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THE OSTRACOD FAUNA AND ENVIRONMENTAL CHARACTERISTICS OF THE VOLCANO SEDIMENTARY YOL ÜSTÜ FORMATION IN THE HINIS REGION, ERZURUM (EASTERN ANATOLIA), TURKEY

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Key words:
Hınıs (Erzurum),
Ostracod,
Freshwater – olihogaline,
Brackish water,
Taxonomy.

ABSTRACT

The volcanosedimentary Yolüstü formation which outcrops in the vicinity of Hınıs Town, the southeast of Erzurum City, consists of conglomerate, marl, agglomerate, claystone, tuffite, fragmented travertine limestone with fragments of sand – pebble - plant, lacustrine limestone and tuffaceous – clayey limestone. In this formation, carefully selected 3 measured stratigraphic sections were taken at levels in which the lithology of hard travertine limestones with plant fragments and soft tuffaceous – clayey limestone are present. Washed samples which had been taken from these sections were studied and assessed, and then ostracods reflecting freshwater and brackish water environments were detected. In the unit, 5 genera and 12 species of ostracod and their taxonomies, which are generally peculiar to Ponto – Caspian basin, were defined. Besides; few micro mollusks, and 2 genera and 1 species of gastropod and 1 species of pelecypod (non well preserved) were found from the recrystallized looking tuffaceous, clayey, consolidated, hard limestone levels. In sequence, genera and species types of osracod such as; *Leptocythere (Amnicythere)* cf. *litiva* Livental, *Tyrrhenocythere bailovi* (Suzin), *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva, *L. agilis* Ruggieri, *Candona (Caspiocypris) araxica* Freels, *C. (Caspiocypris) erzurumensis* Freels, *C. (Caspiocypris)* aff. *alta* (Zalanyi), *C. (Typhlocypris) amblygonica* Freels, *C. (Candona) parallela pannonica* Zalanyi, *C. (Candona) burdurensis* Freels, *C. (Candona) candida* (O.F.Müller), *C. (Candona)* sp. 1 Freels, gastropods like *Valvata piscinalis* (O.F.Müller), *Viviparus* sp. and genus and species types of pelecypod like *Dreissena polymorpha* (Palas) were defined. For the main fossil envrionmtents; *Leptocythere* and *Tyrrhenocythere* indicate the brackish water environment, *Loxoconcha* mesohaline, *Candona (Caspiocypris), C. (Typhlocypris) oligohaline, Candona (Candona), Valvata, Viviparus* and *Dreissena* indicate the freshwater environment.

1. Introduction

1.1. The Aim of the Study

This study has been carried out in Yolüstü formation which is a volcanosedimentary unit in Hınıs Town, Erzurum, Turkey (Figure 1). The formation generally consists of conglomerate, marl, agglomerate, claystone, tuffite, travertine limestone with fragments of sand – pebble – plant, and volcanosedimentary deposits such as; the lacustrine limestone and tuffaceous – clayey limestone (Figure 2).

The purpose of this study is to make an interpretation about the age of ostracod bearing micro fauna which the Yolüstü formation cropping out in the Hınıs Basin (Erzurum) consists of and the environments which the fauna characterizes.

Previous studies about the general geology and volcanism around the study area were carried out by Arni (1939), Pamir and Baykal (1943), Erinç (1953), Tokel (1979), Soytürk (1973), Gedik (1985), Yılmaz et al. (1988), Şengüler and Toprak (1991), Tarhan (1991), Gevrek and Şengüler (1992), Öner et al., (2006). The

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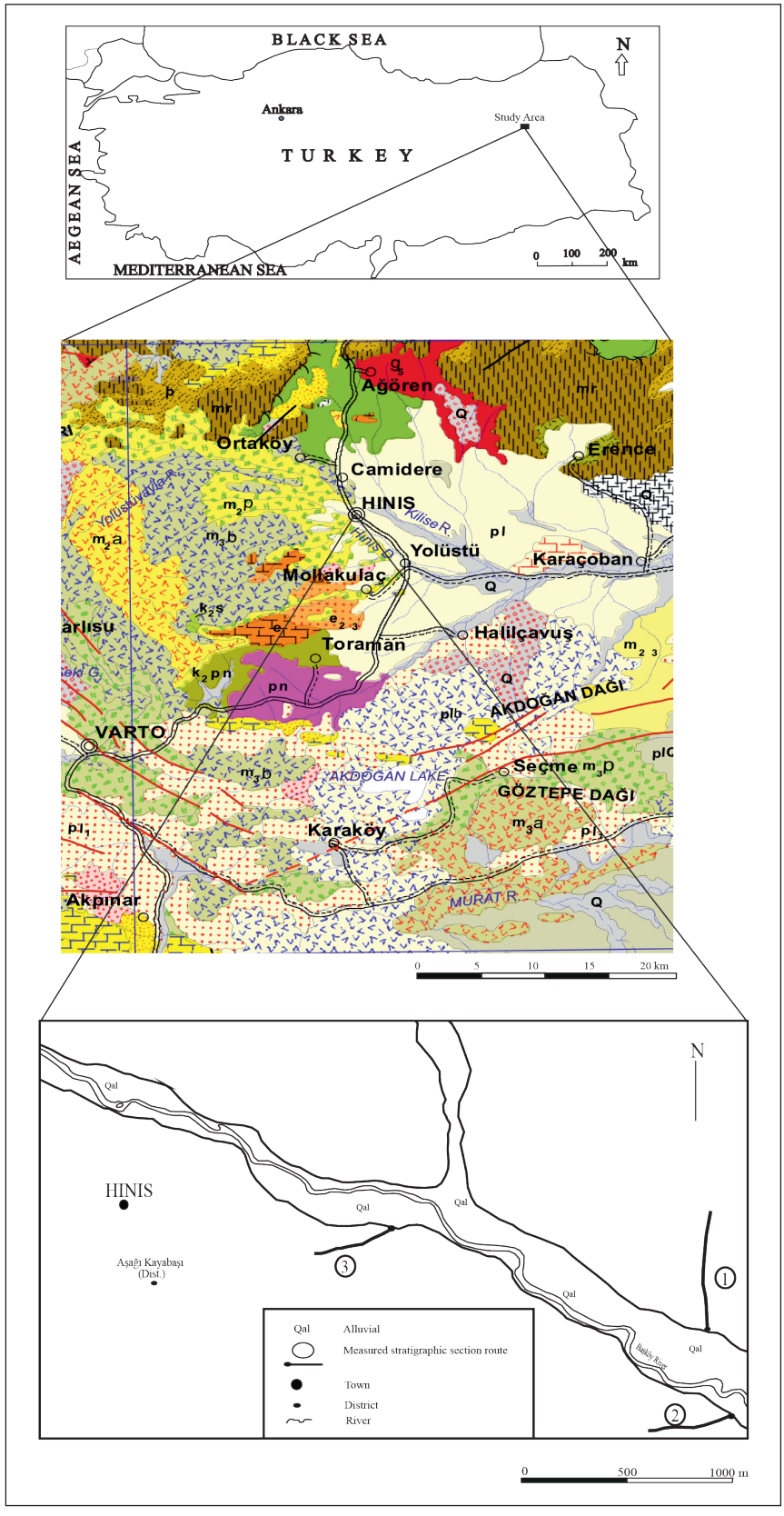

