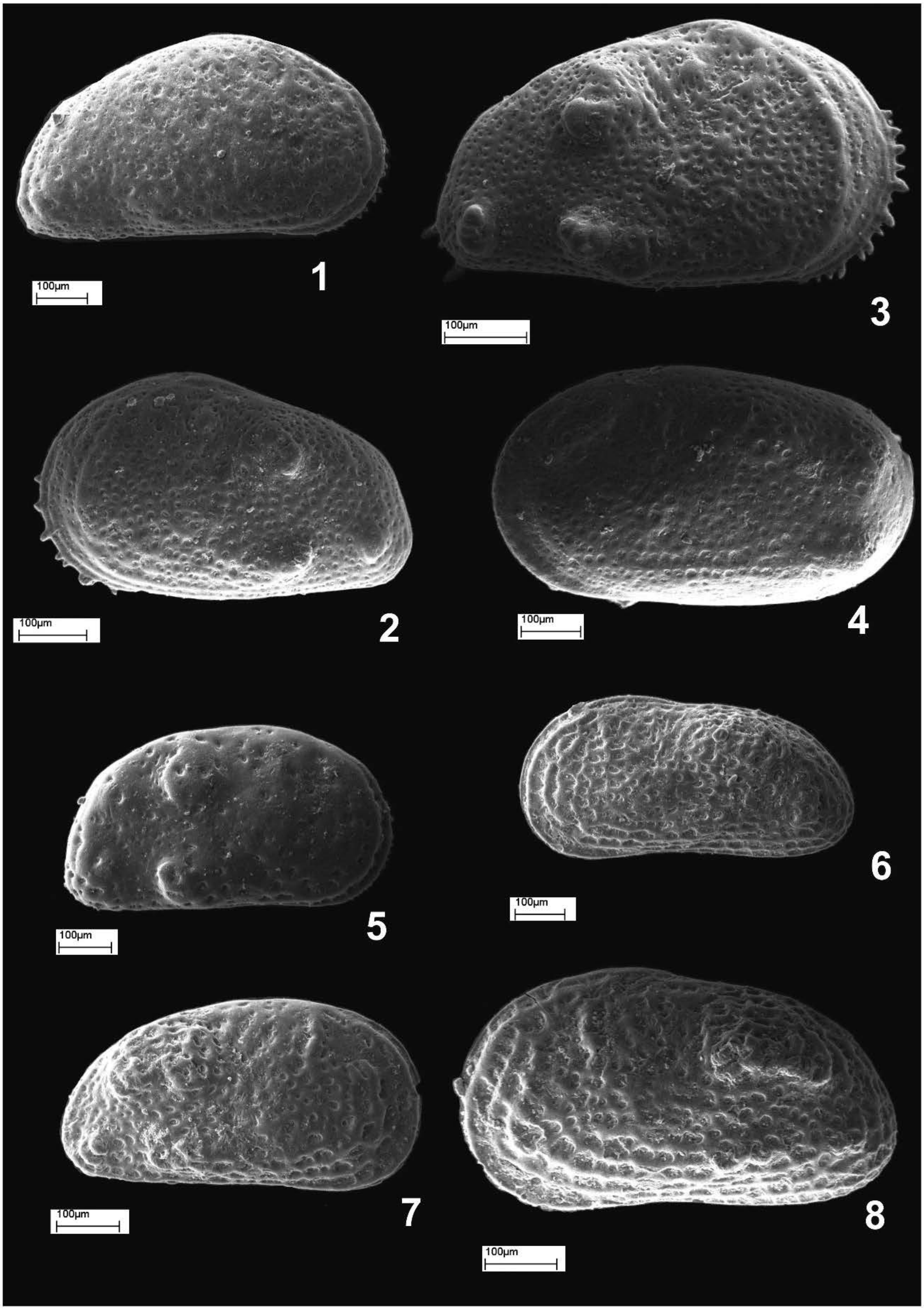
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PLATE - 3

1-2. *Krithe angusta* Brady and Norman

1. Carapace, right side view, Malkara-Tekirdağ Measured Section, 6th sample
2. Carapace, left side view, Malkara-Tekirdağ Measured Section, 6th sample

3. *Candona (Pseudocandona) fertilis* Triebel

3. Left valve, outside view, Hacısungurlu Borehole, 52nd sample

4. *Candona (Lineocypris)* sp.

