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Early Pliocene molluscs from the easternmost Mediterranean region (SE Turkey): biostratigraphic, ecostratigraphic, and palaeobiogeographic implications

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Abstract: The mollusc faunas from Pliocene deposits of the Hatay-İskenderun region were investigated at nine localities and complemented with three localities from earlier studies. The Pliocene units were deposited in three adjacent subbasins, Hatay-Samandağ (HS), Altınözü-Babatorun (AB), and İskenderun-Arsuz (İA); the first two are also known as the Hatay Graben. Basin configurations and shape, environmental evolution, and faunal compositions were affected by differential tectonic histories since the Late Miocene. In total 162 species (94 gastropod, 61 bivalve, and 7 scaphopod) are recorded, 80 of which are recorded for the first time from the region. The occurrence of tropical stenohaline benthic taxa (such as *Persististrombus coronatus* and some conid gastropod species) and a number of chronostratigraphically well-constrained mollusc species shows a Zanclean age. The base of the Early Pliocene is also shown by the occurrence of planktic foraminifer assemblages corresponding to MPL1 and MPL2 biozones and the nannoplankton *Amaurolithus delicatus* assemblage. The Early Pliocene Hatay molluscan assemblages allow for palaeobiogeographic comparisons across the Mediterranean. The Pliocene marine fossiliferous deposits are assigned to the Mediterranean Pliocene Molluscan Unit 1 (MPMU1) of the western Mediterranean and Atlantic regions. However, the eastern Mediterranean assemblages are notably poorer in species and in particular a number of thermophilic groups are lacking. This marine biodiversity gradient has been a characteristic feature of the Mediterranean ever since the Pliocene.

Key words: Zanclean, Gastropoda, Bivalvia, Scaphopoda, stratigraphy, palaeoecology, Hatay basin

1. Introduction

The Hatay Graben (HG) is an asymmetrical fault-controlled basin in the easternmost margin of the Mediterranean. Tectonic activity results from a complex interaction of several major regional fault systems including the East Anatolian Fault, the Cyprus Arc, and the Dead Sea Fault (Aksu et al., 2005; Boulton et al., 2006, 2007; Boulton and Robertson, 2007, 2008; Tarı et al., 2014) (Figure 1). The HG consists of several subbasins that have a Late Miocene-Pliocene infill. The basinal configuration, stratigraphy, and depositional environments of these subbasins were mainly affected by changing tectonic regimes from a late-stage continental collision phase in the Late Miocene (Messinian) to a westward tectonic escape during Early Pliocene (Zanclean) times (Boulton et al., 2006, 2016; Boulton and Robertson, 2007, 2008). The area consists of two tectonically originated NE-SW directed small subbasins, the Hatay-Samandağ (HS) and Altınözü-Babatorun (AB), and the neighbouring İskenderun-Arsuz (İA) basin. The latter is separated by the structural highlands of Amanos-Kızıldağ and the Misis complex, whereas the Ziyaretdağ-Kılıçdağ mountains separate the HS and AB (Kozlu, 1997; Tekin et al., 2010) (Figure 1).

A Late Miocene-Pliocene succession is exposed in these basins. It concerns mostly marine deposits, yet the basin fill has also been affected by lowstands of the Mediterranean Messinian Salinity Crisis prior to the Zanclean reflooding. Pliocene molluscs in the easternmost part of Mediterranean region have been reported since the early 20th century from Turkey and part of Syria and Lebanon (Daus, 1914; Dubertret et al., 1937; Roman, 1940). Erentöz (1955) described different lithological successions in the Samandağ region (Turkey), called "marl", "marl and sandstone", "sandstone", "coral limestone", and "pebble" series. She assigned Lower Tortonian, Upper Tortonian, and Mio-Pliocene ages to the different

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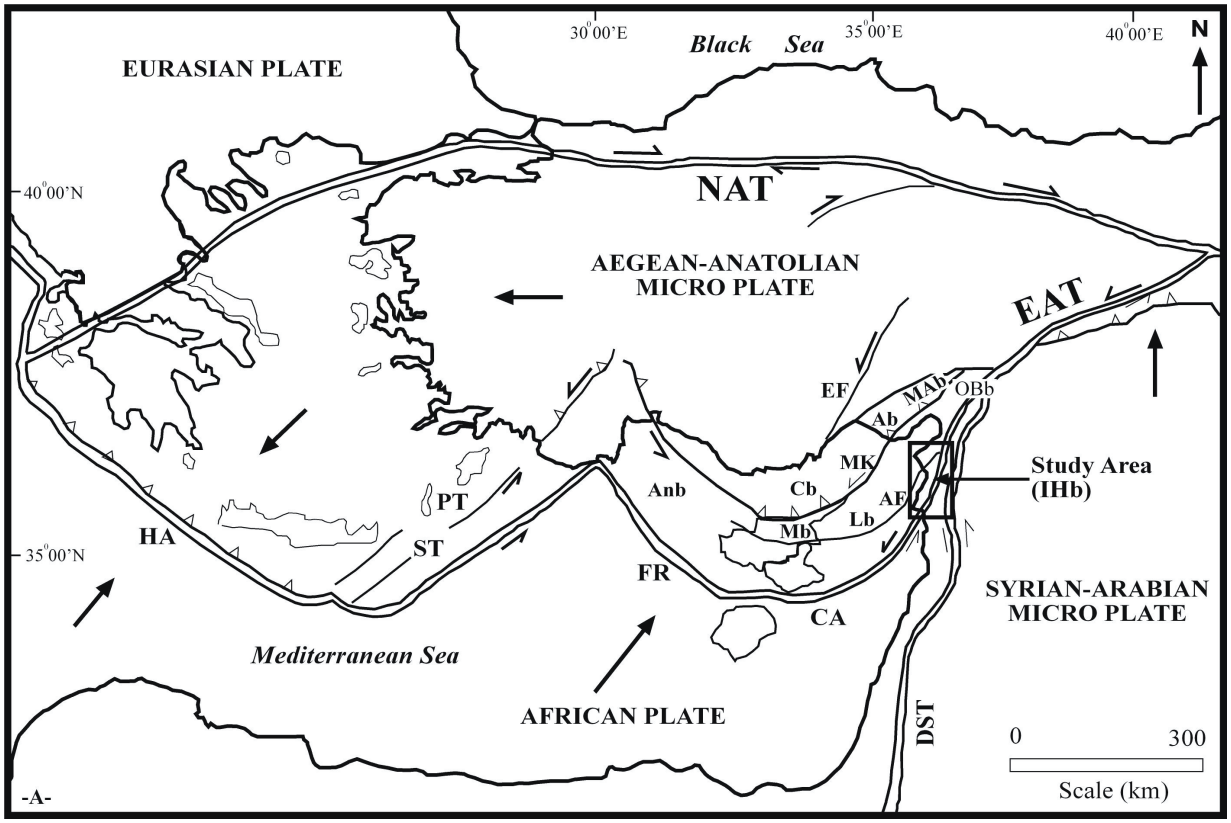


Figure 1. a, b) Studied subbasins (HS, İA, and AB) and main neotectonic units surrounding the region (modified from Şengör and Yılmaz, 1981 and Aksu et al., 2005).

units based on their foraminifer and mollusc content. Erünal-Erentöz (1958) made a comprehensive taxonomic documentation of the mollusc faunas as a part of her PhD thesis and assigned a Piacenzian age based on molluscs. In the 1980s these Pliocene deposits were described as the Samandağ Formation (Selçuk, 1981, 1985). A faunal assessment of these Pliocene deposits in the HS subbasin was made by Karakuş and Taner (1994) but it is in need of revision. Mollusc faunas from the Aktepe Formation of the İA subbasin were briefly reported by İslamoğlu et al. (2009). The newly collected material increases the regional coverage and enables to assess the palaeoecology, age, and biogeographic signature of the entire Pliocene fauna from the Hatay Graben region.

Pliocene-Pleistocene molluscan ecobiostratigraphic units (so-called MPPMUs) have been proposed for the western-central Mediterranean and the eastern Atlantic. These MPPMUs are bounded by a series of molluscan extinction events (Raffi and Monegatti, 1993; Monegatti and Raffi, 2001, 2007; Landau et al., 2011). The Hatay faunas are sufficiently preserved to make a comparison with these MPPMUs and allow for an extension of this scheme into the East Mediterranean area.

The aim of this work is 1) to describe the Early Pliocene molluscan assemblages obtained from the two subbasins (HS and AB) in the Hatay Graben and neighbouring İA subbasin, 2) to constrain their stratigraphic age and understand their palaeoenvironments, and 3) to compare our molluscan data with the western Mediterranean ecostratigraphic units of Monegatti and Raffi (2001) and to explore the biogeographic significance of these East Mediterranean faunas.

2. Geological setting

The Hatay Graben is bounded by the Dead Sea Fault Zone (DSFZ) and East Anatolian Fault Zone (EAFZ) in the east and the Cyprus Arc (CA) in the west. These have shaped the basin since the Late Miocene (Perinçek and Çemen, 1990; Boulton et al., 2006, 2007; Boulton and Robertson, 2008; Ediger et al., 1996 Tarı et al., 2014; Boulton et al., 2016). Late Tortonian normal faults with NW-SE directed right-lateral strike slip components are common. During the Tortonian, fine detritics (marls and sandy marls) of the Nurzeytin Formation formed while the basin underwent an extensional tectonic regime (Boulton and Robertson, 2007; Boulton et al., 2007). Marine Early Messinian deposits have

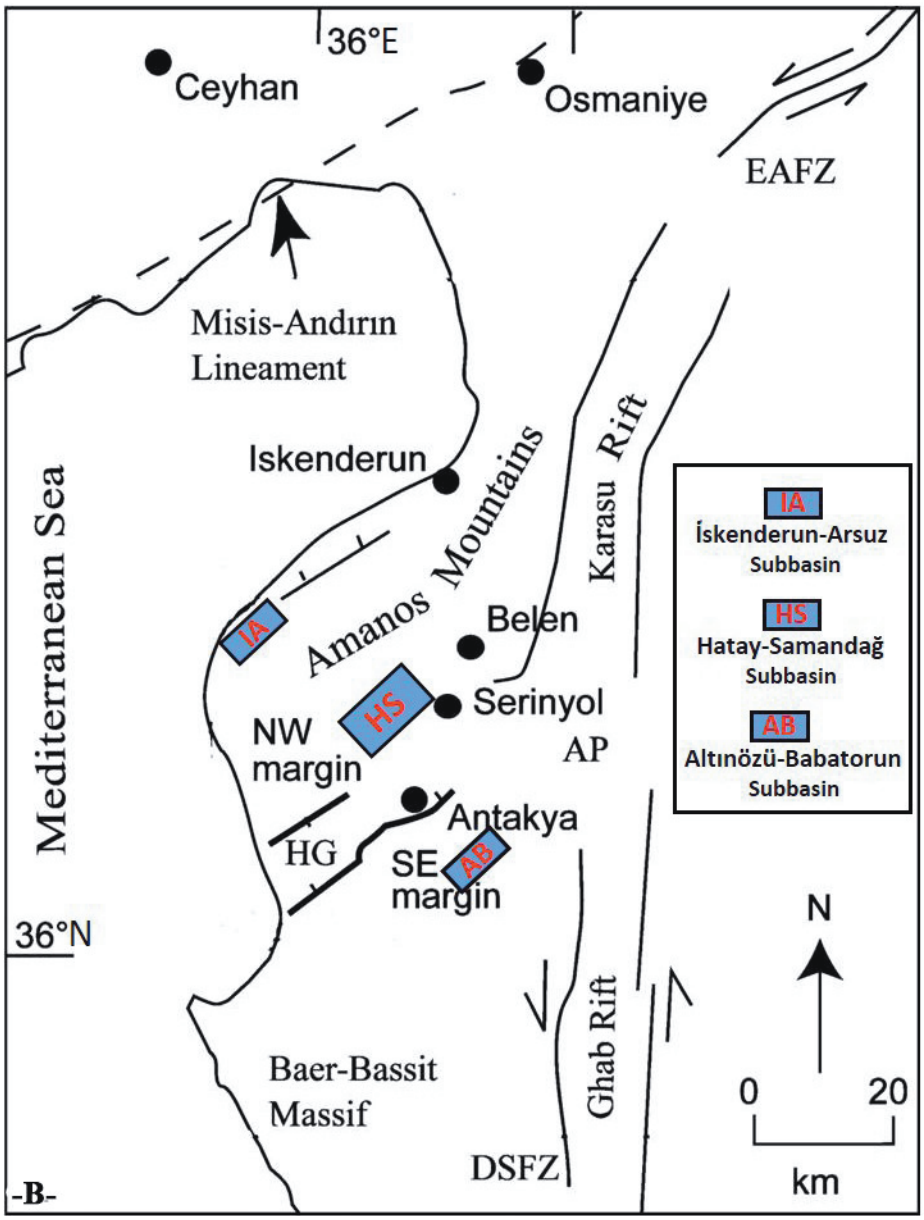


Figure 1. (Continued).

been reported from limited areas in the eastern part of the HG (Tekin et al., 2010). The Late Messinian is represented by evaporitic deposits (Vakıflı Formation), developed in the western and southern margins of the HG (Tekin et al., 2010; Boulton et al., 2016). Evaporitic sediments consist of two gypsum sequences, a lower interbedded unit and an upper chaotic unit (Tekin et al., 2010). During the Early Pliocene the HG consisted of three subbasins reflected in the deposition of three different units: the Samandağ Formation in the HS, the Aktepe Formation in the İA, and the (informal) Altınözü Formation in the AB subbasin. The latter is unconformably overlying Messinian units. Shallow and deeper marine sediments of the Samandağ Formation in the HS subbasin overlay the Tortonian, Messinian, and Mesozoic ophiolitic units (Tekin et al., 2010). Transitional levels from evaporates to nonevaporitic siliciclastic and carbonate units have been examined in several works based on the combination of planktonic foraminifer-ostracod and strontium isotope analyses (Boulton et al., 2007). They showed the resumption of marine deposition during the Early Pliocene. In the İA subbasin, the Early Pliocene shallow marine Aktepe Formation overlies Messinian evaporites (Haymaseki Formation) through a low-grade unconformity (Kozlu, 1997) but there is

conformity in the graben centre. The Altınözü Unit from the AB subbasin is an informal lithostratigraphical that we introduce for the purpose of this study; it includes shallow water siliciclastics and pelagic intervals, but also dyke and sills. In previous works, the fine detritic deposits of the unit were assigned to the Late Miocene (Tortonian) Nurzeytin Formation based on nannoplankton (Tekin et al., 2010, Boulton et al., 2016). Here we report for the first time an early Pliocene mollusc fauna from these intervals. As a full review of stratigraphic units is beyond the scope of this paper, we introduce informally the Altınözü Formation, which represents a fine-grained Early Pliocene lithological unit of the AB subbasin. Late Pliocene deposits in the HG are only exposed in the İA subbasin and are represented by the terrestrial facies, with some plant remains, but these lack mollusc fossils (Erzin Formation: Kozlu, 1997).