Figure 1- Location map of the study area and routes of measured section

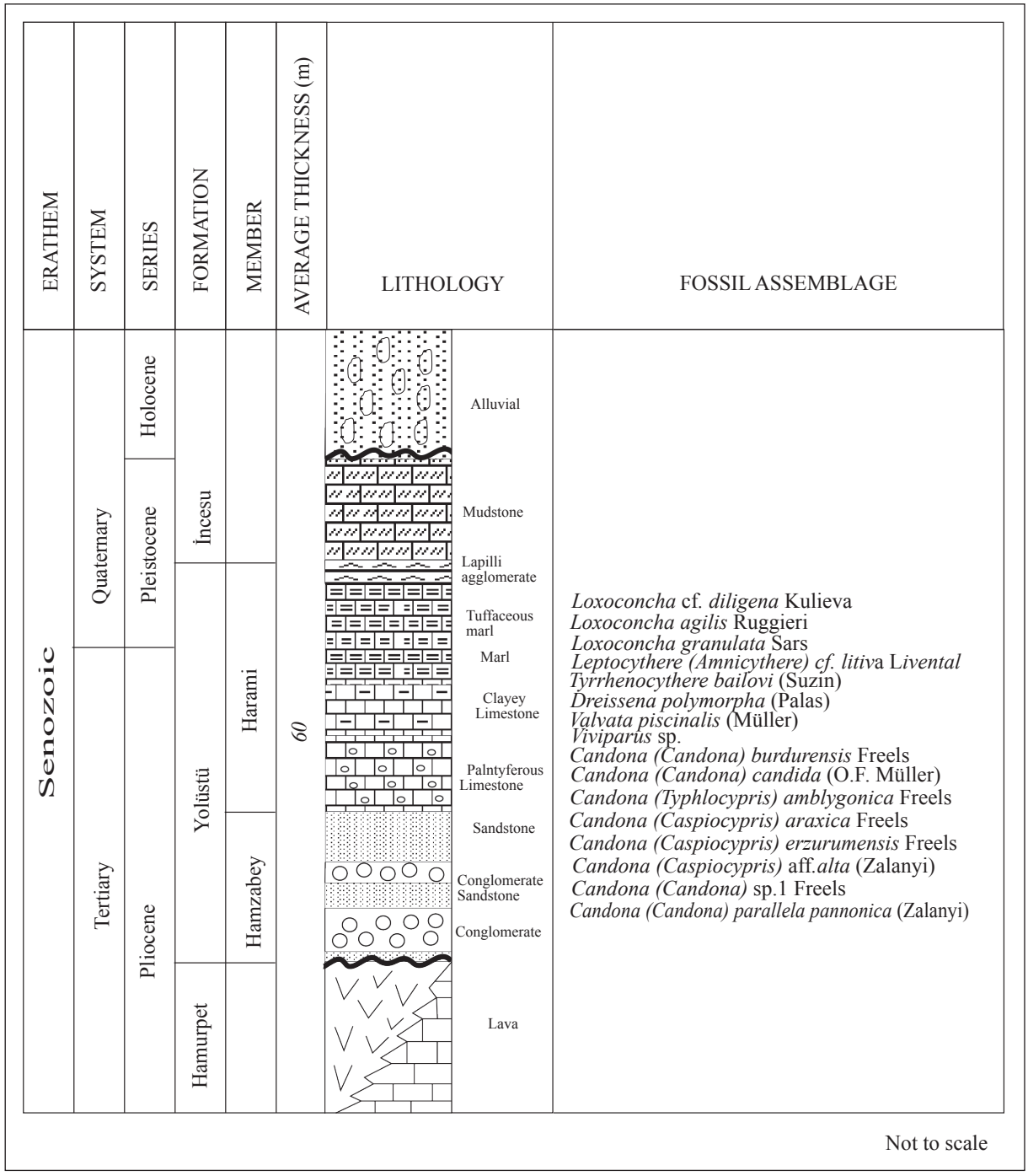

Figure 2- Generalized columnar section of the study area

stratigraphical and sedimantological studies were on the other hand performed by Demirtaşlı et al. (1965), and Gürbüz and Gülbaş (1999). And finally; the investigations about the tectonism and magmatism were carried out by Şengör and Kidd (1979), Şengör (1980), Şaroğlu and Yılmaz (1984), Tokel (1984); Erdoğan (1967) and Özcan (1967).

Total of 3 measured stratigraphical sections have been taken from fragmented and fossiliferous levels of the formation. It has been defined 5 genera and 12 species of ostracod, 2 genera and 1 species of gastropod and 1 species of pelecypod from the washed samples. Plates I and II consist of SEM photos of ostracods which have been defined within this unit.

Some of these genera and species defined are observed in the Central Paratethyan derived basins. The existence of the Central Paratethys in the region can be explained as an effect of closed basin deposit by post Miocene temporal faults of the volcanic sedimentation deposits located at upper levels of depression areas in the transition zone of the Northeast Anatolian – East Anatolian Tertiary basins. This basin then collapsed down at the end of late Miocene (Pontian) by these surrounding faults, and the marshy and shallow deep lagoon was formed by the rivers around it. Looking in regional, disperse and continuous outcrops of this formation in the Hınıs Basin is observed and the volcano sedimentary rocks in this area are horizontally bedded and unfolded. They have preserved their primary structural positions and have been crooscut only by temporal active faults (Tarhan, 1991).

However; the stratigraphy of volcanosedimentary units that had formed during Neogene volcanism around Hınıs (Erzurum – Muş – Bingöl, the eastern Anatolia), the micropaleontological characteristic based on the assemblage of ostracod and their environmental features have been revealed in this study.

2. Stratigraphy

2.1. Yolüstü Formation

The Nomenclature And Description Of The Unit: The formation was first described by Tarhan (1989) and Tarhan (1991) (from Polat, 2011) and took its name from the Yolüstü Village where it was best observed.

Distribution : This formation outcrops in Yeniköy, Karaçoban, Harami, Duman, Halilçavuş, Ovaçevirme, Peyik and Yolüstü villages in the Hınıs Basin. Its type distribution is in Harami – Halife Yards and Yolüstü (Beyazyar, Aros – Peyik ridge and Ziyaret Tepe (hill)). The locations where measured sections were taken in this study are Kayabaşı and Pınarbaşı districts and its surround.

Type Location : The Yolüstü Village located in the Hınıs Basin.

Type Section : The section 2 which was taken in the Yolüstü Formation that unconformably overlies the Hamurpet Lava is in the character of a type section. It was measured within the coordinates of X1: 36775, Y1: 59800, Z1: 1600 m. (start) and as X2: 36800, Y2: 60700, Z2: 1694 m. (end) in 1/25000 scaled in J47 sheet.

Reference Sections : Section numbers 1 and 3 are the reference sections measured within Harami and Hamzabey members of the Yolüstü Formation. These sections were measured at the coordinates of X1: 35125, Y1: 66550, Z1: 1615 m. (start), X2: 34375, Y2: 60320, Z2:1705 m. (end) in 1/25000 scaled J47 sheet, and X1: 35125, Y1: 66550, Z1: 1605 m. (start), X2: 34375, Y2: 60320, Z2: 1702 m. (end) of 1/25 000 scale J47/a3 sheet, respectively.

The horizontally bedding sections were studied in detail and measured from bottom to top as vertically.

Lithological Features : The formation has started its deposition by transgression and ended by regression in the Hınıs Basin. Therefore; the rocks have formed complete series. The unit is generally recognized by the deposits such as; conglomerate, sandstone, siltstone, mudstone, tuffaceous marl, marl, agglomerate, claystone, tuffite, travertine limestone with plant fragments, lacustrine limestone and tuffaceous – clayey limestone, and consists of thin coal seams, sporadically. The dominant lithology of the formation is formed by marl, tuffite, tuffaceous marl and claystones. Sandstone, siltstone and conglomerates are crossbedded. Fine to medium, horizontal beddings are observed in fluvial and in the channel fill deposit unit from place to place.

The Formation has two members distinguished by Tarhan (1991).

The Hamzabey Yard Member : It crops out in Ağması, Yolüstü and in Hamzabey – Zaza yards in map. It takes its name from the Hamzabey yard. It is formed by reddish brown, fine to medium bedded, loose cemented conglomerate and consists of sandstone – mudstone interlayers in places. Conglomerates are well rounded and correlates with the basal conglomerate of the Yolüstü Formation. It vertically and horizontally grades into the units of tuffite, claystone and marl.

The Harami Member : It crops out in Harami, Ovaçevirme, Duman, Halilçavuş villages and in the Halife yard. The travertine limestones with sand – pebble – plant fragments form the bottom of the unit. In upper layers, the agglomerate grades into the dominant lithology of the formation which is; lacustrine limestone, marl, tuffite, tuffaceous marl, sandstone, mudstone, lapilli and agglomerates as a

result of the increase in tuff content at inner parts of the basin. It consists of fragments of plant and thin coal interbands. The dominant rock units of the member are travertine limestones (Demirtaşlı et al., 1965; Aziz, 1971; Gedik, 1985 and Tarhan, 1991). Also the washed samples which form the main subject of this study, belong to this unit of the Yolüstü formation and it was revealed that the age of this member ranged from Pliocene to Early Pleistocene.

Contact Relationships : This formation overlies the ophiolite, metamorphous granitic rocks, upper Cretaceous – Lower Miocene deposits, Middle Miocene Bingöl Dağı group, Late Miocene Varto group and Early Pliocene Hamurpet lava cropping out at the bottom and at the circumference of the Hınıs Basin with an angular unconformity. Then, it grades into the conformable and transitional İncesu formation in upper layers (Tarhan, 1991).

Thickness And Distribution : The formation has continuous and widespread exposures in the Hınıs Basin. It is fine to medium layered and horizontally bedded. The average thickness was determined as 700 – 800 m by Tarhan (1991). However, the average thickness of the formation was detected as 60 m from the measurable sections in this study.

The Fossil Content And Age : Pamir and Baykal (1943) stated that the deposits in the Hınıs Basin are post Late Miocene in age.

Nakoman (1968) directed attention to the lacustrine and carbonaceous units in the Karlıova basin and dated carbonaceous units as Middle – Late Pliocene age as aresults of the pollen analysis carried out in coals of the Karlıova Basin.

Tarhan (1991) has obtained Pliocene–Lower Pleistocene ages from the fossil content of this formation, but has assigned the unit as mid Pliocene according to its stratigraphy.

In this study, a rich assemblageof ostracodafauna with calcified micro molluscs were determined from the washed samples collected from the plant fragmentsbearing hard travertine limestonesand soft clayey limestone layersof the measured sections. According to this fauna the age of the formation is Pliocene–Early Pleistocene.

Correlation : The Yolüstü formation shows similarity with the depositional units in the Tekman, Bulanık, Muş, Pasinler and Erzurum basins in terms of lithological, stratigraphical and structural relationships.

Late Pliocene Tuzluca formation (Şenalp, 1969), Pliocene Horasan formation (Rathur, 1965), Late Miocene – Pliocene Hacıömer formation (Erdoğan, 1966; Yılmaz et al., 1986), Pliocene Bulanık formation (Soytürk, 1973), Pliocene Işıklar formation (Demirtaşlı et al., 1965; Aziz, 1971), Pliocene Zırnak formation (Şaroğlu, 1986) and Late Pliocene – Pleistocene Bulanık formation (Şengüler and Toprak, 1991) can be correlated with this formation.

