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PONTO-CASPIAN AND MEDITERRANEAN FAUNAL AND FLORAL RECORDS OF UPPER PLEISTOCENE-HOLOCENE SEDIMENTS FROM THE İZMİT GULF (MARMARA SEA, TURKEY)

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Abstract İzmit Gulf is located between Kocaeli and Armutlu peninsulas at east of Marmara Sea and the interaction area of North Anatolian Fault Zone (NAFZ) and Marmara Graben systems. In this study, the faunal and floral contents (ostracod, foraminifer, mollusc and diatom) of the samples belonging to seven drilling cores were studied and obtained the radiocarbon and optically stimulated luminescence (OSL) age data in order to establish on the Black Sea – Marmara Sea - Mediterranean water connections and palaeoenvironmental changes.

The sediments in this study are Late Pleistocene-Holocene aged and only cover the Marine Isotope Stages MIS-5 (interglacial), MIS-3 (an interstadial period between MIS-4 and MIS-2 glacial epochs) and MIS-1. The determination of ostracod and mollusc fauna of the Mediterranean and Ponto-Caspian origin provide important clues to water exchange between the Mediterranean and the Black Sea. Although some Mediterranean originated ostracods occur sporadically with low abundance, absence of foraminiferal fauna and existence of Ponto-Caspian ostracods together with fresh water and cosmopolitan diatom flora indicate that the area strongly interacted with the Black Sea waters during MIS-5. The faunal and floral characteristics of the sediments deposited during MIS-3, clearly denote that the Izmit Gulf was connected with the Black Sea and the Mediterranean Sea at the beginning of MIS-3 (ca. 52.0 - 40.0 ky BP) and the shallow shelf areas were frequently affected by both the Black Sea discharge and Mediterranean input. A thick Holocene sedimentary sequence recovered from the southern Hersek Burnu drilling cores reflects the environmental changes after the latest Black-Mediterranean seas connection.

The studied ostracod and mollusc assemblages are mainly characterized by the Mediterranean originated species with a few relict Ponto-Caspian fauna. Also, the benthic foraminiferal assemblages are dominated by normal marine and euryhaline species, reflecting the salinity fluctuations in the Holocene interval.

Keywords: Foraminifera, ostracod, mollusc, diatom, palaeoenvironment, marine isotope stage, NW Turkey

INTRODUCTION

The Quaternary Period containing a series of cold and intervening warm phases (glacials/interglacials) caused sea level variations and drastic environmental changes. Upper Pleistocene stage (126.0-11.7 ky) is characterized by Riss-Würm/Eemian interglacial and Würm/Weichselian glacial episodes. Global to regional climatic and hydrological changes initiated in the surrounding Mediterranean and Ponto-Caspian basins during the glacial and interglacial periods constitute the Quaternary palaeoceanographic evolution of the Marmara Sea (e.g., Stanley and Blanpied, 1980; Aksu et al., 2002; Badertscher et al., 2011; Sorokin, 2011; Yanina, 2014).

İzmit Gulf constitutes the most eastern part of the Marmara Sea (Fig. 1) which is a small intercontinental basin connected to the Mediterranean and the Black Sea and the western part of active North Anatolian Fault Zone (Ketin, 1948, Aksu et al., 2002; Vardar et al., 2014). It is an east-west elongated depression with a 55 km length and 2-10 km width. Along W-E axis, the İzmit Gulf comprises three connected sub-basins namely western (Darıca), Central (Karamürsel) and Eastern (Gölcük) separated by sills at ~55 m and 38 m water depths (Çağatay et al., 2003; Kurt and Yücesoy, 2009). The Central Basin is the largest and deepest with a maximum water depth of around 200 m. The İzmit Gulf has a permanent two-layered water system as an extension of the Marmara Sea. The brackish Black Sea water (18‰) flowing through the İstanbul Strait (Bosphorus) constitutes the upper water layer. The lower water layer originates from the high salinity Mediterranean waters (39‰) inflowing to the Marmara Sea via the Çanakkale Strait (Dardanelles) (Ünlüata et al., 1990; Beşiktepe et al., 1994).