3. Materials and methods

This study is based on newly collected mollusc material as well as material collected by Erünal-Erentöz (1958). The new material derives from sections and localities that were lithologically documented. Age estimates for these deposits were obtained from nannoplankton and planktonic foraminifer analyses performed on sediment samples from the sections. For mollusc analyses about 1 kg of sediment was processed per sample. Sediment was wet-sieved (diameter: 1 mm) in the Ankara University Geological Engineering Department's sedimentology laboratory and at the General Directory of Mineral Research and Exploration (MTA), Department of Geology, Palaeontology Laboratory. In the residues, mollusc shells were sorted and documented by macroscopic photography (Leica MZ8 for shells of <2 cm and Canon camera for shells of >2 cm) in the Ankara University Geological Engineering Department. Mollusc shells are stored in the Geological Engineering Department of Bülent Ecevit University, Zonguldak (Turkey) and the PhD collections of Erünal-Erentöz (1958) reside in the Geological Engineering Department of Ankara University. Mollusc taxonomy for species that are extant follows WoRMS (www.WoRMS.org).

4. Results

In total nine stratigraphical sections were measured from the Early Pliocene deposits and samples were collected from mollusc-rich clayey-silty sands and mudstones of the Aktepe, Samandağ, and Altınözü formations (Figure 2). The sample coordinates and lithologies are given in Table 1.

A total of 162 species of molluscs are investigated in this work, 86 of which are recorded for the first time from the Early Pliocene of the eastern Mediterranean. Results of mollusc analyses are given in Tables 2–5. Specific nannoplankton and planktonic foraminifer species are only found in the HS subbasin (Samandağ Formation), supporting the Early Pliocene age of the deposits (Table 6; Figure 3). Some specific mollusc species are illustrated in Figures 4–9.

4.1. Litho- and biostratigraphy

4.1.1. Samandağ Formation (HS subbasin)

Six stratigraphical sections were measured and sampled (Figures 2 and 10). The earliest Pliocene Samandağ Formation consists of fossiliferous yellow sandstones and grey mudstones (Boulton et al., 2016). The unit overlays Messinian evaporites of the Vakıflı Formation that contain grey mudstone/marl interbeds in the Mızraklı-Kireçtepe section. The sections are rich in microfossils and molluscs.

Mızraklı-Kireçtepe section: In this section a combined micropalaeontological and mollusc inventory was made. The lowermost dark grey muds and marls (samples 08-11-28a–d) yield a very rich planktonic foraminifer fauna (Table 6). The sample is rich in *Sphaeroidinellopsis* species but *Globorotalia margaritae* is lacking. This corresponds to the lowermost Pliocene *Sphaeroidinellopsis* acme zone (MPL1 of Cita, 1973, 1975a, b; Meulenkamp et al., 1979, 1994). Upwards in the section marl intervals occur with abundant planktonic foraminifers (samples 08-11-30a, 08-11-30b, and 08-11-31; Table 6). The assemblage and especially the occurrence of *Globorotalia margaritae* are indicative of the MPL2 biozone (Cita, 1973; Lourens et al., 2004). The Early Pliocene nannoplankton assemblage of the Mızraklı section contains 13 species (Table 6) that are also indicative of a Zanclean age.

The abundant mollusc fauna contains 48 species indicative of an Early Pliocene (Zanclean) age (Tables 2 and 3). The faunal community represents shallow marine conditions with the grazer *Thericium crenatum* indicating the presence of (some) sea grass.

Kuşalanı section: The mollusc fauna (39 species: Tables 2 and 3) is composed of shallow marine species with three cerithid gastropods species (*Bittium latreillei*, *B. reticulatum*, *Thericium crenatum*) indicating sea grass habitats to be present.

Sutaşı section: Here a very similar shallow marine mollusc fauna (25 species: Tables 2 and 3) was found, slightly less rich in species and more dominated by bivalves.

Kesecik/Karlısuyu section: The 9 species (Tables 2 and 3) indicate slightly deeper depositional depths than the previous sections with more common scaphopods, *Amusium cristatum* and *Nucula placentina*.

Telliturna section: Three shallow marine species and 1 subtropical gastropod (*Oliva* sp.) were found in the section (Tables 2 and 3).

Karaali section: In the lower part 12 marine mollusc species were found, including the subtropical *Conus antidiluvianus* (Table 2). In the upper part 14 marine

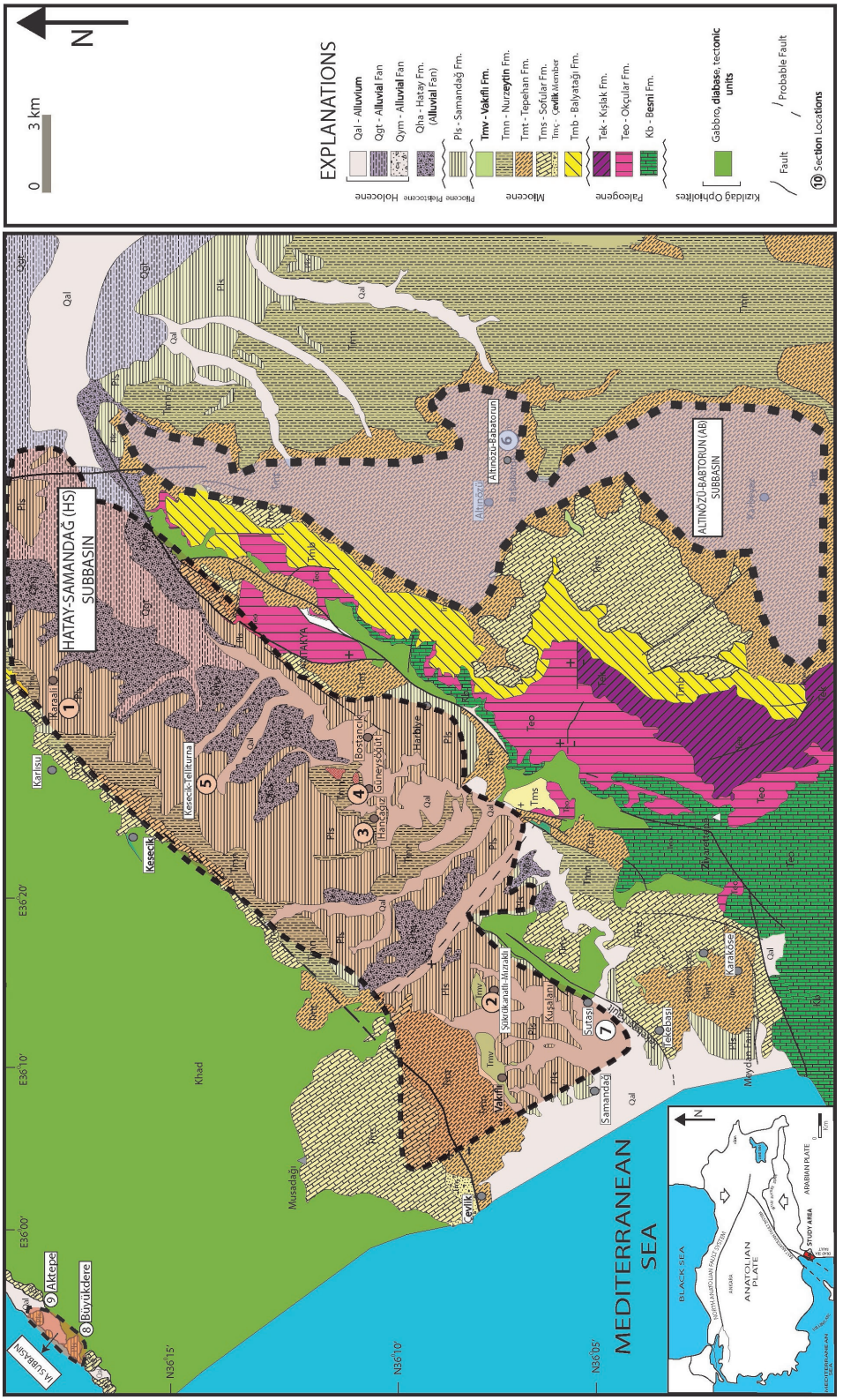


Figure 2. Geological map of the region and localities of the measured stratigraphical sections (1: Mızraklı-Kireçtepe section, 2: Kuşalanı section, 3: Sutaşı section, 4: Kesecik/Karlısuyu section, 5: Telliturna section, 6: Karaali section, 7: Babatorun section; 8: Büyükdere section, 9: Aktepe section) (modified from Tekin et al., 2010).

Table 1. Sample numbers, coordinates, and lithologies of the fossiliferous levels.

ISKENDERUN-ARSUZ (IA) SUBBASIN (Aktepe formation)				
LOCATION	**SAMPLE NUMBER**	**GPS COORDINATES**	**Altitude**	**LITHOLOGY**
Aktepe	08_11_05	4029564 N - 36756507 E	9 m	claystone
Aktepe	08_11_06a	4029564 N - 36756507 E	9 m	black colored marl-clayey
Aktepe	08_11_06b	4029564 N - 36756507 E	9 m	black colored marl
Aktepe	08_11_06c	4029564 N - 36756507 E	9 m	sandstone
Büyükdere	08_11_10	4046104 N - 38234206 E	6 m	sandstone
Büyükdere	08_11_10b2	4046104 N - 38234206 E	6 m	black colored marl-clayey
Büyükdere	08_11_11	4046104 N - 38234206 E	6 m	black colored marl-clayey limestone
Büyükdere	08_11_12	4046104 N - 38234206 E	6 m	dark grey colored claystone-mudstone
Büyükdere	08_11_13	4046104 N - 38234206 E	6 m	yellowish sandstone
Büyükdere	08_11_14	4046104 N - 38234206 E	6 m	limestone with plant fragments
Büyükdere	08_11_15	4046104 N - 38234206 E	6 m	black colored marl- mudstone
Büyükdere	08_11_16	4046104 N - 38234206 E	6 m	black colored marl- mudstone
Büyükdere	08_11_17	4046104 N - 38234206 E	6 m	carbonated gypsum with plant traces
Büyükdere	08_11_18	4046104 N - 38234206 E	6 m	reddish mudstone
Büyükdere	08_11_19	4046104 N - 38234206 E	6 m	clayey sandy limestone
Büyükdere	08_11_20	4046104 N - 38234206 E	6 m	lacustrine limestone (with plant roots)
Büyükdere	08_11_21	4046104 N - 38234206 E	6 m	dark grey, black colored mudstone
HATAY-SAMANDAĞ (HS) SUBBASIN (Samandağ formation)				
Mızraklı/Kireçtepe	08_11_28a	4004512 N - 37234448 E	125 m	dark grey colored mudstone - marl
Mızraklı/Kireçtepe	08_11_28b	4004512 N - 37234448 E	125 m	dark grey colored mudstone - marl
Mızraklı/Kireçtepe	08_11_28c	4004512 N - 37234448 E	125 m	dark grey colored mudstone - marl
Mızraklı/Kireçtepe	08_11_30a	4001880 N - 37230944 E	85 m	marl - claystone
Mızraklı/Kireçtepe	08_11_30b	4001880 N - 37230944 E	85 m	marl - claystone
Mızraklı/Kireçtepe	08_11_31a	4005535 N - 36763852 E	64 m	marl
Mızraklı/Kireçtepe	08_11_31b	4005535 N - 36763852 E	64 m	marl
Mızraklı/Kireçtepe	08_11_32	4001363 N - 37231157 E	90 m	marl-mudstone
Mızraklı/Kireçtepe	08_11_33	4000084 N - 37232813 E	143 m	marl-mudstone
Mızraklı/Kireçtepe	08_11_38	4001257 N- 37232637 E	79 m	marl-claystone
Mızraklı/Kireçtepe	13_10_07	4001363 N - 37231157 E	110 m	dark grey colored mudstone - marl
Mızraklı/Kireçtepe	13_10_06b	4001363 N - 37231157 E	110 m	dark grey colored mudstone - marl
Sutaşı	09_06_17	3997484 N - 37229986 E	32 m	sandstone-mudstone
Sutaşı	09_ 06_ 19	3990557 N - 37229730 E	184 m	marl-mudstone
Sutaşı	09_06_24	4006969 N - 37241416 E	81 m	sandstone-mudstone
Sutaşı	10_11_02	4006969 N - 37241416 E	80 m	marl-mudstone
Sutaşı	10_02_01	3997838 N - 37230287 E	47 m	sandstone-mudstone
Sutaşı	10_02_25	3991870 K - 37230936 E		sandstone-mudstone-marl
Karaali	10_02_14	4019083 N - 37246839 E	134 m	dark grey marl
Karaali	10_02_23a	4014845 N- 37241722 E	216 m	dark grey colored mudstone - marl
Kuşalanı	Kuş1	4000234 N - 36770030 E	370 m	dark grey colored mudstone - marl
Kuşalanı	Kuş2	4000234 N - 36770030 E	370 m	dark grey colored mudstone - marl
Kuşalanı	Kuş3	4000234 N - 36770030 E	370 m	dark grey colored mudstone - marl
Kuşalanı	Kuş4	4000234 N - 36770030 E	370 m	dark grey colored mudstone - marl
Tellituma	10_06_03	4014845 N- 37241722 E	215 m	dark grey colored mudstone - marl
Tellituma	10_06_04	4014848 N- 37241726 E	217 m	dark grey colored mudstone - marl
Tellituma	10_06_07	4014851 N- 37241730 E	218 m	dark grey colored mudstone - marl
Kesecik/Karlısuyu	10_06_14	3999653 N - 370233850 E	132 m	sandstone-marl
Kesecik/Karlısuyu	10_02_14	4019083 N - 37246839 E	134 m	dark grey colored marl
Kesecik/Karlısuyu	10_02_15	4015668 N - 37241087 E	237 m	dark grey colored marl-claystone
ALTINÖZÜ-BABATORUN (AB) SUBBASIN (Altınözü formation)				
Babatorun	13 10_12	3995779 N - 37256516 E	470 m	yellowish sandstone
Babatorun	13 10_12a	3995779 N - 37256516 E	470 m	yellowish sandstone
Babatorun	11_03_14a	3995779 N - 37256516 E	471 m	yellowish sandstone
Babatorun	11_03_14b	3995779 N - 37256516 E	472 m	yellowish sandstone
Babatorun	11_03_14c	3995779 N - 37256516 E	473 m	yellowish sandstone
Babatorun	10_11_08	3995779 N - 37256516 E	467 m	yellowish sandstone
Babatorun	10_11_08a	3995779 N - 37256516 E	468 m	yellowish sandstone
Babatorun	10_11_06	3995779 N - 37256516 E	469 m	yellowish sandstone
Babatorun	10_11_05	3995779 N - 37256516 E	474 m	yellowish sandstone
Babatorun	10_09_12a	3995780 N - 37256517 E	464 m	cream colored clayey limestone
Babatorun	10_09_12d	3995781 N - 37256518 E	465 m	cream colored clayey limestone
Babatorun	10_09_12f	3995782 N - 37256519 E	466 m	cream colored clayey limestone
Babatorun	10_09_13	3995783 N - 37256520 E	463 m	dark colored marl
Babatorun	10_09_14	3995784 N - 37256521 E	453 m	dark colored marl-claystone
Babatorun	10_09_15	3995785 N - 37256522 E	453 m	yellow colored sandstone
Babatorun	11-03-14a	3995774 N - 37256528 E	443 m	dark colored marl-claystone
Babatorun	11-03-14b	3995784 N - 37256521 E	478 m	grey colored marl-claystone
Babatorun	11-03-14c	3995794 N - 37256511 E	473 m	dark colored marl-claystone

Table 2. Sample numbers and distribution of the scaphopod and gastropods.