2.2. Measured Stratigraphic Sections

2.2.1. Hınıs 1 Measured Section

Total of 10 washed samples were collected from a 90 m thick section measured between the coordinates which starts at X1: 36775, Y1: 59800, Z1: 1615 m. and ends at X2: 36800, Y2: 60700, Z2: 1705 m. in the 1/25000 scale J47 sheet.

In general, majority of the samples (2 to 10) were collected, in the following order, from the part of the Yolüstü formation where the Harami member is extensively observed and forms a 22 m thick sequence; sample 2 from marl at 12 m; sample 3 from plant detritus bearing limetone at 15.6 m; sample 4 from traverten limestone at 26.4 m; sample 5 from marl at 36.5 m; sample 6 from marl at 42 m; sample 7 from tuffaceous marl at 55 m; sample 8 from mudstone at 70.8 m; sample 9 from limestone at 82.5 and sample 10 from tuffaceous and clayey limestone respectively.

The following species of ostracoda, such as, *Candona (Caspiocypris) erzurumensis* Freels in sample 2 at 12th m; *Candona (Caspiocypris) araxica* Freels, *C. (Typhlocypris) amblygonica* Freels, *C. (Candona) parallela pannonica* Zalanyi in sample 3 at 15.6th m and *(Amnicythere)* cf. litiva Livental, *Loxoconcha agilis* Ruggieri, *L. granulata* Sars in sample 10 at 87.5th m were identified (Figure 3).These ostracod genera indicate transition into freshwater and brackish water environments (Table 1).

2.2.2. Hınıs 2 Measured Section

Total of 8 washed samples were collected from a 94 m thick measured section. The section starts at X1: 35125, Y1: 66550, Z1: 1600 m and ends at X2: 34375, Y2: 60320, Z2: 1694 m in the 1/25.000 scaleJ47 sheet.

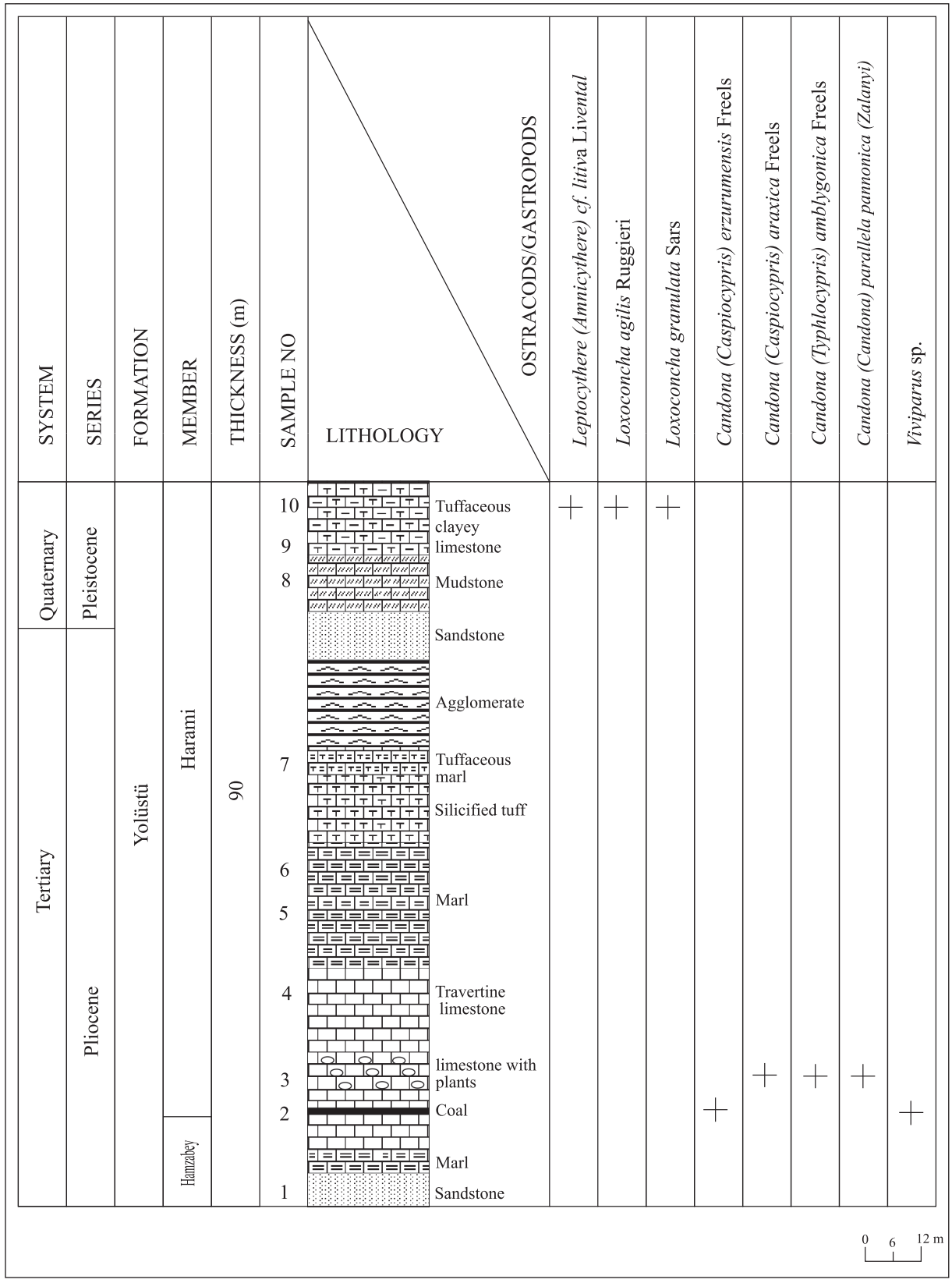

Figure 3- Ostracode and gastropode distribution in Hınıs 1 measured section

Table 1- Environments and salinity degrees in the study area which the Ostracode genera characterize (from Morkhoven,1963 and Krstic,1976)

OSTRACODE GENERA	SALINITY*		
	FRESH WATER % 0,5-3	BRACKISH\ SOMATR % 0,3-8(10)	MARINE % 18-45
Leptocythere			
Tyrrhenocythere			
Loxoconcha			
Candona (Typhlocypris)			
Candona(Caspiocypris)			
Candona(Candona)			

*Remane standards given in Gökçen (1979) were used for the salinity.

The sequence in this section is composed of the conglomerate and mudstone of the Hamzabey member and the limestone, marl and tuffaceous marls of the Harami member of the Yolüstü formation, which overlies the Hamurpet lava unconformably.

The eight samples were collected from the following lithologies; sample 1 from the carbonaceous level of the section at 39th m, sample 2 from travertine limestone at 44th m, samples 3 and 4 from marls at 51th m and 57th m, sample 5 from limestone at 65th m, sample 5 from marl at 36.5th m, sample 6 from tuffaceous marl at 69th m, sample 7 from sandstone at 84th m and sample 10 from hard clayey limestone at 94th m.

From the samples collected in this section, the following ostracoda species, such as, *Candona (Candona) parallela pannonica* Zalanyi, *C. (Candona) burdurensis* Freels (sample 1), *Candona (Candona) parallela pannonica* Zalanyi (sample 4 and 5), *Loxoconcha granulata* Sars (sample 8), and *Loxoconcha* cf. *diligena* Kulieva (sample 8), representing changing environments from fresh water through oligohaline to brackish water, were identified.

2.2.3. Hınıs 3 Measured Section

Total of 10 washed samples were taken from the 103 m thick measured section which starts at X1: 35125, Y1: 66550, Z1: 1605 m and ends at X2: 34375, Y2: 60320, Z2: 1702 m in 1/25.000 scale J47-a3 sheet.

The first 20 m of the section belongs to levels of conglomerate - sandstone alternation of the Hamzabey unit in Yolüstü formation. Sample 1 was taken from the 10th m of this unit. There is a 68 m thickness over this sequence and the coal is observed at 10th m of this sequence and sample 2 which was taken at 28.5th m consists of limestone with plant fragments. Sample 3 which was taken at 33th m of the sequence is coal. Samples 4 and 5 were taken from travertine limestones at 36.3th and 42th meters, respectively; and overlie the coal layer from which the sample 3 was taken. Sample 6 was taken from the lacustrine limestone at 46th m and sample 7 was taken from hard clayey limestone at 58th m. Sample 8 was taken from the top of marl at 64th m of the sequence. Sample 9 was taken from tuffaceous marl at 70th m and sample 10 from marl at 83th m.

The sequence which belongs to the Harami unit of the Yolüstü formation conformably grades into the unconsolidated mudstone and sandstones layers of the overlying İncesu formation at 86th m. The thickness of this unit measured in the section is 7 meters.

An alluvial with a thickness of 8 meters takes place at the uppermost level of the section.

Ostracod genera which show the transition from freshwater – oligohaline to brackish water environment such as; *Candona (Caspiocypris) erzurumensis* Freels, *C. (Caspiocypris) araxica* Freels, *C. (Typhlocypris) amblygonica* Freels in sample 2; *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva, *Candona (Caspiocypris) erzurumensis* Freels, *C. (Caspiocypris) araxica* Freels, *C. (Typhlocypris) amblygonica* Freels in sample 4 and 5; *Candona (Candona) candida* (Müller), *C. (Candona) burdurensis* Freels in sample 6; *Leptocythere (Amnicythere)* cf. *litiva* Livental, *Tyrrhenocythere bailovi* (Suzin), *Loxoconcha agilis* Ruggieri, *L. granulata* Sars, *L.* cf. *diligena* Kulieva in sample 7; *Loxoconcha agilis* Ruggieri, *Candona (Caspiocypris) araxica* Freels, *C (Typhlocypris) amblygonica* Freels, *C. (Caspiocypris)* aff. *alta* (Zalanyi) in samples 8 and 9 were described (Figure 5).