4. Left valve, outside view, Hacısungurlu Borehole, 48th sample

5. *Virgatocypris tenuistriata* (Dollfus)

5. Carapace, left side view, Hacısungurlu Borehole, 14th sample

6. *Ilyocypris boehli* Triebel

6. Right valve, outside view, Hacısungurlu Borehole, 66th sample

7. *Candona (Caspiocypris) alta* (Zalanyi)

7. Left valve, outside view, Silivri-Değirmenköy Measured Section, 9th sample

8. *Heterocypris salina* (Brady)

8. Left valve, outside view, Babaeski-Edirne Road, 1st point sample

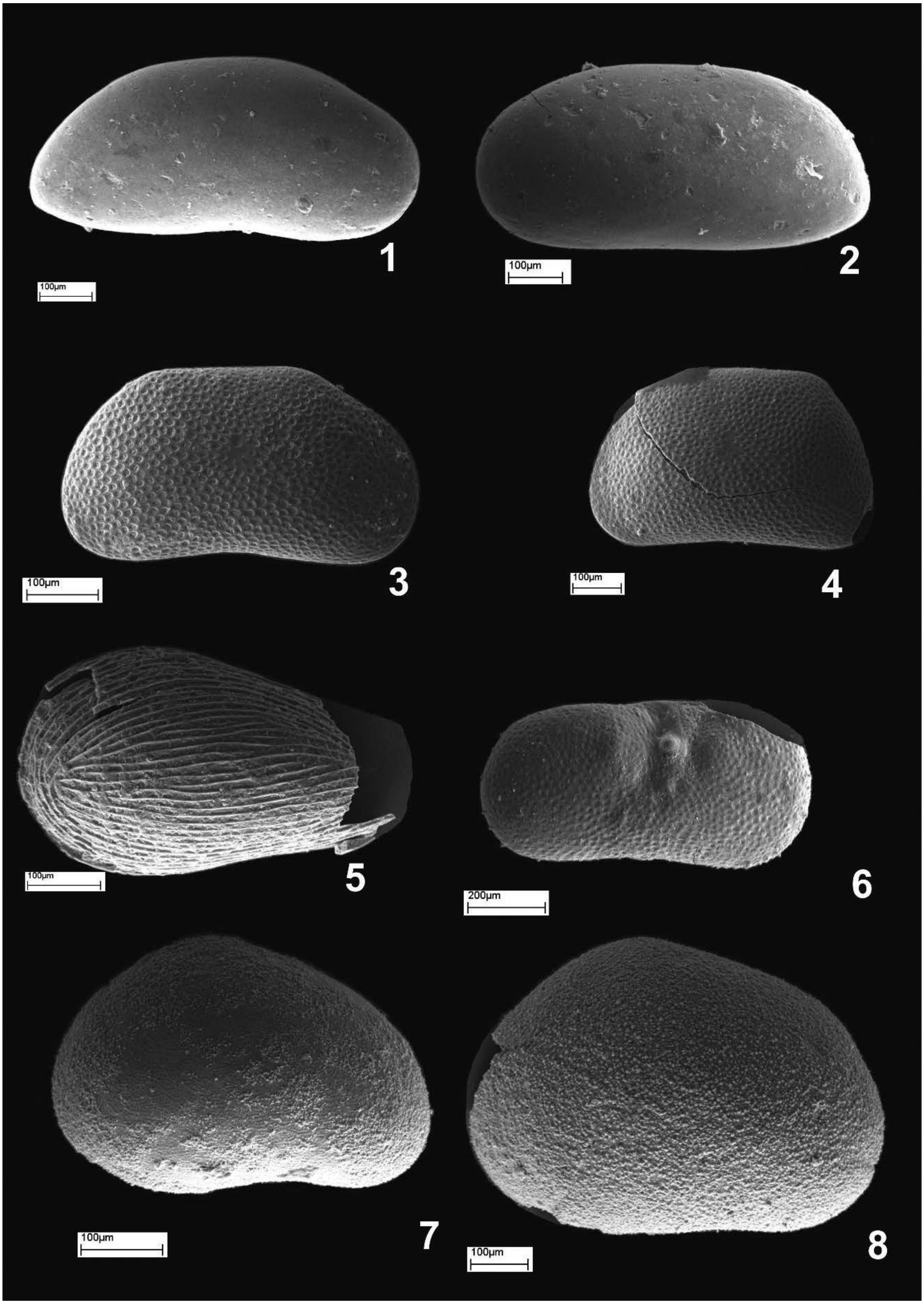
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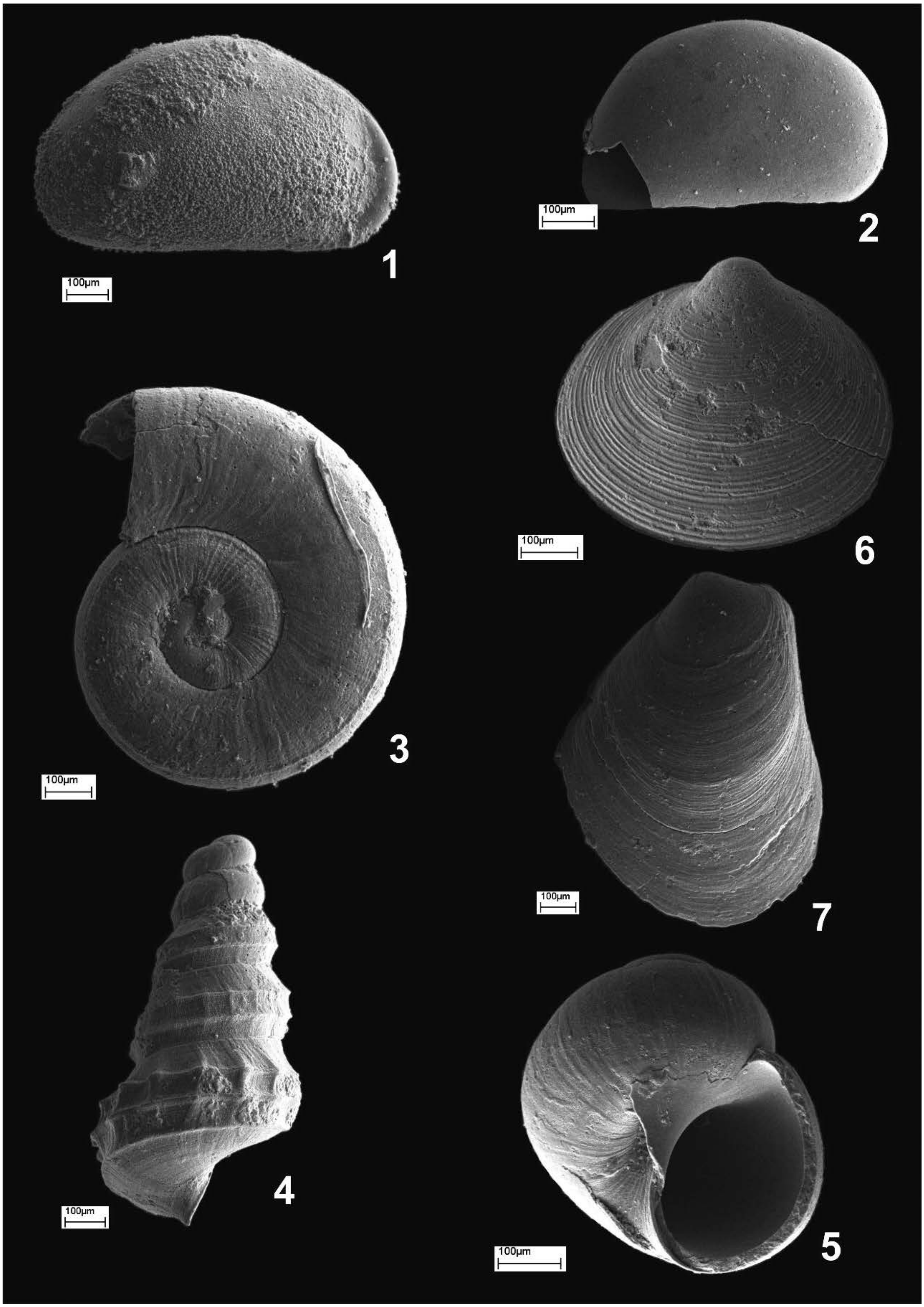
PLATE - 4

1. *Eucypris dulcifons* Diebel and Pietrzenuik
    1. Carapace, left side view, TD-58 Borehole, 2nd sample
2. *Candona (Caspiolla)* sp.
    2. Left valve, outside view, Silivri-Değirmenköy Measured Section, 9th sample
3. *Gyraulus* sp.
    3. Carapace, dorsal view, Hacısungurlu Borehole, 89th sample
4. *Potamides* sp.
    4. Carapace, side view, Hacısungurlu Borehole, 56th sample
5. *Viviparus* sp.
    5. Carapace, oral view, Hacısungurlu Borehole, 56th sample
6. *Avimactra* sp.
    6. Valve, outside view, Hacısungurlu Borehole, 87th sample
7. *Modiolus* sp.
    7. Valve, outside view, Hacısungurlu Borehole, 87th sample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