	İSKENDERUN -ARSUZ (İA)																			
Location	Aktepe						Büyükdere													
Sample Numbers	08_11_05	08_11_06a	08_11_06b	08_11_06c	09_06_05	09_06_06	08_11_10	08_11_10b2	08_11_11	08_11_12	08_11_13	08_11_14	08_11_15	08_11_16	08_11_17	08_11_18	08_11_19	08_11_20	08_11_21	09_06_01
SCAPHOPODA																				
Dentalium sexangulum Schröter, 1784																				
Antalis vulgaris vitrae (Gmelin, 1790)																				
Dentalium (Antalis) fossile Schröter, 1784			X			X														
Dentalium michelotti Hoernes, 1856																				
Gadilina triquetra triquetra (Brocchi, 1814)		X	X																	
Gadilina jani (Hoernes, 1856)																				
Gadila ventricosa (Bronn, 1827)																				
GASTROPODA																				
Jujubinus striatus striatus (Linnaeus, 1767)																				
Gibbula (Gibbula) magus (Linnaeus, 1758)																				
Gibbula sp.					X															
Paraoxystele patulum (Brocchi, 1814)																				
Bolma (Ormastralium) fimbriata (Borson, 1821)																				
Tricolia pullus pullus (Linnaeus, 1758)																				
Thericium varicosum (Brocchi, 1814)																				
Thericium crenatum (Brocchi, 1814)																				
Thericium vulgatum (Bruguiére, 1792)						X														
Strioterebrum pliocenicum (Fontannés, 1880)																				
Bittium latreillei (Payraudeau, 1826)																				
Bittium reticulatum (Da Costa, 1778)																				
Turritella aspera (Sismoda in Mayer, 1866)																				
Turritella erronea Cossmann in Friedberg, 1914																				
Turritella spirata (Brocchi, 1814)						X														
Turritella tricarinata Brocchi, 1814																				
Tenagodus (Tenagodus) cf. *obtusus* (Schumacher,1817)																				
Ceratia proxima (Forbes & Hanley, 1850)																				
Rissoina (Zebinella) cf. *decussata* (Montagu, 1803)																				
Petaloconchus intortus (Lamarck, 1818)																				
Serpulorbis deshayesi (Mayer, 1889)																				
Aporrhais cf. *uttingerianus* (Risso, 1826)		X		X		X														
Xenophora sp.																				
Cochlis pseudoepiglottina funicillata (Sacco, 1891)																				
Tectonica tectula (Sacco, 1890)																				
Euspira helicina helicina (Brocchi, 1814)																				
Neverita olla (De Serres, 1829)																				
Sinum sp.																				
Malea sp.																				
Galeodea echinophora (Linnaeus, 1758)																				
Semicassis cf. *laevigata* (Defrance, 1817)																				
Monoplex sp.																				
Seila plioiberica Landau, Perna & Marquet, 2006																				
Epitonium sp.																				
Eulimella pyramidata (Deshayes, 1835)																				
Niso terebellum pygmaea (Sequenza, 1876)						X														
Murex sp.																				
Bolinus cf. *brandaris torularius* (Lamarck, 1822)																				
Typhis fistulosus (Brocchi, 1814)																				
Nassarius cf. *clathratus* (Born, 1778)																				
Nassarius semistriatus (Brocchi, 1814)		X				X														
Nassarius elatus (Gould, 1845)																				
Nassarius prysmaticus (Brocchi, 1814)																				
Nassarius serraticosta (Bronn, 1852)																				
Nassarius pliomagnus (Sacco, 1904)																				
Nassarius striatulus striatulus (Eichwald, 1829)																				
Tritia gibbosula pliocallosa (Sacco, 1890)																				
Mitrella (Clinurella) minima (Sacco, 1890)																				
Mitrella villavarnensis (Sacco, 1890)																				
Mitrella erythrostoma (Bellardi, 1848)			X																	
Mitrella semicaudata (Bellardi, 1848)																				
Pseudolatirus ligusticus (Bellardi,1884)																				
Pusia pyramidella (Brocchi, 1814)																				
Bathytoma cataphracta (Brocchi, 1814)						X														
Conolithes dujardini (Deshayes, 1845)																				
Conus (Chelyconus) pyrula Brocchi, 1814																				
Conus (Chelyconus) pyrula mucronata (Brocchi, 1814)																				
Conus (Chelyconus) curtus Erünal –Erentöz, 1958																				
Eucithara cf. *fusiformis* (Reeve, 1846)																				
Clathurella spreafici Bellardi, 1877																				
Mangelia vaguelini (Payraudeau, 1827)																				
Mangelia attenuata (Montagu, 1803)			X																	
Lyromangelia crassicostata Scarponi & Della Bella, 2010																				
Bela sp.																				
Raphitoma sp.																				
Daphnella (Daphnella) textile (Brocchi, 1814)																				
Turriclavus harpulus (Brocchi, 1814)																				
Clavatula (Surcula) dimidiata (Brocchi, 1814)				X		X														
Gemmula rotata (Brocchi, 1814)																				
Gemmula rotata dertocarinulata Sacco																				
Terebra acuminata Borson, 1820																				
Psilaxis simplex (Bronn, 1831)																				
Chrysallida obtusa (Brown, 1827)																				
Chrysallida interstincta (J. Adams, 1797)																				
Turbonilla densecostata (Philippi, 1844)																				
Turbonilla rufa (Philippi, 1836)																				
Ringicula (Ringiculina) auriculata (Ménard, 1811)																				
Ringicula buccinea (Brocchi, 1814)																				
Bulla ampulla Linnaeus, 1758																				
Roxania utriculus (Brocchi, 1814)																				
Scaphander lignarius (Linnaeus, 1758)																				

	HATAY-SAMANDAĞ (HS)																												
Location	Mızraklı-Kireçtepe												Sutaşı					Karali		Kuşalanı				T.turna			Kesecik		
Sample Numbers	08_11_28	08_11_28a	08_11_28b	08_11_28c	08_11_29	08_11_30a	08_11_30b	08_11_31	08_11_32	08_11_33	08_11_38	13_10_06b	09_06_17	09_06_24	10_02_01	10_11_02	10_02_25	10_02_14	10_02_23a	Kuş-1	Kuş-2	Kuş-3	Kuş-4	10_06_03	10_06_04	10_06_07	10_06_14	10_02_14	10_02_15
SCAPHOPODA																													
Dentalium sexangulum Schröter, 1784								X	X	X																			
Antalis vulgaris vitrae (Gmelin, 1790)									X				X					X	X										
Dentalium (Antalis) fossile Schröter, 1784						X		X					X					X											
Dentalium michelotti Hoernes, 1856																													
Gadilina triquetra triquetra (Brocchi, 1814)						X		X	X	X		X																	
Gadilina jani (Hoernes, 1856)									X																				
Gadila ventricosa (Bronn, 1827)																											X		
GASTROPODA																													
Jujubinus striatus striatus (Linnaeus, 1767)																							X						
Gibbula (Gibbula) magus (Linnaeus, 1758)									X																				
Gibbula sp.																													
Paraoxystele patulum (Brocchi, 1814)											X											X	X						
Bolma (Ormastralium) fimbriata (Borson, 1821)									X																				
Tricolia pullus pullus (Linnaeus, 1758)													X								X	X	X						
Thericium varicosum (Brocchi, 1814)													X																
Thericium crenatum (Brocchi, 1814)											X										X		X						
Thericium vulgatum (Bruguiére, 1792)																													
Strioterebrum pliocenicum (Fontannés, 1880)											X										X	X							
Bittium latreillei (Payraudeau, 1826)																					X	X							
Bittium reticulatum (Da Costa, 1778)																													
Turritella aspera (Sismoda in Mayer, 1866)																					X	X							
Turritella erronea Cossmann in Friedberg, 1914						X			X										X		X	X							
Turritella spirata (Brocchi, 1814)																		X											
Turritella tricarinata Brocchi, 1814											X											X							
Tenagodus (Tenagodus) cf. *obtusus* (Schumacher,1817)																													
Ceratia proxima (Forbes & Hanley, 1850)																													
Rissoina (Zebinella) cf. *decussata* (Montagu, 1803)																													
Petaloconchus intortus (Lamarck, 1818)																													
Serpulorbis deshayesi (Mayer, 1889)																													
Aporrhais cf. *uttingerianus* (Risso, 1826)						X												X	X										
Xenophora sp.																					X								
Cochlis pseudoepiglottina funicillata (Sacco, 1891)								X	X		X	X									X	X							
Tectonica tectula (Sacco, 1890)																						X	X						
Euspira helicina helicina (Brocchi, 1814)												X	X									X							
Neverita olla (De Serres, 1829)											X										X								
Sinum sp.																													
Malea sp.																					X								
Galeodea echinophora (Linnaeus, 1758)																					X								
Semicassis cf. *laevigata* (Defrance, 1817)								X	X	X											X								
Monoplex sp.												X																	
Seila plioiberica Landau, Perna & Marquet, 2006																													
Epitonium sp.																							X						
Eulimella pyramidata (Deshayes, 1835)																							X						
Niso terebellum pygmaea (Sequenza, 1876)																						X							
Murex sp.																					X								
Bolinus cf. *brandaris torularius* (Lamarck, 1822)																					X								
Typhis fistulosus (Brocchi, 1814)																					X								
Nassarius cf. *clathratus* (Born, 1778)									X																				
Nassarius semistriatus (Brocchi, 1814)								X	X	X				X								X					X		
Nassarius elatus (Gould, 1845)									X																				
Nassarius prysmaticus (Brocchi, 1814)								X	X										X		X								
Nassarius serraticosta (Bronn, 1852)																													
Nassarius pliomagnus (Sacco, 1904)											X										X						X		
Nassarius striatulus striatulus (Eichwald, 1829)									X			X																	
Tritia gibbosula pliocallosa (Sacco, 1890)								X	X																				
Mitrella (Clinurella) minima (Sacco, 1890)																													
Mitrella villavarnensis (Sacco, 1890)																					X	X	X						
Mitrella erythrostoma (Bellardi, 1848)									X	X																			
Mitrella semicaudata (Bellardi, 1848)																													
Pseudolatirus ligusticus (Bellardi,1884)																								X	X				
Pusia pyramidella (Brocchi, 1814)																			X										
Bathytoma cataphracta (Brocchi, 1814)								X																					
Conolithes dujardini (Deshayes, 1845)																													
Conus (Chelyconus) pyrula Brocchi, 1814											X										X	X	X						
Conus (Chelyconus) pyrula mucronata (Brocchi, 1814)											X										X		X						
Conus (Chelyconus) curtus Erünal –Erentöz, 1958								X	X	X	X																		
Eucithara cf. *fusiformis* (Reeve, 1846)																					X	X	X						
Clathurella spreafici Bellardi, 1877																													
Mangelia vaguelini (Payraudeau, 1827)																							X						
Mangelia attenuata (Montagu, 1803)								X	X	X										X		X							
Lyromangelia crassicostata Scarponi & Della Bella, 2010																						X							
Bela sp.																													
Raphitoma sp.																													
Daphnella (Daphnella) textile (Brocchi, 1814)									X																				
Turriclavus harpulus (Brocchi, 1814)									X																				
Clavatula (Surcula) dimidiata (Brocchi, 1814)																													
Gemmula rotata (Brocchi, 1814)																													
Gemmula rotata dertocarinulata Sacco																													
Terebra acuminata Borson, 1820											X										X	X							
Psilaxis simplex (Bronn, 1831)																						X							
Chrysallida obtusa (Brown, 1827)																													
Chrysallida interstincta (J. Adams, 1797)																													
Turbonilla densecostata (Philippi, 1844)																													
Turbonilla rufa (Philippi, 1836)																						X	X						
Ringicula (Ringiculina) auriculata (Ménard, 1811)													X																
Ringicula buccinea (Brocchi, 1814)													X																
Bulla ampulla Linnaeus, 1758											X								X			X	X						
Roxania utriculus (Brocchi, 1814)																													
Scaphander lignarius (Linnaeus, 1758)																													

	ALTINÖZÜ-BABATORUN (AB)																				
Location	Babatorun																				
Sample Numbers	10_11_02	10_11_05	10_11_06	10_11_08	10_11_08A	10_11_10	10_11_11	10_09_12a	10_09_12d	10_09_12f	10_09_13	10_09_14	10_03_14a	10_03_14b	10_03_14c	10_09_15	13_10_12a	13_10_12	11_03_14a	11_03_14b	11_03_14c
SCAPHOPODA																					
Dentalium sexangulum Schröter, 1784							X														
Antalis vulgaris vitrae (Gmelin, 1790)	X												X	X	X				X	X	X
Dentalium (Antalis) fossile Schröter, 1784	X														X			X			X
Dentalium michelotti Hoernes, 1856														X							
Gadilina triquetra triquetra (Brocchi, 1814)																				X	
Gadilina jani (Hoernes, 1856)													X	X	X				X	X	X
Gadila ventricosa (Bronn, 1827)													X	X					X	X	
GASTROPODA																					
Jujubinus striatus striatus (Linnaeus, 1767)																					
Gibbula (Gibbula) magus (Linnaeus, 1758)																					
Gibbula sp.														X							
Paraoxystele patulum (Brocchi, 1814)																					
Bolma (Ormastralium) fimbriata (Borson, 1821)																					
Tricolia pullus pullus (Linnaeus, 1758)																					
Thericium varicosum (Brocchi, 1814)	X																				
Thericium crenatum (Brocchi, 1814)																					
Thericium vulgatum (Bruguiére, 1792)																					
Strioterebrum pliocenicum (Fontannés, 1880)															X					X	X
Bittium latreillei (Payraudeau, 1826)													X						X		
Bittium reticulatum (Da Costa, 1778)													X	X					X	X	
Turritella aspera (Sismoda in Mayer, 1866)																					
Turritella erronea Cossmann in Friedberg, 1914														X							
Turritella spirata (Brocchi, 1814)																				X	
Turritella tricarinata Brocchi, 1814													X								
Tenagodus (Tenagodus) cf. *obtusus* (Schumacher,1817)													X	X					X		
Ceratia proxima (Forbes & Hanley, 1850)													X	X					X		
Rissoina (Zebinella) cf. *decussata* (Montagu, 1803)													X								
Petaloconchus intortus (Lamarck, 1818)																				X	X
Serpulorbis deshayesi (Mayer, 1889)													X	X	X				X	X	
Aporrhais cf. *uttingerianus* (Risso, 1826)																					
Xenophora sp.																					
Cochlis pseudoepiglottina funicillata (Sacco, 1891)																					
Tectonica tectula (Sacco, 1890)																					
Euspira helicina helicina (Brocchi, 1814)														X							
Neverita olla (De Serres, 1829)																				X	
Sinum sp.																	X				
Malea sp.																					
Galeodea echinophora (Linnaeus, 1758)																					
Semicassis cf. *laevigata* (Defrance, 1817)																					
Monoplex sp.																					
Seila plioiberica Landau, Perna & Marquet, 2006																				X	
Epitonium sp.																					
Eulimella pyramidata (Deshayes, 1835)																					
Niso terebellum pygmaea (Sequenza, 1876)																			X	X	
Murex sp.																					
Bolinus cf. *brandaris torularius* (Lamarck, 1822)													X	X							
Typhis fistulosus (Brocchi, 1814)																					
Nassarius cf. *clathratus* (Born, 1778)																					
Nassarius semistriatus (Brocchi, 1814)																					X
Nassarius elatus (Gould, 1845)																					
Nassarius prysmaticus (Brocchi, 1814)														X							
Nassarius serraticosta (Bronn, 1852)																			X	X	
Nassarius pliomagnus (Sacco, 1904)																					
Nassarius striatulus striatulus (Eichwald, 1829)																					
Tritia gibbosula pliocallosa (Sacco, 1890)														X							
Mitrella (Clinurella) minima (Sacco, 1890)																			X	X	
Mitrella villavarnensis (Sacco, 1890)													X	X							
Mitrella erythrostoma (Bellardi, 1848)													X	X					X	X	
Mitrella semicaudata (Bellardi, 1848)																					
Pseudolatirus ligusticus (Bellardi,1884)													X								
Pusia pyramidella (Brocchi, 1814)																					
Bathytoma cataphracta (Brocchi, 1814)																					
Conolithes dujardini (Deshayes, 1845)																			X		
Conus (Chelyconus) pyrula Brocchi, 1814																					
Conus (Chelyconus) pyrula mucronata (Brocchi, 1814)																					
Conus (Chelyconus) curtus Erünal –Erentöz, 1958																					
Eucithara cf. *fusiformis* (Reeve, 1846)																					
Clathurella spreafici Bellardi, 1877														X							
Mangelia vaguelini (Payraudeau, 1827)																					
Mangelia attenuata (Montagu, 1803)							X								X					X	
Lyromangelia crassicostata Scarponi & Della Bella, 2010																					
Bela sp.													X	X							
Raphitoma sp.															X						
Daphnella (Daphnella) textile (Brocchi, 1814)																					
Turriclavus harpulus (Brocchi, 1814)																					
Clavatula (Surcula) dimidiata (Brocchi, 1814)																					
Gemmula rotata (Brocchi, 1814)															X						
Gemmula rotata dertocarinulata Sacco																					X
Terebra acuminata Borson, 1820														X	X						
Psilaxis simplex (Bronn, 1831)																					
Chrysallida obtusa (Brown, 1827)														X					X	X	
Chrysallida interstincta (J. Adams, 1797)																				X	
Turbonilla densecostata (Philippi, 1844)														X							
Turbonilla rufa (Philippi, 1836)														X						X	
Ringicula (Ringiculina) auriculata (Ménard, 1811)																					
Ringicula buccinea (Brocchi, 1814)													X							X	
Bulla ampulla Linnaeus, 1758																				X	
Roxania utriculus (Brocchi, 1814)																				X	
Scaphander lignarius (Linnaeus, 1758)																			X		