2.3. Paleoenvironmental Interpretation

It is suggested that the Yolüstü formation generally deposited in littoral,lagoonal and lacustrine environments.The findings of the previous studies of Morkhoven (1963), Freels (1980), Wenz (1922), Taner (1980), Sayar (1991) were considered in the paleoenvironmental interpretation of the ostracoda

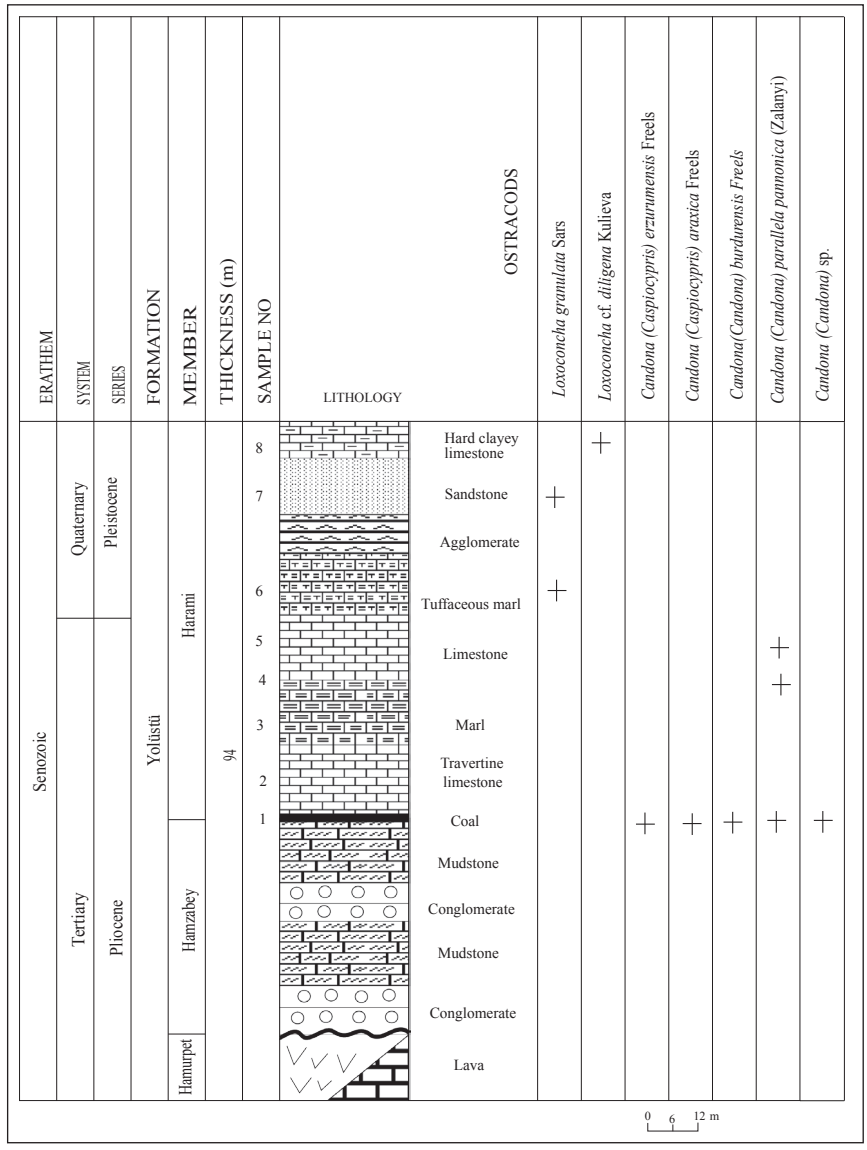

Figure 4- Ostracode distribution in Hınıs 2 measured section

and the accompanying mollusc genera identified in the study.

The genera and subgenera of the ostracoda, such as, *Candona (Caspiocypris), C (Typhlocypris), C (Candona),* which are determined from the sample collected from the plant fragments bearing hard traverten limestone in the lower level of the second member of the Yolüstü formation, characterize a lacustrine environment. The ostracoda genera, such as, *Leptocythere (Amnicythere), Tyrrhenocythere, Loxoconcha,* which are identified from the soft clayey limestone deposits in the upper levels, indicate brackish water, but the accompanying mollusc genera such as, *Valvata, Viviparus, Dreissena* represent fresh water environment.

In considering the vertical distribution of the ostracoda in the sections, it is realised that the environmental conditions in the study area changed from fresh water through oligohaline to brakish water.

3. Taxonomy

In this study, 13 ostracods were defined as follows; 1 species of *Leptocythere*, 1 species of *Tyrrhenocythere*, 3 species of *Loxoconcha;* 3 subgebera of *Candona (Caspiocypris)*, 1 subgenera of *Candona (Typhlocypris)*, 4 subgenera of *Candona (Candona)* and 6 species of *Candona* one of which is at sp. level. SEM microphotographs of the ostracod genera and species determined in this study are presented in Plates I - II.

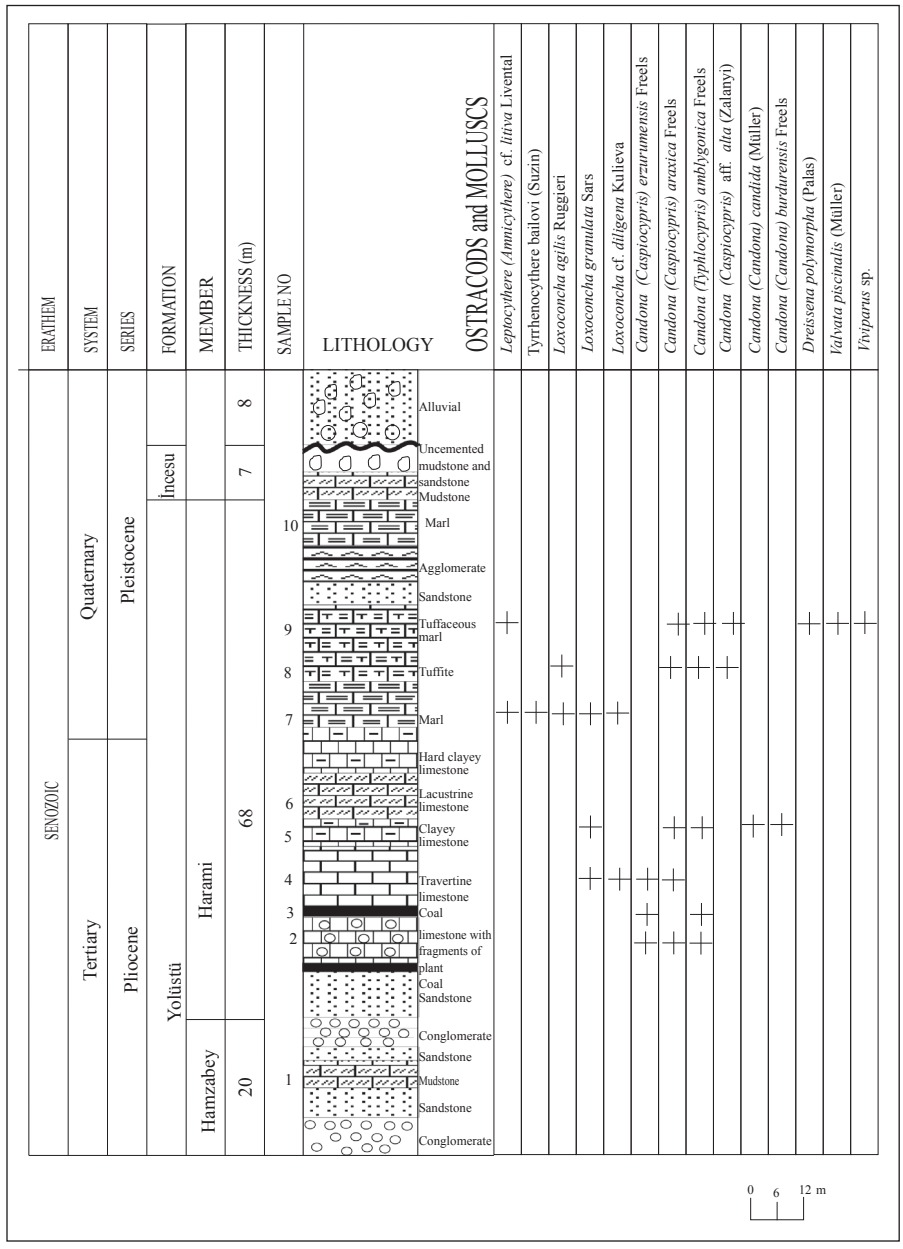

Figure 5- Ostracode distribution in Hınıs 3 measured section

The taxonomy of Hartmann and Puri (1974) was used in the classification and the taxonomy of Moore (1961), Morkhoven (1962) and Freels (1980) were also considered.