mollusc species were found. Both intervals are dominated by bivalve species (Table 3).

4.1.2. Altınözü Formation (AB subbasin)

One stratigraphical section (Babatorun) was logged and sampled assigned to the Altınözü Formation (Figures 2 and 11). Unlike the other subbasins, the assemblage includes mixed marine and reworked brackish water fossils.

Babatorun section: *Theodoxus* cf. *mutinense* (D'Ancona 1869), *Ecrobia* sp., *Gyraulus* sp., *Melanoides* sp., and *Mytilopsis* sp. are oligohaline-mesohaline species that represent latest Miocene anomalohaline lacustrine conditions. These lake intervals are overlain and partially mixed with a shallow marine fauna (Tables 2 and 3), indicating the rapid environmental change from anomalohaline lacustrine (latest Miocene) to shallow marine (early Pliocene) settings.

4.1.3. Aktepe Formation (İA subbasin)

The lowest Pliocene mollusc-bearing unit comprises lagoon-beach and channelised tidal flat filled with conglomerate and cross-bedded sandstone deposits with interbedded channelised sandstones and conglomerates. Two stratigraphical sections were measured (Aktepe and Büyükdere sections) (Figures 2 and 12).

Table 3. Sample numbers and distribution of the bivalves.

	STRATIGRAPHICAL RANGE								Eastern Atlantic						Western Mediterranean					Central Mediter.			E. Mediterranean		
	Miocene			Plio.		Ple.		H	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
BIVALVIA	E	M	L	E	L	E	L																		
Nucula nucleus (Linnaeus, 1758)											X	X		X									X	X
Leionucula cf. *laevigata* (Sowerby, 1818)											X													
Nucula placentina Lamarck, 1819														X					X	X			X	X	X
Saccella commutata (Philippi, 1844)									X			X	X	X	X				X			X		X	
Lembulus pella (Linnaeus, 1767)											X										X	X		X	
Jupiteria concava (Bronn, 1831)															X				X						
Yoldia longa Bellardi, 1875													X	X	X				X						X
Yoldia nitida (Brocchi,1814)														X								X			X
Anadara diluvii (Lamarck, 1805)									X			X	X	X	X				X		X	X		X	X
Acar clathrata (Defrance, 1816)											X	X					X			X		X			X
Barbatia empolensis Micheli & Torre, 1966																				X					
Striarca lactaea (Linnaeus, 1758)											X	X	X	X								X			
Tucetona pectinata (Gmelin, 1791)									X						X				X			X			X
Glycymeris glycymeris (Linnaeus, 1758)											X	X													
Glycymeris rogeri Erünal – Erentöz, 1958																						X			
Glycymeris nummaria (Linneaus, 1758)											X	X	X	X					X						
Glycymeris aff. *cor* (Lamarck, 1805)										X					X	X				X			X		X
Gibbomodiola adriatica (Lamarck, 1819)									X						X				X						
Lima lima (Linné, 1758)											X	X	X												X
Ostrea forskali Chemnitz, 1791																				X		X	X		
Ostrea edulis Linné, 1758												X	X	X				X			X	X		X	X
Palliolum excisum (Bronn, 1848)									X			X	X	X	X		X		X						
Palliolum) excisum perstriatula (Sacco, 1897)																			X						
Pecten maximus (Linnaeus, 1758)																					X			X	
Aequipecten scabrella (Lamarck, 1819)									X				X	X	X		X		X	X			X	X	X
Flabellipecten flabelliformis (Brocchi, 1814)																X	X		X	X			X	X	
Dimya tenuiplicata (Sequenza, 1879)																					X				
Propeamussium felsineum (Foresti, 1895)																				X					
Propeamussium (Parvamussium) duodecimlamellatum (Bronn, 1831)																			X	X				X	
Costellamussiopecten cristatus (Bronn, 1827)													X	X			X	X	X					X	X
Anomia ephippium Linné, 1758									X				X	X	X			X		X		X	X		X
Lucina orbicularis Deshayes, 1836																				X	X		X	X	
Divaricella divaricata (Linnaeus, 1758)													X	X	X			X	X		X				
Loripes lacteus (Linnaeus,1758)									X			X		X	X				X		X			X	
Loripes dentatus (Defrance, 1823)													X												
Anodontia (Loripinus) fragilis (Philippi,1836)													X		X			X		X				X	
Glans (Centrocardita) intermedia (Brocchi, 1814)													X	X			X			X				X	X
Chama gryphoides (Linné, 1758)												X	X	X								X			
Acanthocardia aculeatum (Linnaeus, 1758)																				X			X	X	
Acanthocardia paucicostata G.B. Sowerby, 1834													X	X						X				X	
Acanthocardia tuberculata Linnaeus, 1758											X	X	X				X			X	X	X		X	X
Acanthocardia cf. erinacea (Lamarck, 1819)											X	X	X												
Acanthocardia echinata (Linnaeus, 1758)													X	X	X					X	X	X		X	
Papillicardium papillosum (Poli, 1791)												X		X	X						X	X			
Spisula (Spisula) subtruncata triangula (Renieri in Brocchi, 1814)											X	X	X	X							X				
Peronaea planata (Linneaus, 1758)									X				X	X	X				X		X			X	
Serratina serrata (Brocchi, 1814)																									
Gastrana fragilis (Linnaeus, 1758)												X	X	X											
Moerella donacina (Linnaeus, 1758)												X	X	X										X	
Abra alba (W. Wood, 1802)												X							X			X			
Donax trunculus (Linnaeus, 1758)															X				X	X			X		
Venus (Ventricoloidea) multilamella (Lamarck, 1818)									X			X	X	X	X		X		X		X	X		X	X
Gouldia minima (Montagu, 1803)												X	X	X	X							X			
Chamalea gallina (Linnaeus, 1758)														X	X					X	X	X			X
Clausinella fasciata (da Costa, 1778)										X				X	X		X	X	X	X	X	X		X	X
Timoclea ovata (Pennant, 1777)									X			X	X	X	X							X			
Pitar rudis (Poli, 1795)											X	X	X	X								X			
Paphia (Callistotapes) cf. *vetulus* (Basterot, 1825)																				X					
Dosinia lupinus (Linnaeus, 1758)											X	X	X	X			X		X						
Dosinia cf. *orbicularis* (Agassız, 1845)																			X						
Corbula (Varicorbula) gibba (Olivi, 1792)									X		X	X	X	X	X						X	X		X	

Büyükdere section: Only a few marine species were found (*Anomia ephippium* and *Corbula gibba*) in the Büyükdere section.

Akdere section: The Akdere section is rich in marine molluscs and nannoplankton. The unit is overlying a series of mostly dolomitic carbonates, clayey carbonate (attapulgite/palygorskite), and coal-bearing layers (Karakaş et al., 2009) containing plant remains but lacking mollusc fossils.

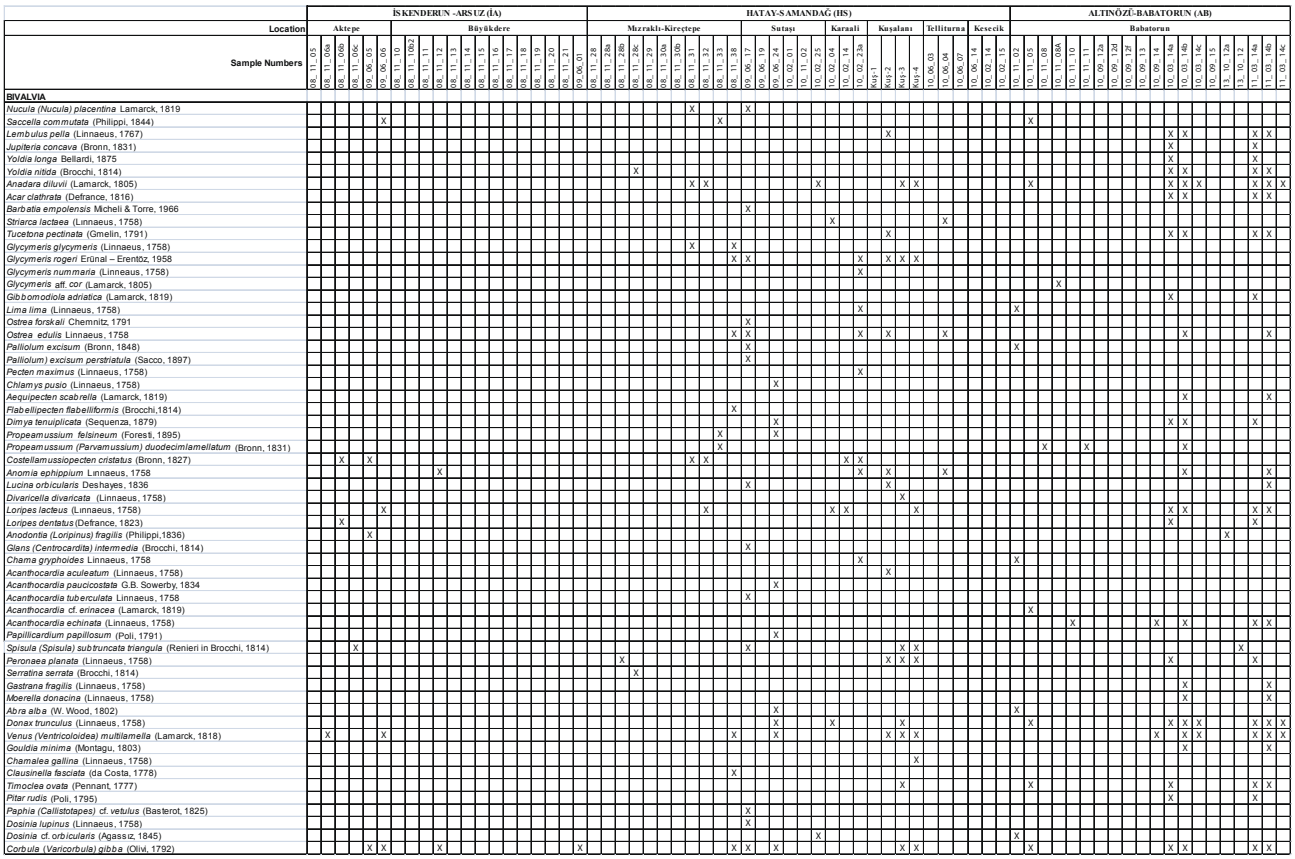
4.2. Palaeoecology and ecobiostratigraphy

The general preservation of molluscs is very good with very little abrasion, indicating deposition below the storm wave base. An exception is the basal interval of the Aktepe Formation of the İA subbasin that represents very shallow (possibly tidal flat) environments. Furthermore, some of the Altınözü faunas are a mixture of very shallow marine and oligohaline lacustrine biota. The studied faunas represent marine conditions and different depth ranges. The occurrence of sea grass-related species in several sections is indicative of relative clear water habitats in the photic zone whereas faunas with common propeamusiid bivalves, pteropod, and scaphopod species represent conditions well below the storm wave base and possibly even below water depths of 100 m. Especially within the Mızraklı-Kireçtepe section, the fossiliferous grey mudstones and marls rich in propeamusiid-scaphopod molluscs, planktic foraminifers, and nannoplankton show the rapid deepening at the onset of the Zanclean. Today, nuculoid-, propeamusiid-, and scaphopod-dominated faunas typically occur below water depths of 100 m in the Mediterranean (Büyükmeriç, 2016).

Table 4. Stratigraphical range and early Pliocene palaeobiogeographic distribution of the Hatay Graben scaphopods and gastropods (*: species found by Erünal-Erentöz, 1958 in the HS subbasin only). **Stratigraphical range:** Sacco (1895a,b,c, 1896, 1897), Erünal-Erentöz (1958), Nevesskaya (1963), Malatesta (1974), Lauriat-Rage (1981), Pavia (1991), Ben Moussa (1994), Landau et al. (2003, 2004a, 2004b, 2009, 2013). **Palaeobiogeographical distribution in early Pliocene:** N. Sea: Belgium (1): Marquet (1997a, 1997b, 1998); England (2): Wood (1872), Harmer (1914–1918, 1920); E. Atlantic (3): Adam and Glibert (1974), Malatesta (1974), Brebion (1979), Lauriat-Rage (1981), Gonzalez Delgado (1988, 1989), Ben Moussa (1994); Portugal/Montego (4): Gili et al. (1995), da Silva (2001); France/Loiré (5): Brébion (1964), Adam and Glibert (1976), Lauriat-Rage et al. (1989a,b); Morocco (6): Adam and Glibert (1974), Ben Moussa (1994); Canaries (7): Meco (1977); NW Spain (8): Gonzales-Delgado (1985, 1986, 1988, 1989); Spain/Guadalquivir (9): Landau et al. (2003, 2009, 2011); W. Mediterranean (10): Adam and Glibert (1974); SE France/Roussillon (11): Fontannes (1879–1882), Martinell and Domenech (1984a), Chirli and Richard (2008); Morocco (12): Lecointre (1952), Brebion et al. (1971); Spain/Estepona (13): Landau et al. (2004a, 2004b, 2007); Velerin (14): Landau et al. (2003, 2004a, 2004b, 2007), Vera-Pelaez et al. (2002); NE Spain (15): Brebion et al. (1971), Martinell (1979, 1982), Martinell and Domenech (1984a, 1984b, 1985), Llop Castella (1990), Bernasconi (1990), Gili (1991), Solsona (1998); C. Mediterranean (16): Brocchi (1814); Tunisia (17): Fekih (1975); Algeria (18): Adam and Glibert (1974, 1976), Gili (1991); Italy (19): Bellardi (1882, 1884), Sacco (1890, 1891, 1892a, 1892b, 1895c, 1897), Pelosio (1967), Palla (1967), Caprotti (1974, 1975), Pavia (1975, 1980, 1991), Malatesta (1974), Robba (1978), Robba (1981), Anfossi et al. (1983), Chirli (1988, 2000, 2002, 2008), Bernasconi (1990), Bernasconi and Robba (1984), Mauro and Giuseppe (2005), Chirli and Micali (2011); E. Mediterranean - Cyprus-Israel (20): Moshkovitz (2012); Hatay/Samandağ basin (21): Erünal-Erentöz, 1958; Former Syria, Hatay, and Lebanon (22): Roman (1940).

	STRATIGRAPHICAL RANGE								N.Sea		Eastern Atlantic							Western Mediterranean						Central Mediterranean				E. Mediterranean		
	Miocene			Plio.		Ple.		H	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	E	M	L	E	L	E	L																							
SCAPHOPODA																														
Dentalium sexangulum Schröter, 1784											X			X				X		X							X		X
Antalis vulgaris vitrae (Gmelin, 1790)																										X			
Dentalium (Antalis) fossile Schröter, 1784														X								X							X
Dentalium michelotti Hoernes, 1856											X							X								X			
Gadilina jani (Hoernes, 1856)																										X			
Gadilina triquetra triquetra (Brocchi, 1814)																										X			
Gadila ventricosa (Bronn, 1827)																										X			
GASTROPODA																														
Jujubinus striatus striatus (Linnaeus, 1767)																				X	X					X			
Gibbula (Gibbula) magus (Linnaeus, 1758)											X						X			X	X	X					X		X
Gibbula sp.																													
Paraoxystele patulum (Brocchi, 1814)																				X	X	X		X		X		X	X
Bolma (Ormastralium) fimbriata (Borson, 1821)																					X	X		X				X	
Tricolia pullus pullus (Linnaeus, 1758)																					X	X	X	X		X			
Thericium varicosum (Brocchi, 1814)																					X					X	X		X
Thericium crenatum (Brocchi, 1814)																					X	X				X	X		X
**Thericium vulgatum* (Bruguière, 1792)														X					X		X		X	X			X	X		X
Bittium latreillei (Payraudeau, 1826)																					X		X						
Bittium reticulatum (Da Costa, 1778)												X		X				X			X		X	X			X	X		X
Turritella aspera (Sismoda *in* Mayer, 1866)																			X		X		X			X			
Turritella erronea Cossmann *in* Friedberg, 1914																					X								
Turritella spirata (Brocchi, 1814)														X							X		X			X	X		X
Turritella tricarinata Brocchi, 1814														X			X		X			X	X			X	X		X
Tenagodus (Tenagodus) cf. obtusus (Schumacher,1817)									X				X								X					X	X		
Ceratia proxima (Forbes & Hanley, 1850)																	X												
Rissoina (Zebinella) cf. decussata (Montagu, 1803)																		X			X			X			X		
Petaloconchus intortus (Lamarck, 1818)													X	X		X	X	X	X	X	X	X		X			X			X
Serpulorbis deshayesi (Mayer, 1889)																										X				X
**Persististrombus coronatus* (Defrance, 1827)														X	X				X	X	X		X				X	X		X
Aporrhais cf. uttingerianus (Risso, 1826)														X					X		X					X	X	X		
Xenophora sp.																														
Cochlis pseudoepiglottina funiciliata (Sacco, 1891)													X	X			X									X	X		
Cochlis catena latoastensis (Sacco, 1890)																										X			
**Cochlis plicatula* (Bronn, 1831)																	X									X		X	
Tectonica tectula (Sacco, 1890)																											X		
**Euspira helicina helicina* (Brocchi, 1814)														X			X		X		X		X	X		X	X		X
Neverita olla (De Serres, 1829)														X			X				X		X				X		
Sinum sp.																													
Malea sp.																													
Galeodea echinophora (Linnaeus, 1758)											X						X				X	X				X			
Semicassis cf. laevigata (Defrance, 1817)									X	X		X		X			X		X	X	X	X	X		X		X	X		
**Cypraecassis cypraeiformis* (Borson, 1820)																	X				X					X			
Monoplex sp.																													
**Aspa marginata* (Gmelin, 1791)																	X		X	X	X		X		X		X			
Seila plioiberica Landau, Perna & Marquet, 2006																						X								
Epitonium sp.																														
Niso terebellum pygmaea (Sequenza, 1876)														X			X							X						X
Murex sp.																														
Bolinus cf. *brandaris torularius* (Lamarck, 1822)																	X		X		X		X		X		X			
Typhis fistulosus (Brocchi, 1814)																					X		X				X			
Nassarius cf. *clathratus* (Born, 1778)												X		X			X			X							X			
Nassarius semistriatus (Brocchi, 1814)											X				X		X	X	X		X	X	X	X	X	X	X	X		X
**Nassarius pliomagnus* (Sacco, 1904)												X			X		X		X	X	X		X				X			
Nassarius elatus (Gould, 1845)											X				X		X	X	X					X	X	X	X			
**Nassarius nitidus* (Jeffreys, 1867)											X	X						X			X	X	X	X	X		X			
**Nassarius turritus* (Borson, 1820)												X					X		X		X	X	X				X			
Nassarius prysmaticus (Brocchi, 1814)										X		X	X			X	X			X	X		X		X	X	X			
Nassarius serraticosta (Bronn, 1852)											X			X			X	X	X		X		X	X			X	X		
Nassarius striatulus striatulus (Eichwald, 1829)																	X		X		X		X				X			
Tritia gibbosula pliocallosa (Sacco, 1890)														X														X		
Mitrella (Clinurella) minima (Sacco, 1890)											X													X						
Mitrella villavarnensis (Sacco, 1890)																										X				
Mitrella erythrostoma (Bellardi, 1848)																	X													
Mitrella semicaudata (Bellardi, 1848)																	X													
Pseudolatirus ligusticus (Bellardi,1884)																										X				
Pusia pyramidella (Brocchi, 1814)																					X					X				
Bathytoma cataphracta (Brocchi, 1814)																	X		X	X	X					X				
Striotrebrum pliocenicum (Fontannès, 1880)																	X	X						X				X		
Conus (Conolithus) canaliculatus Brocchi, 1814																	X	X						X						
Conolithes dujardini (Deshayes,1845)													X				X													X
**Conus (Dendroconus) pseudo-textilis pliocenica* Erünal –Erentöz, 1958																													X	
Conus (Chelyconus) pyrula Brocchi, 1814																														
Conus (Chelyconus) pyrula mucronata (Brocchi, 1814)																														
Conus (Chelyconus) curtus Erünal –Erentöz, 1958																														
Eucithara fusiformis (Reeve, 1846)																										X				
Clathurella spreafici Bellardi, 1877																														
Mangelia attenuata (Montagu)											X													X						X
Mangelia vaguelini (Payraudeau, 1827)																	X													
Lyromangelia crassicostata Scarponi & Della Bella, 2010																	X													
Bela sp.																														
Raphitoma sp.																														
Daphnella (Daphnella) textile (Brocchi, 1814)																														
Turriclavus harpulus (Brocchi, 1814)										X											X					X			
Clavatula ditissima (Mayer, 1874)																														
Clavatula (Surcula) dimidiata (Brocchi, 1814)																														X
Gemmula rotata (Brocchi, 1814)																		X						X		X		X	X	X
Gemmula rotata dertocarinulata Sacco, 1904																										X				
**Unedogemmula contigua* (Brocchi, 1814)																	X										X			
Terebra acuminata Borson, 1820																	X				X		X		X		X	X		X
Psilaxis simplex (Bronn 1831)													X	X			X		X		X				X		X			X
Megastomia conoidea (Brocchi 1814)									X	X							X				X		X		X		X			
Chrysallida obtusa (Brown, 1827)																											X			
Chrysallida interstincta (J. Adams, 1797)																											X			
Turbonilla densecostata (Philippi, 1844)											X								X					X				X		
Turbonilla rufa (Philippi, 1836)											X						X							X			X			
Turbonilla ligusticoterebralis (Sacco, 1892)																										X				
Eulimella pyramidata (Deshayes, 1835)																										X				
Ringicula (Ringiculina) auriculata (Ménard, 1811)																														X
Ringicula buccinea (Brocchi, 1814)																	X	X						X			X	X		
Bulla ampulla Linnaeus, 1758													X									X	X						X	X
Roxania utriculus (Brocchi, 1814)									X								X		X		X		X		X					X
Scaphander lignarius (Linnaeus, 1758)											X						X	X					X							

Table 5. Early Pliocene palaeobiogeographic distribution of the Hatay Graben bivalves. **Stratigraphical range:** Roman (1940), Erünal-Erentöz (1958), Malatesta (1974), Rouchy and Freneix (1979), Laurat-Rage (1981, 1986), Ben Moussa (1994). **Palaeobiogeographical distribution in early Pliocene:** E. Atlantic (1): Laurat-Rage (1981, 1986); Portugal/Montego (2): Dollfus and Cotter (1909); NW France/Normandia and Western France (3): Lauriat-Rage (1981, 1986); France/Loiré Atlantic and Vendée (4): Lauriat-Rage et al. (1989a, 1989b); NW Morocco (5): Ben Moussa (1994); NW Morocco (6): Lecointre (1952), Ben Moussa (1994); W. Mediterranean: NE Morocco (7): Ben Moussa (1994); SE France/Rohn (8): Dollfus and Cotter (1909); Spain/d'Alcante (9): Brébion et al. (1971); Spain/Murcia (10): Brébion et al. (1979); Algeria (11): Brebion et al. (1971), Rouchy and Freneix (1979); C. Mediterranean: Italy/Piedmonte (12): Sacco (1897, 1898, 1899, 1900, 1901), Cerulli-Irelli (1908), Malatesta (1974); Italy/Emilia (13): Corselli and Bernocchi (1992); Italy/Liguria (14): Robba (1978, 1981); E. Mediterranean: Hatay/Samandağ basin (15): Erünal-Erentöz (1958); Former Syria, Hatay, and Lebanon (16): Roman (1940); Cyprus-Israel (17): Moshkovitz (2012).



Within the İskenderun subbasin a lateral relationship was observed at the base of the Pliocene succession: the lowest mollusc-bearing layer represents tidal flat deposits with the interbeds of channelised sandstone and conglomerates grading laterally into 10-m-thick marly shelf deposits with fossils of the Aktepe Formation. Upwards the unit becomes dominated by mudstones with abundant marine faunas containing Zanclean indicator taxa such as the gastropods *Niso terebellum pygmaea* and *Cochlis epiglottina funicillata*. These faunas represent salinities of about 35 ppm or even slightly higher.

5. Discussion

The Hatay region is important to understand the Early Pliocene palaeobiogeography in the eastern Mediterranean region. A complete faunal recolonisation occurred in the Mediterranean after the Messinian Salinity Crisis and the succeeding brackish Lagomare phase (Hsü et al., 1978). At the onset of the Pliocene, Mediterranean basins were recolonised with marine biota from the Atlantic while many Tethyan taxa that were abundant until the Late Tortonian-Early Messinian were not reestablished (Harzhauser et al., 2002). The post-Messinian marine fauna represents a subtropical fauna that is the ancestor of the modern Mediterranean-Atlantic Region (MAR) fauna whose composition evolved through the cooling and further immigration events of the Late Pliocene and Quaternary. The Early Pliocene fauna studied here reflects the early recolonisation of the Mediterranean after the Messinian.

Table 6. Sample numbers and distribution of the nannoplankton and planktic foraminifers.

Mızraklı-Kireçtepe SAMPLE NUMBER	NANNOPLANKTON																								
	Helicosphaera kamptneri	*Coccolithus pelagicus*	*Coccolithus spp.*	*Cycligargolithus sp*	*Reticulofenestra cf. minutula*	*Reticulofenestra spp*	*Calcidiscus macintyrei*	*Calcidiscus leptoporus*	*Amaurolithus delicatus*	*Sphenolithus abies*	*Sphenolithus sp.*	*Hayaster perplexus*	*Discoaster surculus*	*Discoaster brouweri*	*Discoaster pentaradiatus*	*Discoaster variabilis*	*Discoaster challengeri*	*Discoaster cf. asymmetricus*	*Calcidiscus leptoporus*	*Amaurolithus tricorniculatus*	*Sphenolithus moriformis*	*Scyphosphaera spp*	*Rhabdosphaera sp*	*Scyphosphaera pulcherrima*	*Dictyococcites bisecta*
08_11_28a	X			X		X		X	X			X	X	X	X		X	X	X		X	X	X		
08_11_28b	X	X	X	X		X				X		X		X	X		X	X	X	X		X			
08_11_28c	X		X	X		X		X				X		X	X		X	X					X	X	
08_11_29																									
08_11_30a	X				X		X		X		X		X		X	X						X			
08_11_30b	X	X	X		X		X		X					X	X	X					X				
08_11_31	X	X	X				X			X					X	X	X								X
08_11_32																									

Mızraklı-Kireçtepe SAMPLE NUMBER	PLANKTIC FORAMINIFERA																
	Sphaeroidinellopsis seminulina	*Sphaeroidinellopsis subdehiscens*	*Globorotalia margaritae*	*Globoturborotalita apertura*	*Globigerinoides obliquus extremus*	*Globigerinoides conglobatus*	*Globigerinoides elongatus*	*Globigerinoides extremus*	*Globigerinoides ruber*	*Globigerinoides trilobus*	*Globigerinoides sacculifer*	*Globigerina bulloides*	*Globigerinella siphonifera*	*Globigerinoides elongatus*	*Orbulina bilobata*	*Orbulina suturalis*	*Orbulina universa*
08_11_28a	X	X	X		X	X	X		X	X	X		X		X	X	X
08_11_28b																	
08_11_28c																	
08_11_29																	
08_11_30a																	
08_11_30b	X	X				X			X				X			X	X
08_11_31	X	X		X		X		X	X			X	X	X		X	X
08_11_32																	

Biogeographical boundaries reflecting the latitudinal changes are determined by major changes in thermal gradients (Monegatti and Raffi, 2001). Mollusc assemblages, and thermophilic benthic molluscs in particular, are important proxies for the determination of palaeobiogeographical boundaries and the estimation of ancient shallow marine thermal conditions, as well as excellent ecostratigraphic tools. Diverse faunas with common thermophilic taxa such as *Persististrombus coronatus* and species of Conidae, Terebridae, Cypraidae, and Veneridae are characteristic for Mediterranean Plio-Pleistocene Molluscan Unit 1 (MPPMU1: 5.33–3.6 Ma: Raffi and Monegatti, 1993; Monegatti and Raffi, 2001; Landau et al., 2011). In our material and especially that of Erünal-Erentöz (1958) a number of mollusc species characterise MPPMU1 (Figure 3; nomenclature updated adapted from Raffi and Monegatti, 1993; Landau et al., 2003, 2004a, 2004b): *Persististrombus coronatus*, *Bolma fimbriata*, *Phalium cypraeiformis*, *Aspa marginata*, *Vexillum plicatula*, *Conus pseudo-textilis, C. pyrula*, *C. curtus*, *C. antediluvianus*, *Terebra acuminata*, *Callista italica*, *Meretrix gigas*, *Clausinella scalaris*, and *Venus multilamella*. The Early Pliocene malacofauna is characterised by a high number of warm-water taxa and high taxonomic diversity with respect to that of today. The MPPMU1 faunas contain subtropical to tropical taxa that still live or whose descendants today have a western African occurrence (Monegatti and Raffi, 2007). During the Late Pliocene a gradual cooling took place with three stepwise events (at c. 3.0, 2.7, and 2.5 Ma) decreasing the number of the (sub-)tropical mollusc taxa in the Mediterranean (Raffi and Monegatti, 1993; Monegatti and Raffi, 2001, 2007). Most of the tropical taxa of the Hatay Graben derive from the Erentöz collections from Samandağ Formation outcrops that nowadays seem to have largely disappeared. Based on the planktonic foraminiferal data (MPL1 and MPL2 biozones), the Hatay faunas are assigned an Early Zanclean age.