Subclass : Ostracoda Latreille, 1806

Order : Podocopda Sars, 1866

Suborder : Cytheraca Baird, 1850

Family : Leptocytheridae Hanai, 1957

Genus : *Leptocythere* Sars, 1928

Subgenus : *Leptocythere* Sars, 1928 and *Amnicythere* Devoto, 1965

Species Type : *Cythere pellucida* Baird, 1850

Stratigraphic Distribution : Oligocene-Recent

Environment : Some species represent brackish water, the others represent shallow marine (littoral) environments (Morkhoven, 1963).

Leptocythere (Amnicythere) cf. *litica* Livental, Agalarova et al., 1961

(Plate I, Figure 1)

Leptocythere (Amnicythere) cf. *litica*, Carbonnel, 1978, plate 2, figure 9

Leptocythere (Amnicythere) cf. *litica* Livental, Agalarova et al., Krstic and Dermitzakis, 1981, plate VI, figures 5-6.

Stratigraphical and geographical distribution : Azerbaijan, Pontic and Caspian Basin, Pontian-Pliocene (Agalarova et al., 1961), Corinth Canal – Greece, Pleistocene (Krstic and Dermitzakis, 1981).

Localities in this study : Hınıs 1 Measured section, sample 10, Early Pleistocene; Hınıs 3 Measured Section, samples 7 and 9, Early Pleistocene.

Family : Hemicytheridae Puri, 1953

Subfamily : Hemicytherinae Puri, 1953

Genus : *Tyrrhenocythere* Ruggieri, 1955

Species-Type : *Tyrrhenocythere pignatti* Ruggieri, 1955

Stratigraphic Distribution : Late Messinian / Pontian – Recent. It forms a starting level especially in Paratethys since Pontian (Krstic, 1976).

Environment : Recent species occur in brackish and freshwater conditionswith up to 9-13% salinity and 30 m depth (Krstic, 1976).

Tyrrhenocythere bailovi (Suzin, 1956)

(Plate I, Figure 2)

Tyrrhenocythere bailovi Suzin = 1956 *Tyrrhenocythere pseudocandona* Livental,1929

Tyrrhenocythere bailovi (Suzin), Krstic and Dermitzakis, 1981, plate III, figures 17-22

Stratigraphic and geographical distribution : Moscow, Tertiary (Suzin, 1956), Corinth Canal – Greece, Pleistocene (Krstic and Dermitzakis, 1981)

Localities in this study : Hınıs 3 Mesaured Section, sample 7, Pliocene – Early Pleistocene.

Family : *Loxoconchidae* Sars, 1925

Genus : *Loxoconcha* Sars, 1866 (= Normania Brady, 1866,= Loxoleberis Sars, 1866)

Species Type : *Cythere rhomboidea* Fischer, 1855

Stratigraphical Distribution : Paleocene – Recent

Environment : Littoral depth, mesohaline salinity (Morkhoven, 1963)

Loxoconcha agilis Ruggieri, 1967

(Plate I, Figure 5)

1964 *Loxoconcha agilis* Ruggieri, Puri, Bonaduce and Malloy.

1975 *Loxoconcha agilis* Ruggieri, Bonaduce, Ciampo and Masoli, page102, plate 65, figures 9-14.

1985 *Loxoconcha agilis* Ruggieri, Stambolidis, page 218, plate 6, figures 3-5.

1995 *Loxoconcha agilis* Ruggieri, Kubanç, page 108, plate 10, figure 3.

2002 *Loxoconcha agilis* Ruggieri, Tunoğlu, page 40, plate 1, figures 6-7.

2008 *Loxoconcha agilis* Ruggieri, Şafak, page 1.

Stratigraphical and geographical distribution : Bay of Naples - Recent (Puri et al., 1964); Adriatic Sea - Recent (Bonaduce et al., 1975); Evros Delta – North Aegean / Greece –Recent (Stambolidis, 1985); Aegean Sea – Recent (Kubanç, 1995); Black Sea, Zonguldak -Coasts of Amasra - Recent (Tunoğlu, 2002); Mersin Gulf - Recent (Şafak, 2008).

Localities in this study : Hınıs 1 Measured Section, sample 10, Pliocene – Early Pleistocene; Hınıs 3 Measured Section, samples 7 and 8, Pliocene – Early Pleistocene.

Loxoconcha cf. *diligena* Kulieva, 1961

(Plate I, Figures 3-4)

1961 *Loxoconcha* cf. *diligena* Kulieva, Agalarova et al., 46 page.

1981 *Loxoconcha* cf. *diligena* Kulieva, Krstic and Dermitzakis, page 488, plate VI, figures 7-8.

Stratigraphical and Geographical Distribution: Azerbajian – Pliocene and Post Pliocene (Kulieva et al., 1961); Corinth Canal, Greece – Pleistocene (Krstic and Dermitzakis, 1981).

Localities in the study: Hınıs 2 Measured Section, sample 8, Early Pleistocene; Hınıs 3 Measured Section, samples 4 and 7, Pliocene.

Loxoconcha granulata Sars, 1866

(Plate I, Figures 6-8)

1865 *Palmoconcha guttata*, Norman

1866 *Loxoconcha granulata*, Sars

1956 *Loxoconcha unodensa= Loxoconcha gorschkovi*, Mandelstam,

1962 *Loxoconcha unodensa= Loxoconcha gorschkovi,* Mandelstam et al., Turkmenistan

1969 *Loxoconcha granulata*, Shornikov, Izd. Naukova Dumka, II, pages 163-269, Kiev.

1981 *Loxoconcha granulata*, Athersuch and Horne, in Stereo Atlas A.8: 117-124.

1981 *Loxoconcha granulata*, Krstic and Dermitzakis, plate III, figures 17-22.

1985 *Loxoconcha granulata,* Horne, Stereo Atlas 12, 28: 158.

1999 *Loxoconcha granulata,* Şafak, page 162, plate VI, figure 1.

2004 *Loxoconcha granulata,* Opreanu, pages 9-10.

2005 *Loxoconcha granulata,* Opreanu, Tom LI, pages 62-70.

2008 *Loxoconcha granulata,* Şafak, pages 5, 14, table 1

Stratigraphical and geographical distribution: Warsaw – Pleistocene (Mandelstam, 1956), Pliocene and Post Pliocene in Turkmenistan (Mandelstam et al.,1962); Russia - Recent (Shornikov; 1969, 2011); Netherlands – Recent (Athersuch and Horne, 1981); Corinth Canal, Greece - Pleistocene (Krstic and Dermitzakis, 1981); Gökçeada-Bozcaada-Çanakkale - Recent (Şafak, 1999); Black Sea Coast – Recent (Opreanu, 2004), NW Black Sea Romania – Recent (Opreanu, 2005); Mersin Gulf – Recent (Şafak, 2008).

Localities in this study : Hınıs 2 Measured Section, sample 7, Early Pleistocene.

Upper family : Cypridoidea s. str. Baird, 1845

Family : Candonidae Kaufmann, 1900

Subfamily : Candoninae Kaufmann, 1900

Genus : *Candona* Baird, 1845

Subgenus : *Candona (Typhlocypris)* Vejdovsky, 1882

Synonym : *Kochia* Hejjas, 1894

Advenocypris Snejder, 1956

Cavernocandona Hartmann, 1964

Species - Type : *Cypris eremita* Vejdovsky, 1880

Candona (Typhlocypris) amblygonica Freels, 1980

(Plate I, Figure 9)

1980 *Candona (Typhlocypris) amblygonica* Freels, Turkey Taf.9, figures 15-20. 1981

Stratigraphical and geographical distribution: Erzurum – Hınıs / Turkey, Mid-Upper Miocene (Freels, 1980).

Localities in this study : Hınıs 1 Measured Section, sample 3, Pliocene.

Subgenus : *Candona (Caspiocypris)* Mandelstam, 1956

Species- Type : *Bairdia candida* Livental, 1929

Stratigraphical Distribution : Oligocene (Eocene?) - Recent

Environment : Freshwater, seldom brackish (Morkhoven, 1963)

Candona (Caspiocypris) araxica Freels, 1980

(Plate II, Figures 1-2)

1980 *Candona (Caspiocypris) araxica* Freels

2001 *Candona (Caspiocypris) araxica* Freels,

Tunoğlu, page 134, table 4, page 138, table 5.

Stratigraphical and Geographical distribution: Erzurum – Pasinler/Turkey, Upper Miocene – Pliocene (Freels, 1980), Black Sea Region/Turkey, Middle – Late Miocene - ? Pliocene (Tunoğlu, 2001).

Localities in this study : Hınıs 1 Measured Section, sample 3, Pliocene; Hınıs 2 Measured Section, sample 1, Pliocene; Hınıs 3 Measured Section, samples 2, 3, 5, 8, 9, Pliocene – Early Pleistocene.

Candona (Caspiocypris) erzurumensis Freels, 1980

(Plate II, Figure 3)

1980 *Candona (Caspiocypris) erzurumensis* Freels

Stratigraphical and geographical distribution : Erzurum - Pasinler/Turkey, Upper Miocene (Freels, 1980).

Localities in the study : Hınıs 1 Measured Section, sample 2, Pliocene; Hınıs 2 Measured Section, sample 1, Pliocene; Hınıs 3 Measured Section, samples 2, 3 and 4, Pliocene.