The total number of gastropod species from the Early Pliocene of the HG (94) is lower than that of the western Mediterranean and adjacent Atlantic. A total of 269 gastropod species were found in the Guadalquivir basin (SW Spain, Atlantic: Landau et al., 2011) that has a lower habitat diversity than the Hatay region, whereas more than 1000 species have been estimated in the Estepona region (southern Spain: Landau et al., 2004a, 2004b, 2006, 2007). The longitudinal drop in diversity is also seen in the tropical MPPMU1 taxa: several gastropod groups with good preservation potential such as *Cymbium*, *Scaphella*, Olividae, *Perrona*, Clavatulinae, and Terebriidae known from the western Mediterranean are lacking in the Early Pliocene faunas of the Central Mediterranean (Landau and Silva, 2006; Landau et al., 2011).

Similarly, the Early Pliocene bivalve assemblage of MPPMU1 is characterised by a high number of warm-water taxa with respect to that of the present time (Marasti and Raffi, 1977, 1980; Monegatti and Raffi, 2001; Raffi and Monegatti, 1993). A total of 348 bivalve species of

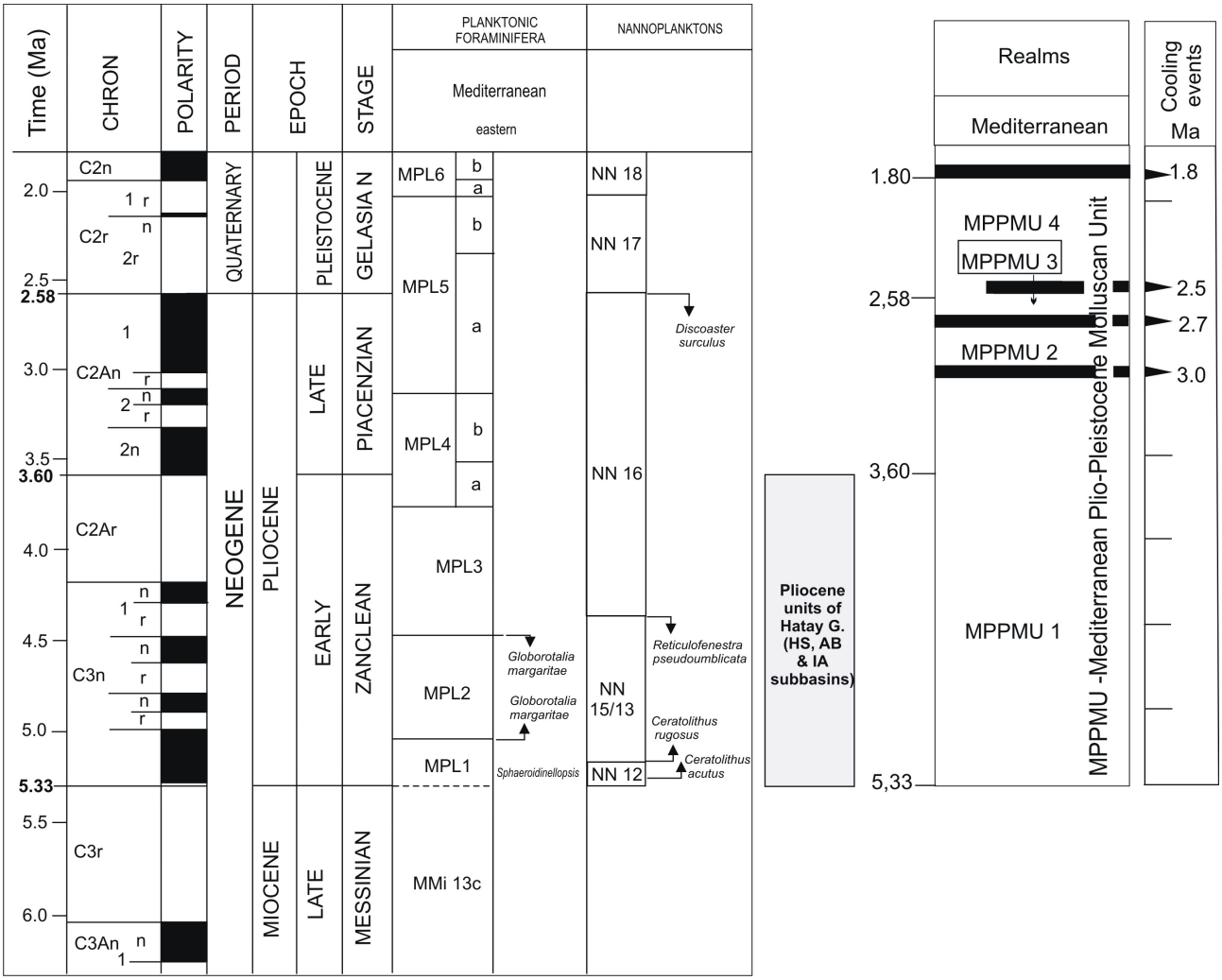


Figure 3. Pliocene stratigraphy (Lourens et al., 2004), ecobiostratigraphic settings of Pliocene Mediterranean molluscan units (Monegatti and Raffi, 2007; Landau et al. 2011; Cohen et al. 2012), and the age interval of the Early Pliocene molluscan assemblages of the HS, AB, and İA subbasins.

infralittoral and circalittoral environments are recorded from the Italian Pliocene (Marasti and Raffi, 1977, 1980). According to data available on the Italian Pliocene distribution of bivalves, *Aequipecten scabrella* (Lamarck, 1819) and *Flabellipecten flabelliformis* (Brocchi, 1814) are the most common and most representative of the Mediterranean Pliocene (Monegatti and Raffi, 2001). In the Hatay basin, 61 bivalve species have been determined. Although the species numbers are lower, the Hatay assemblage can be correlated to MPPMU1 of the Middle Mediterranean, having warm-water taxa, pectinids, glycymerids, *Acanthocardia*, and *Cardita* (Monegatti and Raffi, 2001; Raffi and Monegatti, 1993). This diversity trend exists even today with eastern Mediterranean faunas being less diverse than those in the central and western Mediterranean (Coll et al., 2010; Matalpa et al. 2011; Giacobbe, 2012). The relative low diversity of the Hatay faunas may be partially explained by the apparent lack of firm-ground habitats and the upwelling of well-ventilated oceanic water masses that in part explain the extreme high diversity in the western Mediterranean at the same time. However, the potential sea grass-related faunal component in the Hatay faunas consists of only 3 cerithiid and one *Tricolia* species and is lacking the highly diverse rissoid faunas that did occur within the western and central Mediterranean during the Early Pliocene. At this stage it is unclear why such large diversity gradients developed but it is likely that the location of the Hatay Graben farthest away from the source area of the post-Messinian recolonisation in the Mediterranean may explain part of the pattern. Furthermore, a relative low habitat diversity may contribute to the low number of species.

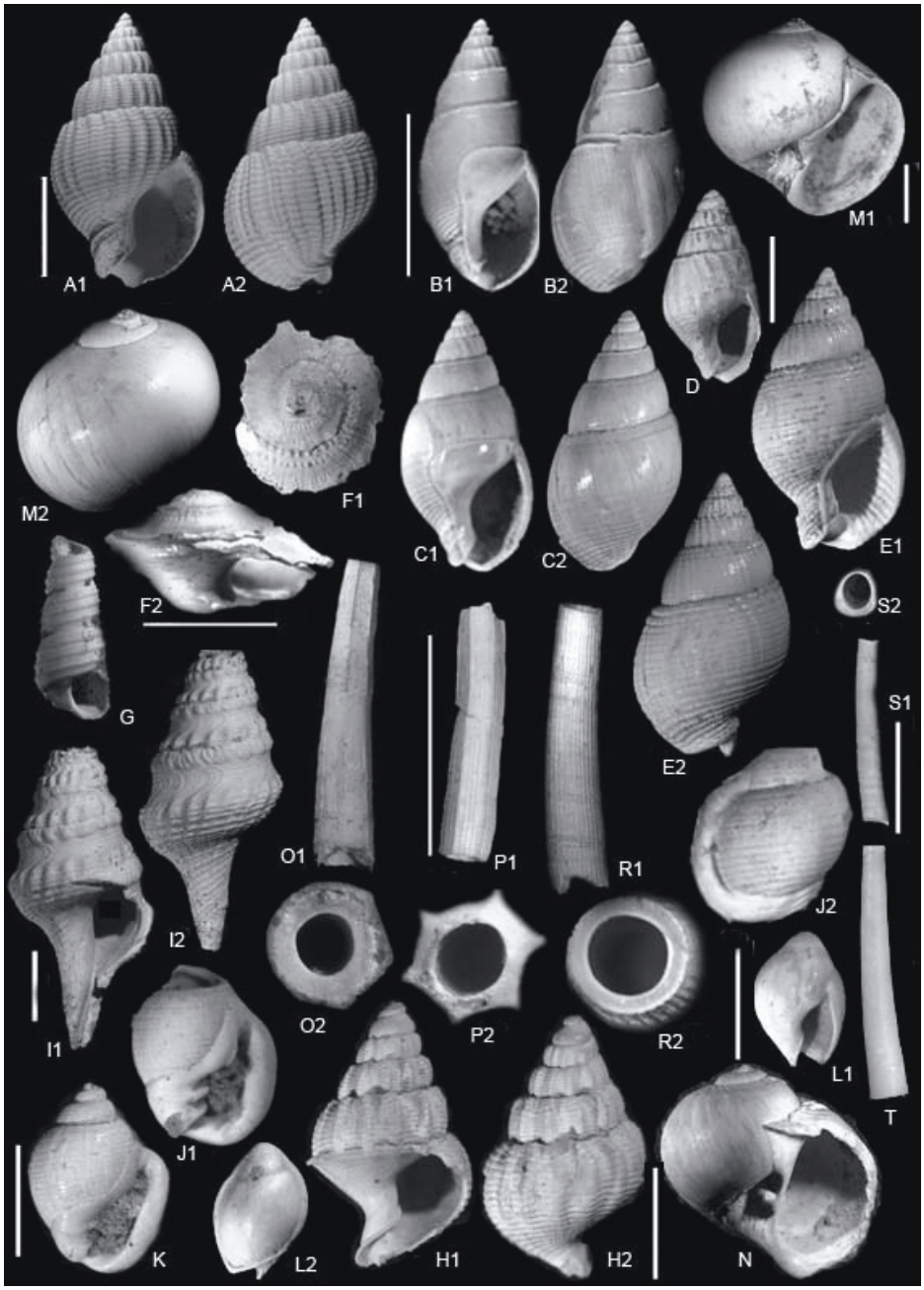


Figure 4. A1, A2- *Nassarius prismaticus* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; B1, B2- *Nassarius semistriatus* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-31; C1, C2- *Nassarius semistriatus* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-31; D- *Nassarius elatus* (Gould, 1845), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; E1, E2- *Nassarius striatulus striatulus* (Eichwald, YB collection, 1829), HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-30a; F1, F2- *Bolma* (*Ormastralium*) *fimbriata* (Borson, 1821), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; G- *Turritella tricarinata* Brocchi, 1814, YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; H1, H2- *Nassarius* cf. *clathratus* (Born, 1778), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; I1, I2- *Clavatula* sp., YB collection, İA subbasin, Aktepe Formation, Aktepe section, 08-11-06c; J1, J2- *Ringicula* (*Ringiculina*) *auriculata* (Ménard, 1811), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; K- *Ringicula* (*Ringiculina*) *auriculata* (Ménard, 1811), HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, YB collection, 08-11-31; L1, L2- *Arcularia gibbosula pliocallosa* (Sacco, 1890), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; M1, M2- *Cochlis catena latoastensis* (Sacco, 1890), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; N- *Cochlis pseudoepiglottina* (Sacco, 1890), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; O1, O2- *Antalis vulgaris vitrae* (Gmelin, 1790), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; P1, P2- *Dentalium sexangulum* Schröter, 1784, YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-30a; R1, R2- *Dentalium* (*Antalis*) *fossile* Schröter, 1784, YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; S1, S2- *Gadilina triquetra triquetra* (Brocchi, 1814), YB collection, İA subbasin, Aktepe Formation, Aktepe section, 08-11-06a; T- *Antalis vulgaris vitrae* (*Gmelin, 1790*), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-31. Scale bar: 0.5 cm.

Figure 5. A1, A2- *Niso terebellum pygmaea*, YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; B1, B2- *Mitrella (Clinurella) minima* (Sacco, 1890), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; C- *Daphnella* (*Daphnella*) *textile* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; D- *Siphonochelus fistolosus* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-33; E- *Bela* sp., YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 8-11-31; F- *Turritella tricarinata* Brocchi, 1814, YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; G- *Vexillum ebens pyramidella*, YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; H- *Nassarius elatus* (Gould, 1845), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-33; I- *Nassarius pliomagnus* (Sacco, 1904), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-33; J1, J2- *Drillia* sp., YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; K1, K2- *Olivella* sp., YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; L- *Conus* sp.**,** YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-38; M- *Turritella aspera* (Sismoda in Mayer, 1866), YB collection, İA subbasin, Aktepe Formation, Aktepe section, 09-06-06; N- *Bullaria subampulla* d'Orbigny, 1852, YB collection, İA subbasin, Aktepe Formation, Aktepe section, 09-06-17; O- *Lyromangelia crassicostata* Scarponi and Della Bella, 2010, YB collection, İA subbasin, Aktepe Formation, Aktepe section, 09-06-06; P1, P2- *Clavatula ditissima* (Mayer, 1874), YB collection, İA subbasin, Aktepe Formation, Aktepe section, 09-06-06; R- *Bathytoma cataphracta* (Brocchi, 1814), YB collection, İA subbasin, Aktepe Formation, Aktepe section, 09-06-06. Scale bar: 1 mm.

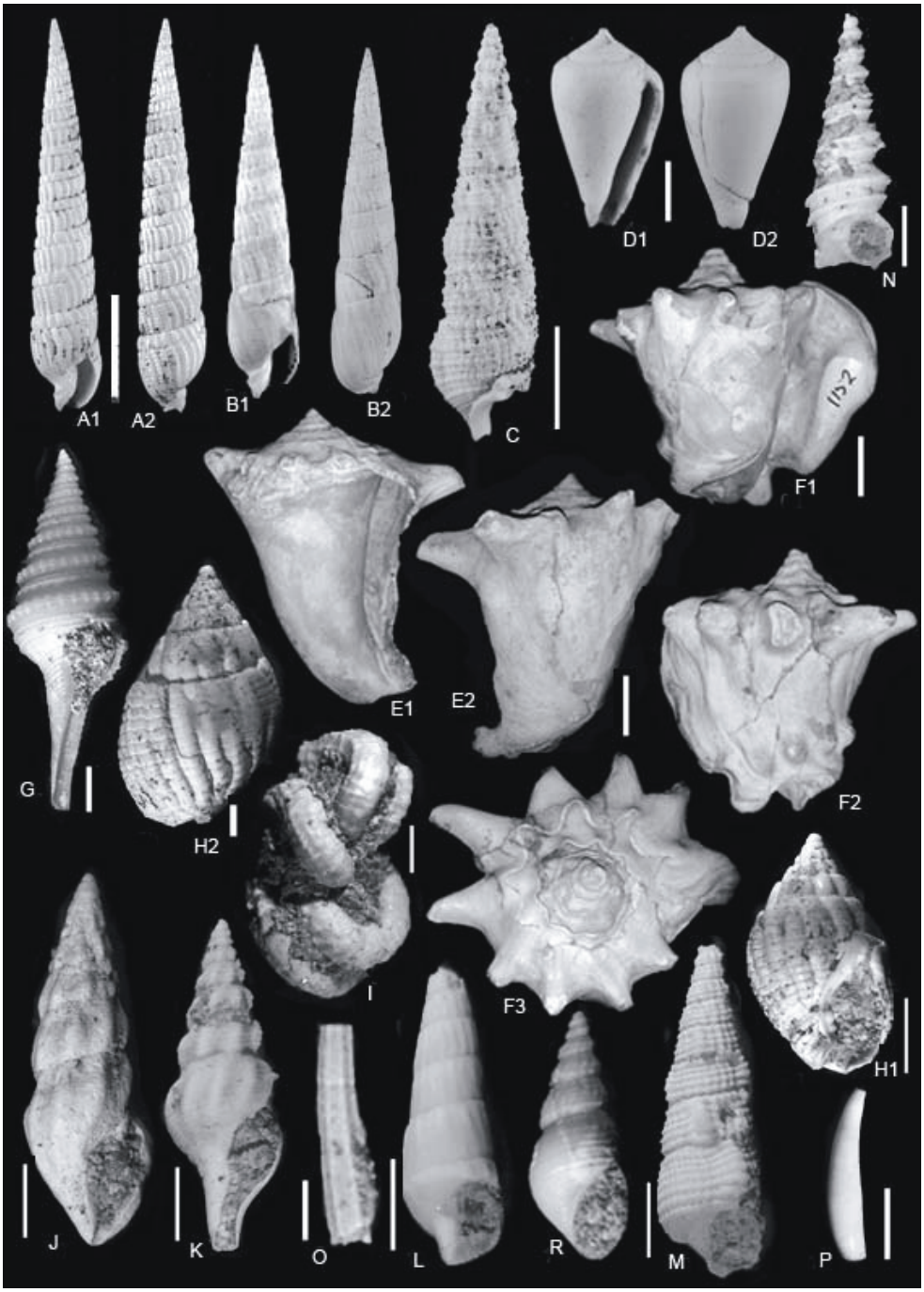


Figure 6. A1, A2- *Strioterebrum pliocenicum* (Fontannés, 1880), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-2; B1, B2- *Terebra acuminata* Borson, 1820, YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-2; C- *Thericium crenatum* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-2; D1, D2- *Conus* (*Chelyconus*) *pyrula mucronata* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-2; E1, E2- *Persististrombus coronatus* (Defrance, 1827), L. Erentöz collection, HS subbasin, Samandağ Formation (scale bar: 1 cm); F1, F2, F3- *Persististrombus coronatus* (Defrance, 1827), L. Erentöz collection, HS subbasin, Samandağ Formation (scale bar: 1 cm); G- *Gemmula rotata* (Brocchi, 1814), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14c; H1, H2- *Nassarius nitidus* (Jeffreys, 1867), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 03-14c; J- *Petaloconchus intortus* (Lamarck, 1818), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14c; J- *Raphitoma* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; K- *Clathurella spreafici* Bellardi, 1877, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; L- *Turbonilla rufa* (Philippi, 1836), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; M- *Thericium crenatum* (Brocchi, 1814, YB collection, AB, Altınözü Formation, Babatorun section, 11-03-14b; N- *Turritella erronea* Cossmann in Friedberg, 1914, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; O- *Dentalium sexangulum* Schröter, 1784, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; P- *Gadilina jani* (Hoernes, 1856), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; R- *Melanoides* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b (transported fauna from the lacustrine environment, possibly pre-Pliocene). Scale bar: 1 mm.

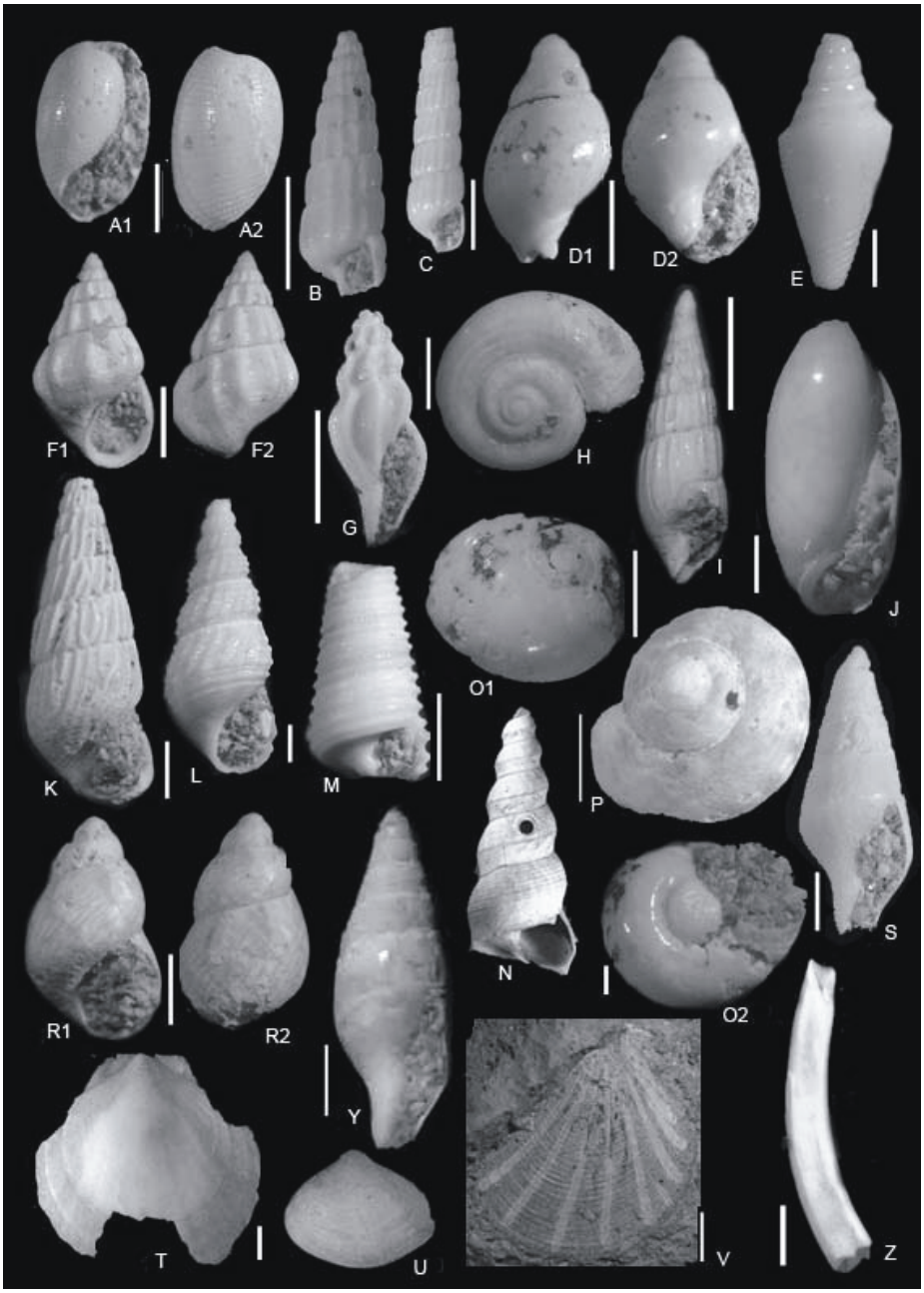


Figure 7. A1, A2- *Bulla ampulla* Linnaeus, 1758, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; B- *Turbonilla* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b, C- *Turbonilla densecostata* (Philippi, 1844), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; D1, D2- *Nassarius* (?) sp. - YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; E- *Conolithes dujardini* (Deshayes, 1845), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; F1, F2- *Rissoa* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; G- *Mangelia attenuata* (Montagu, 1803), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-2; H- *Gyraulus* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b (transported fauna from the lacustrine environment, possibly pre-Pliocene); I- *Turbonilla* sp. 1, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; J- *Oliva* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; K- *Turbonilla* sp. 2, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; L- *Bittium latreillei* (Payraudeau, 1826), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; M- *Seila plioiberica* Landau, Perna and Marquet, 2006, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; N- *Turritella spirata* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; O1, O2- *Neverita olla* (De Serres, 1829), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; P- *Gibbula* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; R1, R2- *Tricolia pullus pullus* (Linnaeus, 1758), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; S- *Mitrella* sp. 1, YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; T- *Costellamussiopecten cristatus* (Bronn, 1827), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32**; U**- *Corbula* (*Varicorbula*) *gibba* (Olivi, 1792), YB collection, İA subbasin, Aktepe Formation, Aktepe section, 08-11-06c; V- *Propeamussium* (*Parvamussium*) *duodecimlamellatum* (Bronn, 1831), YB collection, HS, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-37; Y- *Mitrella semicaudata* (Bellardi, 1848), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; Z- *Gadilina triquetra triquetra* (Brocchi, 1814), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-30a. Scale bar: 1 mm.

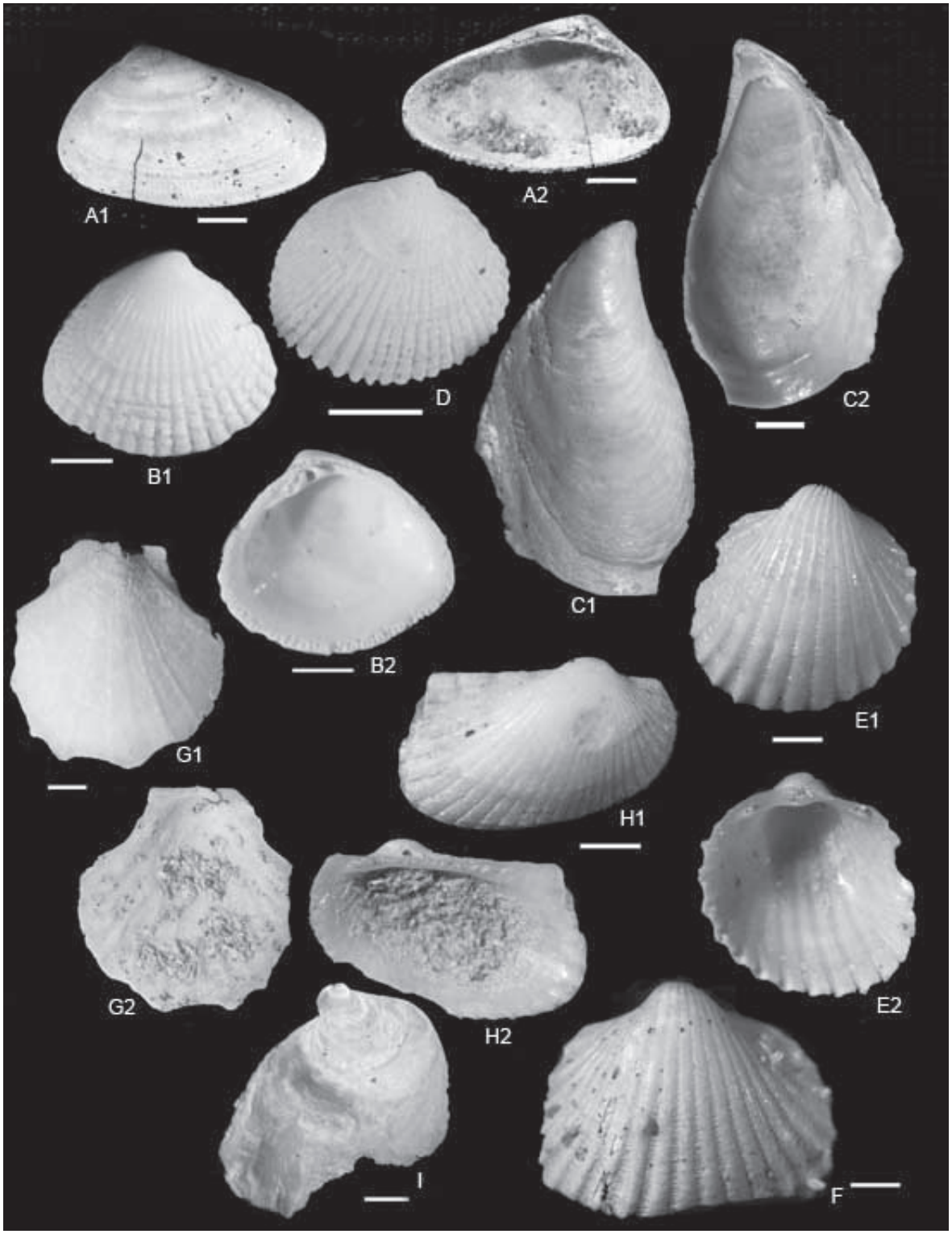


Figure 8. A1, A2- *Donax trunculus* (Linnaeus, 1758), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-2; B1, B2- *Timoclea ovata* (Pennant, 1777), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-3; C1, C2- *Mytilopsis* sp., AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; D- *Timoclea ovata* (Pennant, 1777), YB collection, HS subbasin, Samandağ Formation, Kuşalanı section, Kuş-3; E1, E2- *Acanthocardia echinata* (Linnaeus, 1758), AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; F- *Acanthocardia echinata* (Linnaeus, 1758), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; G1, G2- *Propeamusium* sp., YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-33; H1, H2- *Anadara gibbosa* (Reeve, 1844), YB collection, HS subbasin, Samandağ Formation, Mızraklı-Kireçtepe section, 08-11-32; I- *Ostrea forskali* Chemnitz, 1791, YB collection, HS subbasin, Samandağ Formation, Sutaşı section, 09-06-17. Scale bar: 1 mm.