Candona (Caspiocypris) aff. *alta* (Zalanyi, 1929)

(Plate II, Figures 4-5)

Aff. 1929 Paracypris *alta* n. sp., Zalanyi, Morpho-System, Studien, page 44, figure 14.

Aff. 1971 *Candona (Thaminocypris) alta* (Zalanyi), Krstic, Neogene Ostracod, Serbien, table II, 3-5.

1974 *Candona (Caspiocypris) alta* (Zalanyi,), Hanganu, Danube-Motru, table III: 10-12.

1980 *Candona (Caspiocypris)* aff. *alta* (Zalanyi), Freels, Turkey, Taf. 4, figures 1-8.

1992 *Candona (Caspiocypris) alta* (Zalanyi), Şafak et al., Sarız (Kayseri)/Turkey, plate 4, figure 1.

1992 *Candona (Caspiocypris) alta* (Zalanyi), Nazik et al., Tufanbeyli (Adana)/Turkey, plate II, figure 8.

2005 *Candona (Caspiocypris) alta* (Zalanyi), Vasiliev et al., pages 3-6, table 1.

Stratigraphical and geographical distribution: Caspian Basin (Zalanyi, 1929); Romania-Sarmatian (Hanganu, 1974); Sivas and Şebinkarahisar/Turkey, Upper Miocene (Freels, 1980), Sarız and Tufanbeyli/Turkey - Pliocene (Şafak et al., 1992; Nazik et al., 1992); Southern Carpathians – Mio-Pliocene (Vasiliev et al., 2005).

Stratigraphical and geographical distribution : Caspian Basin

Localities in this study : Hınıs 3 Measured Section, samples 8 and 9, Pliocene – Early Pleistocene.

Species -Type : *Cypris candida* Müller, 1776

Candona (Candona) parallela pannonica Zalanyi, 1959

(Plate II, Figure 6)

1959 *Candona parallela pannonica* Zalanyi, pages 200-202, plate 3, figure a-c

1963 *Candona pokornyi* Kheil, pages 23-25, plate 2, figures 1-4.

1979 *Candona (Candona) parallela pannonica* Zalanyi, Gökçen, page 119, plate 7, figures 1,2.

1988 *Candona parallela pannonica* Zalanyi, Nazik, page 80, plate 4, figure 8-11, plate 7, figure 11.

1989 *Candona parallela pannonica* Zalanyi, Tanar, pages 143-144, plate 11, figures 1-3.

1997 *Candona (Candona) parallela pannonica* Zalanyi, Şafak and Meriç, page 194, plate V, figures 8-9.

1997*b* *Candona (Candona) parallela pannonica* Zalanyi, Şafak, pages 262-266.

1998 *Candona (Candona) parallela pannonica* Zalanyi, Şafak and Taner, plate 1, figure 9.

1999 *Candona (Candona) parallela pannonica* Zalanyi, Kubanç et al., page 791.

1999 *Candona (Candona) parallela pannonica* Zalanyi, Şafak et al., page 184, plate IV, figure 7.

1999 *Candona (Candona) parallela pannonica*

Zalanyi, Nazik et al., page 117.

1999 *Candona (Candona) parallela pannonica* Zalanyi, Nazik et al., page 144, plate III, figures 6-7.

2001 *Candona (Candona) parallela pannonica* Zalanyi, Tunoğlu, page 131, table 1.

2001 *Candona parallela pannonica* Zalanyi, Tunoğlu and Ünal, page 177, plate 3, figures 2-4.

2002 *Candona (Candona) parallela pannonica* Zalanyi, Atay and Tunoğlu, page 143, plate 3, figures 1-5.

2004 *Candona (Candona) parallela pannonica* Zalanyi, Atay and Tunoğlu, page 13.

2008 *Candona parallela pannonica* Zalanyi, Nazik et al., page 494, plate 1, figure 4.

2009 *Candona parallela pannonica* Zalanyi, Şafak et al., page 206, plate 3, figure 10.

2010 *Candona (Candona) parallela pannonica* Zalanyi, Nazik et al., plate 4, figure 4.

2010 *Candona (Candona) parallela pannonica* Zalanyi, Şafak, page 57, plate 3, figures 1-2.

Stratigraphical and geographical distribution: Pannoninan Basin, Hungary, Late Pannonian (Zalanyi, 1959); Trebon basin, Czechoslovakia, Tortonian (Kheil, 1963); Denizli – Muğla / Turkey, Pontian (Gökçen, 1979); Ulukışla, Adana / Turkey, Pontian (Nazik, 1988); Mut Basin, Turkey, Burdigalian (Tanar, 1989); Kahta / Adıyaman, Messinian (Şafak and Meriç, 1997); Bakırköy Basin - İstanbul / Turkey, Messinian = Pontian (Şafak, 1997); NW Karaman - İçel / Turkey – Quaternary (Şafak and Taner, 1998); İzmit Bay - Pleistocene (Kubanç et al, 1999); western İstanbul - Pliocene (Şafak et al., 1999); Anadolu Hisarı / İstanbul - Holocene (Nazik et al., 1999); Akyatan Lagoon / SE Adana Turkey - Holocene (Nazik et al., 1999); Black Sea Region / Turkey, Pontian (Tunoğlu, 2001); Gelibolu Peinnsula / NW Turkey, Mid – Late Pannonian - Pontian (Tunoğlu and Ünal, 2001); Eceabat / Çanakkale (NW Turkey), Pannonian (Atay and Tunoğlu, 2002); Kilitbahir / Çanakkale – Upper Miocene (Atay and Tunoğlu, 2004); Arguvan / Malatya (Eastern Anatolia), Upper Miocene (Nazik et al., 2008); Adıyaman / Southeastern Anatolia, Messinian (Şafak et al., 2009); İznik and Sapanca lakes / Turkey, Quaternary (Nazik et al., 2010); Denizli / SW Anatolia – Late Miocene (Şafak, 2010).

Localities in this study: Hınıs 1 Measured Section, sample 3, Pliocene, Hınıs 2 Measured Section, samples 1, 3 and 4, Pliocene

Candona (Candona) burdurensis Freels, 1980

(Plate II, Figures 7-8)

1980 *Candona (Candona) burdurensis* Freels, page 101, taf. 17, figures 15-23.

1996 *Candona (Candona) burdurensis* Freels, Tunoğlu and Bayhan, page 101, Taf.17, figures 15-23.

1999 *Candona (Candona) burdurensis* Freels, Kubanç et al., page 791.

2005 *Candona (Candona) burdurensis* Freels, Matzke-Karasz and Witt, page 118, plate 1, figure 2.

Stratigraphical and geographical distribution : Burdur Lake - Burdur / Turkey, Late Pleistocene (Freels, 1980); Burdur Basin / Turkey, Pliocene (Tunoğlu and Bayhan, 1996); İzmit Bay - Pleistocene (Kubanç et al., 1999); Yalova (İzmit vicinity / Turkey) - Meotian (Matzke-Karasz and Witt, 2005).

Locaities in this study : Hınıs 2 Measured Section, sample 1, Pliocene; Hınıs 3 Measured Section, sample 5, Pliocene.

Candona (Candona) candida Müller, 1776

(Plate II, Figure 9)

1776 *Candona candida* Müller

1965 *Candona candida* Müller, Devoto, page 337, figure 36.

1973 *Candona (Candona) candida* pliocenica Müller, Krstic, page 151-173, figures 1,2.

1978 *Candona candida* Müller, Sokac, pages 24-25, plate 9, figures 1-4.

1980 *Candona candida* Müller, Freels, pages 80-82, plate 13, figures 6-8.

1984 *Candona (Candona)* aff. c*andida* Müller,

Tunoğlu, pages 118-119, plate 9, figures 1-3.

1991 *Candona candida* Müller, Pietrzenuik, page 106, plate 2, figures 5-7.

1996 *Candona candida* Müller, Ünal, pages 116-117, plate 7, figures 3, 4; plate 13, figure 1.

1997 *Candona (Candona) candida* Müller, Şafak, page 94, plate IV, figure 8.

2001 *Candona candida* Müller, Tunoğlu and Ünal, page 177, plate 3, figure 7.

2002 *Candona (Candona) candida* Müller, Atay and Tunoğlu, page 143, plate 3, figures 6-8.

2003-2004 *Candona candida* Müller, Bossio et al., page 69.

2004 *Candona candida* Müler, Atay and Tunoğlu, page 13.

2008 *Candona candida* Müller, Beker, Tunoğlu and Ertekin, page 14, plate2, figures 2,3.

2010 *Candona candida* Müller, Şafak, page 56, figure 7.

Stratigraphical and geographical distribution : Liri Valley / Italy, Pleistocene (Devoto, 1965); Jugoslavia, Pontian (Krstic, 1973); Pannonian Basin, Pontian (Sokac, 1978); Aydın / Turkey, Late Miocene (Freels, 1980); Sinop Peninsula / Turkey, Pontian (Tunoğlu, 1984); Germany, Miocene (Pietrzenuik, 1991); Gelibolu Peninsula, Early Pannonian – Pontian (Ünal, 1996); Karaman / Turkey, Pliocene (Şafak, 1997); Gelibolu Basin / NW Turkey, Pannonian-Pontian (Tunoğlu and Ünal, 2001); Ecaabat / Çanakkale / NW Turkey, Pannonian (Atay and Tunoğlu, 2002); Toscana, Italy, Neogene (Bossio et al., 2003-2004); Kilitbahir / Çanakkale – Upper Miocene (Atay and Tunoğlu, 2004); Karapınar - Konya / Central Anatolia, Pliocene – Lower Pleistocene (Beker et al., 2008); Denizli / SW Anatolia, Late Miocene (Şafak, 2010).