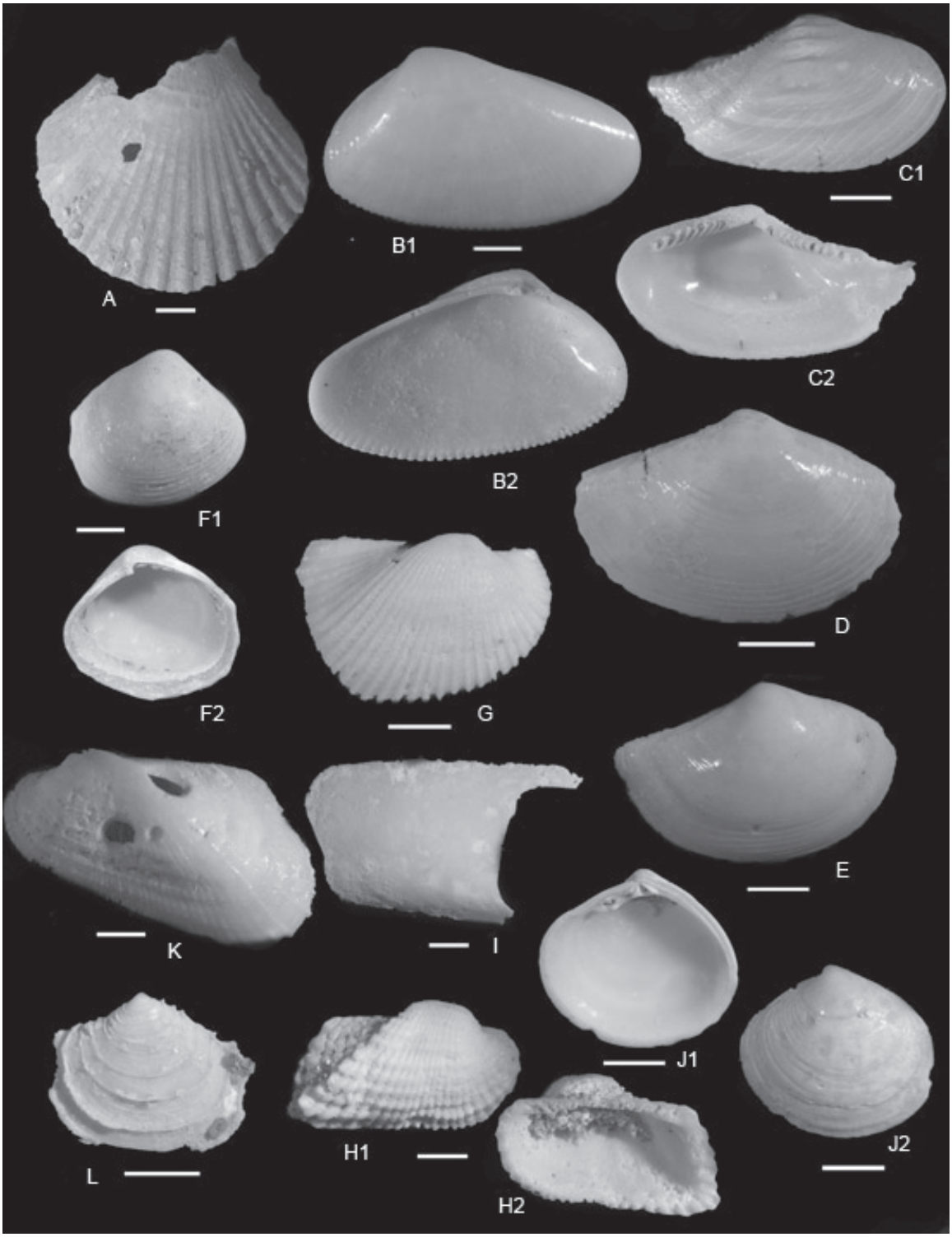


Figure 9. A- *Aequipecten* cf. *seniensis* (Lamarck, 1819), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; B1, B2- *Donax trunculus* (Linnaeus, 1758), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; C1, C2- *Lembulus pella* (Linnaeus, 1767), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 10-03-14b; D, E- *Yoldia nitida* (Brocchi, 1814), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 10-03-14a; F1, F2- *Corbula* (*Varicorbula*) *gibba* (Olivi, 1792), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; G- *Anadara* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; H1, H2- *Barbatia empolensis* (Micheli and Torre, 1966), YB collection, HS subbasin, Samandağ Formation, Sutaşı section, 09-06-17; I- *Ensis* sp., YB collection, AB subbasin, Altınözü Formation, Babatorun section, 10-03-14a; J1, J2- *Gouldia minima* (Montagu, 1803), AB subbasin, Altınözü Formation, Babatorun section, 10-03-14b; K- *Pectinarca pectinata* (Brocchi, 1814), YB collection, AB subbasin, Altınözü Formation, Babatorun section, 11-03-14b; L- *Venus* (*Ventricoloidea*) *multilamella* (Lamarck, 1818), Babatorun section, 11-03-14b. Scale bar: 1 mm.

HS SUBBASIN SECTIONS

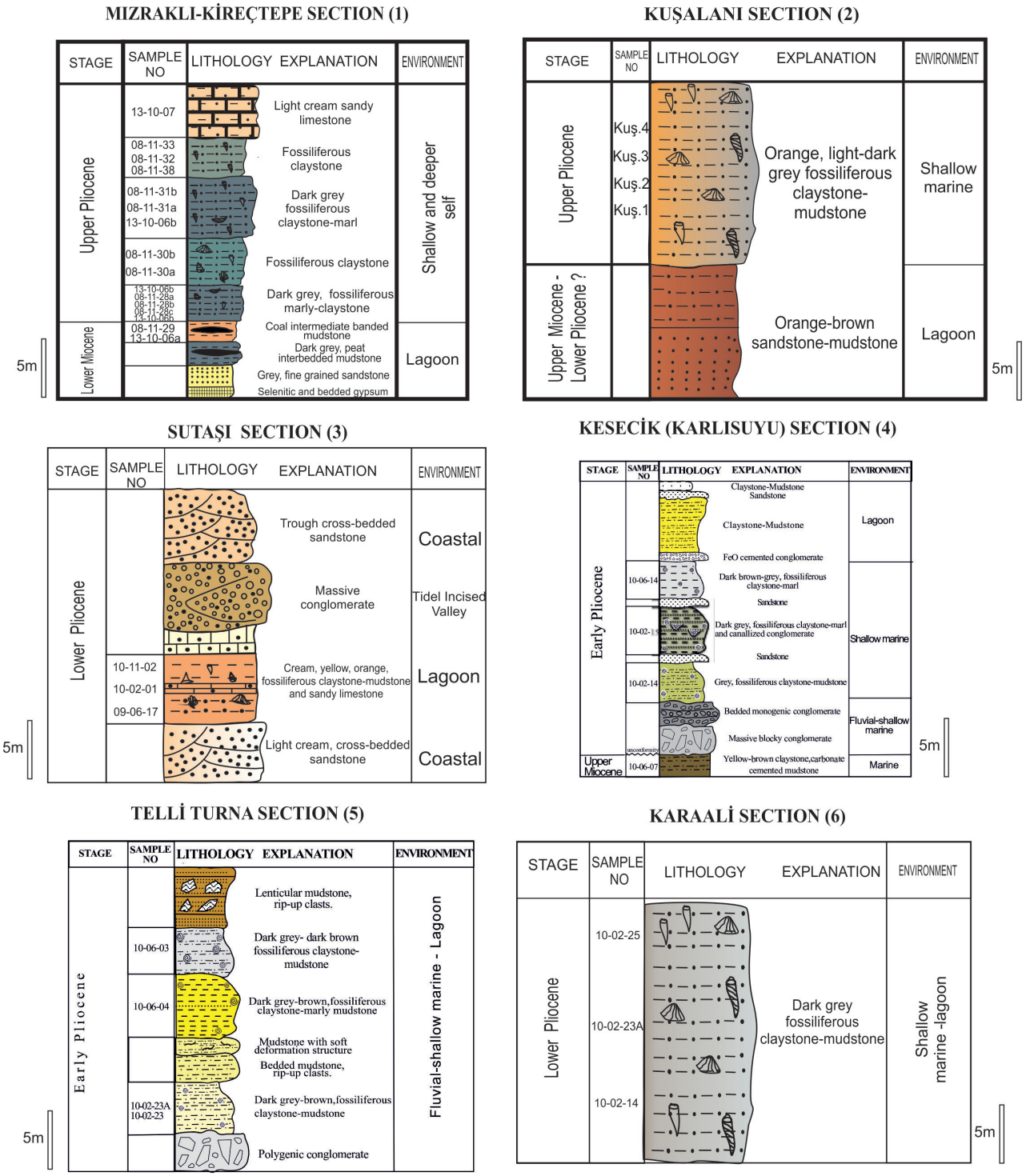


Figure 10. Mızraklı-Kireçtepe section, Kuşalanı section, Sutaşı section, Kesecik/Karlısuyu section, Telliturna section, Karaali section (HS subbasin).

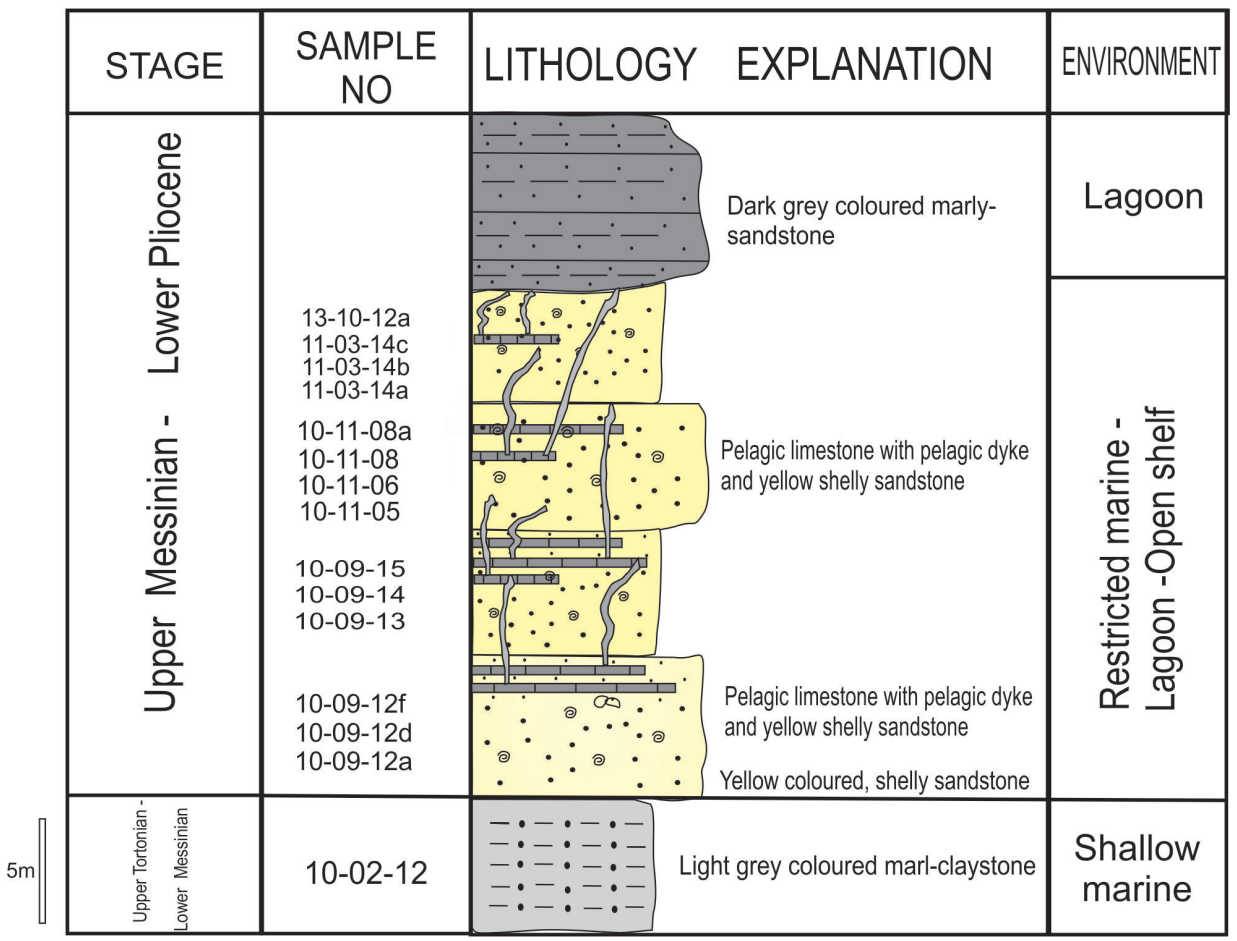


Figure 11. Babatorun section (AB subbasin).

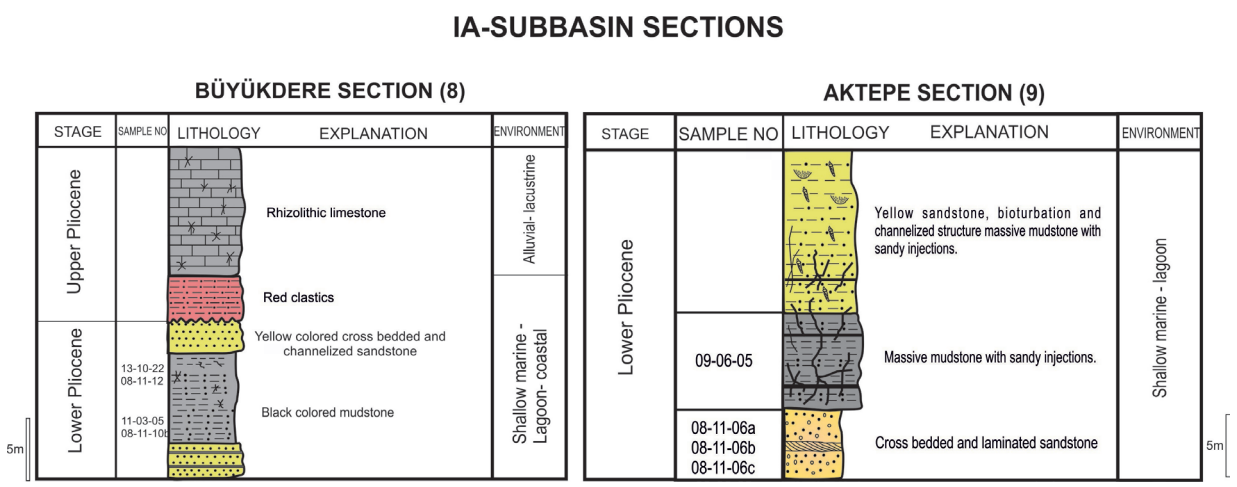


Figure 12 Büyükdere and Aktepe sections (İA subbasin).

6. Conclusions

In total 162 Pliocene mollusc species are reported from the Hatay Graben (southern Turkey). The stratigraphic age is constrained with microfossils to the Early Zanclean and the fauna represents the situation just after recolonisation after the Messinian Salinity crisis. Both the age of the fauna and the presence of various tropical taxa (such as *Strombus coronatus* and *Conus* species) show that the Hatay fauna is the easternmost Mediterranean MPPMU1 fauna. The faunas represent mostly fully marine upper infralittoral-circalittoral habitats with salinities of around 35 psu, although in one sample admixed anomalohaline lacustrine species were found. Species lived on sandy and muddy seafloors where some sea grass must have occurred, while firm-ground habitats appear to have been lacking. The Hatay faunas are diverse but harbour far fewer species than contemporary central and western Mediterranean faunas. This strong latitudinal diversity drop is attributed to relatively low habitat diversity in the Hatay region as well as its distal location compared to the western Atlantic that is the source of marine biota for the Mediterranean after the Messinian. The Hatay faunas do represent tropic-subtropic climatic conditions.

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