Localities in this study : Hınıs 3 Measured Section, sample 5, Pliocene.

Candona (Candona) sp.1 Freels, 1980

(Plate II, Figure 10)

1980 *Candona (Candona)* 1Freels, p. 97, Taf. 17, figure 1-3.

Stratigraphical and geographical distribution : Muş Basin / Turkey, Pliocene – Lower Pleistocene (Freels, 1980).

Localities in this study : Hınıs 2 Measured Section, sample 4, Pliocene.

4. Discussion and Results

Rich ostracod assemblages and micro molluscs,which constitutes the subject matter of this study,were identifined from the washed samples collected from the soft clayey limestone and plant fragments bearing travertine limestones in the Yolüstü formation.

Ostracods, such as, *Leptocythere (Amnicythere)* cf. *litiva* Livental, Agal., et al., *Tyrrhenocythere bailovi* (Suzin), *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva, *L. agilis* Ruggieri, *Candona (Caspiocypris) araxica* Freels, *C. (Caspiocypris)erzurumensis* Freels, *C (Caspiocypris)* aff. *alta* (Zalanyi), *C. (Typhlocypris) amblygonica* Freels, *C. (Candona) parallela pannonica* Zalanyi, *C. (Candona) burdurensis* Freels, *C. (Candona) candida* (O.F.Müller), *C (Candona)* Freels, and micro gastropods and pelecypods like *Valvata piscinalis* (O.F.Müller), *Viviparus* sp., *Dreissena polymorpha* (Palas) are the fossils observed in the formation. *Leptocythere (Amnicythere)* cf. *litiva* Livental, *Tyrrhenocythere bailovi* (Suzin), *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva, *L. agilis* Ruggieri, *Candona (Caspiocypris) araxica* Freels, *C. (Caspiocypris) erzurumensis* Freels, *C.(Caspiocypris)* aff. *alta* (Zalanyi), *C. (Typhlocypris) amblygonica* Freels, *C. (Candona) parallela pannonica* Zalanyi, *C. (Candona) burdurensis* Freels, *C. (Candona) candida* (O.F.Müller), *C. (Candona)* sp. 1 Freels gibi ostrakod ve *Valvata piscinalis* (O.F.Müller), *Viviparus* sp., *Dreissena polymorpha* (Palas) are the fossils observed in the formation. Ostracods like, *Candona (Caspiocypris) araxica* Freels, *C. (Caspiocypris) erzurumensis* Freels, *C. (Caspiocypris)* aff. *alta* (Zalanyi), *C. (Typhlocypris) amblygonica* Freels, *C. (Candona) parallela pannonica* Zalanyi, *C. (Candona) burdurensis* Freels, *C. (Candona) candida* (O.F.Müller), *C. (Candona)* sp.1 Freels generally indicate age for the travertine limestone and the ostracods, such as, *Leptocythere (Amnicythere)* cf. *litiva* Livental, *Tyrrhenocythere bailovi* (Suzin), *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva, *L. agilis* Ruggieri together with the micro mollusks such as; *Valvata piscinalis* (O.F.Müller), *Viviparus* sp., *Dreissena polymorpha* (Palas), in general, indicate Early Pleistocene age for

the plant fragments bearing hard travertine (Figure 2).

Freels (1980) assigned the following ostracod fauna as Late Miocene; *C (Caspiocypris) erzurumensis* Freels, *C. (Caspiocypris)* aff. *alta* (Zalanyi), *C (Typhlocypris) amblygonica* Freels, *C (Candona) candida* (O.F.Müller), *C. (Candona)* 1 Freels. But he recognized *C. (Candona) burdurensis* Freels genus as Pleistocene. However; Krstic and Dermitzakis (1981) considered the fossil assemblage characterized by *Leptocythere (Amnicythere)* cf. *litiva* Livental, *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva, *Tyrrhenocythere bailovi* (Suzin) occur as Pleistocene.

C. (Candona) parallela pannonica species was defined as Miocene – Quaternary age by many investigators (Nazik et al.,1992; Şafak et al., 1999; Tunoğlu et al., 1995; Ünal, 1996; Şafak and Meriç, 1997; Şafak, 1997; Şafak and Taner, 1998; Kubanç et al., 1999; Nazik et al., 1999*a*; Nazik et al., 1999*b*; Tunoğlu, 2001; Tunoğlu and Ünal, 2001; Atay and Tunoğlu, 2002 ; Atay and Tunoğlu, 2004; Nazik et al., 2008; Şafak et al, 2009; Nazik et al., 2010; Şafak, 2010).

L. agilis Ruggieri species was defined in the numereous studies carried out in the Bay of Naples, Adriatic Sea, Evros Delta, Aegean Sea, Black Sea, along the coasts of Zonguldak–Amasra and in the Gulf of Mersin (Puri et al., 1964; Bonaduce et al., 1975; Stambolidis, 1985; Kubanç, 1995; Tunoğlu, 2002; Şafak, 2008). Furthermore, the mollusc fauna defined within this unit wereconsidered as Pliocene in the Dardanelles by Taner (1997). Loxoconcha cf. diligena Kulieva sp., an ostracod species, was defined in Azerbaijan and Corinth Canal (Greece) as Pliocene - Post Pliocene and Pleistocene (Kulieva et al., 1961; Krstic and Dermitzakis, 1981).

Loxoconcha granulata Sars species was considered as Pleistocene – Recent in age in several studies carried out in Warsaw, Russia, Netherlands, Greece (Corinth Canal), Turkey (Gökçeada – Bozcaada – Çanakkale, Black Sea Coast, and in the Gulf of Mersin) and the NW Black Sea of Romania (Mandelstam, 1956 and 1962; Shornikov, 1969; Athersuch and Horne, 1981; Krstic and Dermitzakis, 1981; Şafak, 1999; Opreanu, 2003- 2004 and 2005; Şafak, 2008).

Previous investigators regarded the İncesu formation as late Pleistocene, since it rests on the lacustrine, tuff and clayey limestone units of the Yolüstü formation with an gradational contact. Therefore the Yolüstü formation is considered to have deposited at the interval of middle Pliocene (Tarhan, 1961). In this study, the fossil assemblage of the ostracoda forms identified in this unit (the Yolüstü formation) indicates an age interval of Pliocene-early Pleistocene.

The following ostracoda fauna,in particular, *Tyrrhenocythere bailovi* (Suzin), *Candona (Caspiocypris) araxica* Freels, *C. (Caspiocypris) erzurumensis* Freels, *C. (Caspiocypris)* aff. *alta* (Zalanyi) are regarded as characteristic forms of Ponto – Caspian and Pannonian Basin (Central Paratethys) in origin, and they indicate transition starting from oligohaline to brackish water environments representing of closed and different basinal characteristics.

As it has already been noted in many ostracoda studies carried out in Hungary, Azerbaijan, Russia and in other places that the following fauna like *Leptocythere (Amnicythere)* cf. *litiva* Livental, Agal., *Loxoconcha granulata* Sars, *L.* cf. *diligena* Kulieva occur in gulf and marine influenced canal, i.e. Corinth canal,environments, and they represent transition into brackish water. *Loxoconcha agilis* Ruggieri sp. has not been referred among the Mediterranean originated Loxoconcha species in the study of Schornikov (2011) but its occurence has been noted in the studies carried out along the coasts of the Black Sea.

Ostracods, such as, *C (Candona) parallela pannonica* Zalanyi, *C. (Candona) burdurensis* Freels, *C (Candona) candida* (O.F.Müller), *C (Candona)* sp. 1 Freels and micro molluscs as *Valvata piscinalis* (O.F.Müller), *Viviparus* sp., *Dreissena polymorpha* (Palas) indicate a freshwater environment. This faunal assemblage indicates a continuous intake of fresh water into the depositional environment of the plant fragment bearing travertine limestone.

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PLATES

PLATE I

Figure 1- *Leptocythere (Amnicythere)* cf. *litica* Livental, in Agalarova et al., 1961

Hınıs 1 Measured Section, Yolüstü formation, Harami member, Sample 10, Early Pleistocene

1.Left valve, external view.

Figure 2- *Tyrrhenocythere bailovi* (Suzin, 1956)

Hınıs 3 Measured Section, Yolüstü formation, Harami member, Sample 7, Early Pleistocene

2. Left valve, external view.

Figures 3-4- *Loxoconcha* cf. *diligena* Kulieva, 1961

Hınıs 2 Measured Section, Yolüstü formation, Harami member, Sample 8, Early Pleistocene

3. Shell, right valve, external view.

4. Shell, left valve, external view.

Figure 5- *Loxoconcha agilis* Ruggieri, 1967

Hınıs 3 Measured Section, Yolüstü formation, Harami member, Sample 7, Pliocene - Early Pleistocene

5. Shell, left valve, external view.

Figure 6-8- *Loxoconcha granulata* Sars, 1866

Hınıs 3 Measured Section, Yolüstü formation, Harami member, Sample 7, Pliocene - Early Pleistocene

6. Shell, left valve, external view

7. Shell, right valve, external view

8. Shell, left valve, external view

Figure 9- *Candona (Typhlocypris) amblygonica* Freels

Hınıs 1 Measured Section, Yolüstü formation, Harami member, Sample 3, Pliocene

9. Left valve, external view

PLATE I

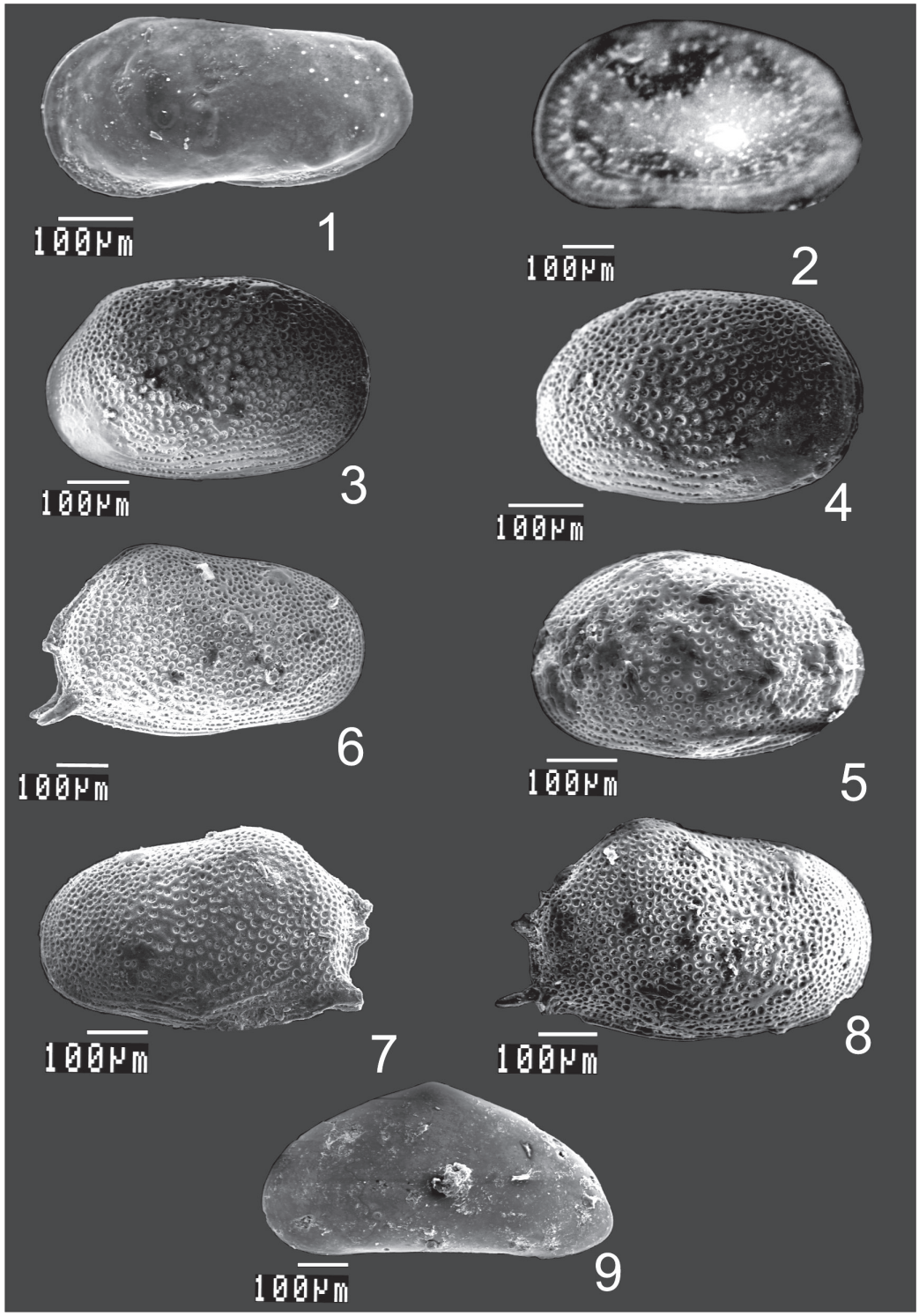
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PLATE II

Figures 1-2- *Candona (Caspiocypris) araxica* Freels, 1980

Hınıs 1 Measured Section, Yolüstü formation, Harami Member, Sample 3, Pliocene

1. Right valve, external view

2. Left valve, external view

Figure 3- *Candona (Caspiocypris) erzurumensis* Freels, 1980

Hınıs 1 Measured Section, Yolüstü formation, Hamzabey Member, Sample 2, Pliocene

3. Right valve, external view

Figure 4-5- *Candona (Caspiocypris)* aff. *alta* (Zalanyi, 1929)

Hınıs 3 Measured Section, Yolüstü formation, Harami Member, Sample 8, Early Pleistocene

4. Right valve, external view

5.Right valve, external view

Figure 6- *Candona (Candona) parallela pannonica* Zalanyi, 1959

Hınıs 2 Measured Section, Yolüstü formation, Harami Member, Sample 1, Pliocene

6. Right valve, external view

Figure 7-8- *Candona (Candona) burdurensis* Freels, 1980

Hınıs 2 Measured Section, Yolüstü formation, Harami Member, Sample 1, Pliocene

7. Left valve, external view

Figure 9- *Candona (Candona) candida* Müller, 1976

Hınıs 3 Measured Section, Yolüstü formation, Harami Member, Sample 5, Pliocene

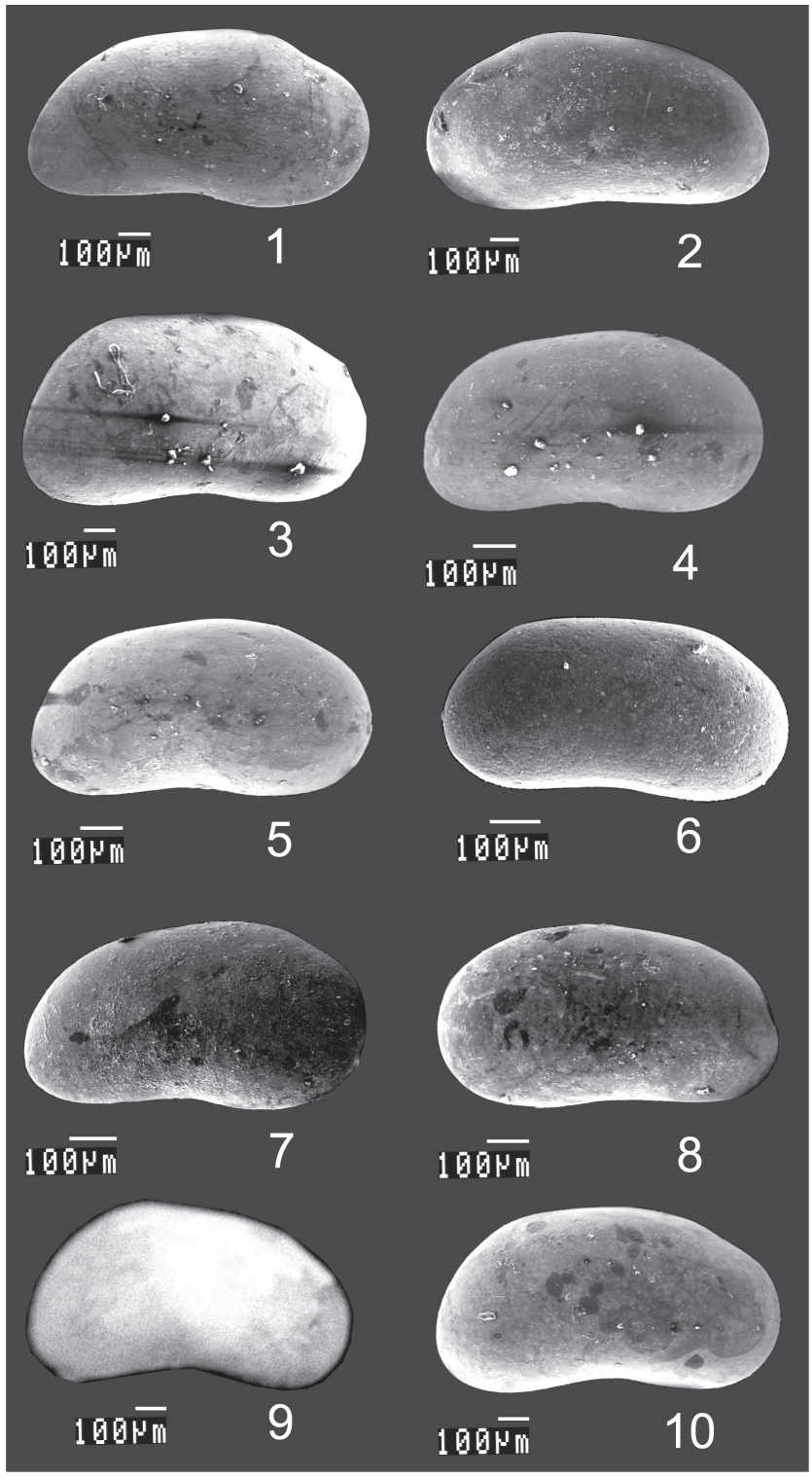
9. Right valve, external view

Figure 10- *Candona (Candona)* sp.1 Freels, 1980

Hınıs 2 Measured Section, Yolüstü formation, Harami Member, Sample 1, Pliocene

10. Right valve, external view

PLATE II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