Important geological investigations in the Izmit Gulf and its vicinity have been carried out since 1950's (Pfannenstiel, 1944; Ardel and İnandık, 1957). Marmara Sea, a waterway between the Mediterranean and the Black Sea, has been affected by the changing sea levels during Quaternary. Recent studies have focused on the relations between the Marmara Sea and the Black Sea and their evolution during the Quaternary. Meriç (1995a) conducted a pioneering study that documented Quaternary sequence of the İzmit Bay between Hersek and Kaba Burun in detail. Meriç (1995b) point out a water-way connection between the Marmara and Black Sea by İzmit-Sapanca and Sakarya

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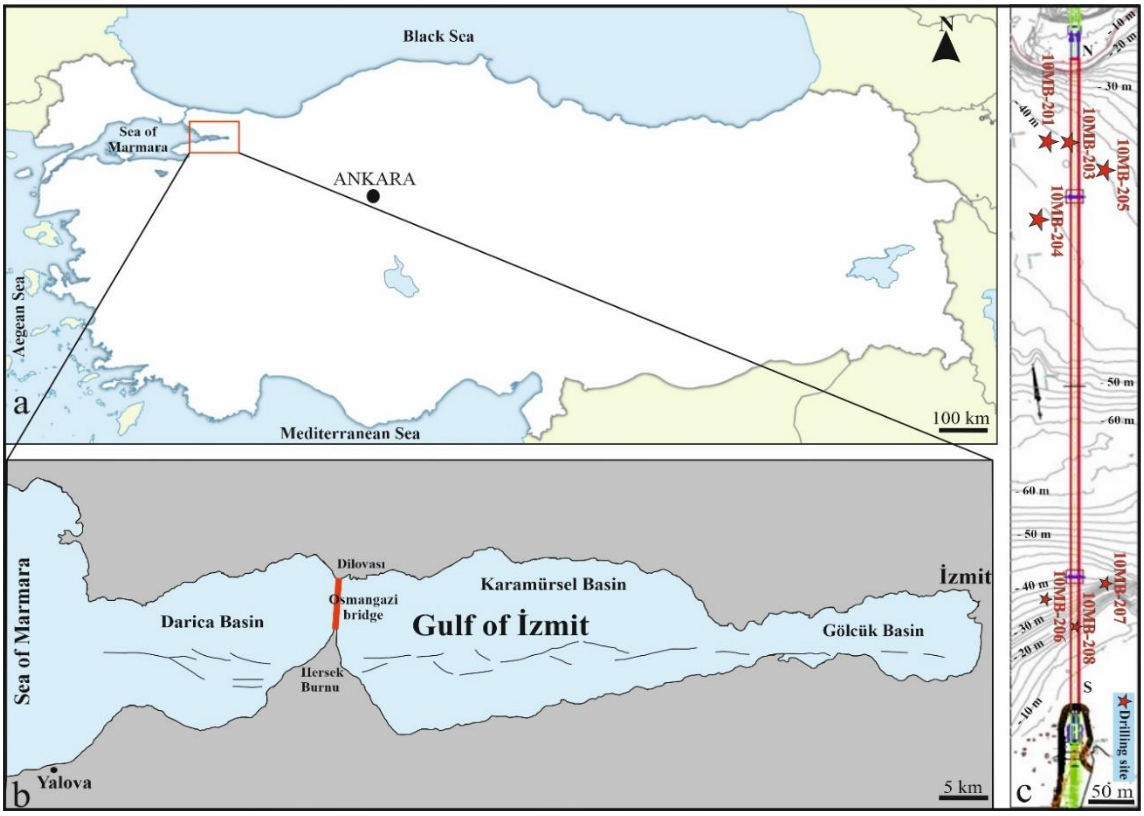

Fig. 1 Location map. **a**. Turkey map, **b**. Gulf of İzmit and Osmangazi Bridge Route, **c.** Locations and numbers of drillings.

valleys before of the existence of Bosphorus, Major et al. (2002) studied the Marmara and Black Sea connections during the periods between Late Glacial and Interglacial by using sedimentological and radiometric methods. Some researhers studied the connection of the Marmara and Black Sea by the way the İznik Lake (Meriç et al., 2009; Nazik et al., 2011; 2012; Meriç et al., 2018). Taviani et al. 2014 emphasized that the Marmara Sea is a lake connected to the Black Sea from time to time according to their studies performed in the Gemlik Gulf. Badertscher et al. (2011) indicate that 12 times Mediterranean intrusions have been carried out to the Black Sea since 670 ky BP. The latest lake stage of the Marmara Sea during Marine Isotop Stage 2 (MIS-2). Black Sea-Mediterranean connection with the İstanbul Strait-Marmara Sea-Çanakkale Strait during MIS-1 has been studied in detail by many authors (e.g., Stanley and Blanpied, 1980; Ryan et al., 1997; Çağatay et al., 2000; Aksu et al., 2002; Sperling et al., 2003; Kırcı-Elmas et al., 2008; McHugh et al., 2008; Vidal et al., 2010; Eriş et al., 2011; Ivanova et al., 2015; Büyükmeriç, 2016). However, our knowledge of water-exchange events before Holocene in this region is still limited and controversial.

The evidence on the basis of the deposition of sapropel of sediments recovered from the Marmara Sea's Central Basin (Aksu et al., 2002; Tolun et al., 2002), a raised marine terrace from the southwestern Marmara Sea (Yaltırak et al., 2002) as well as marine deposits dated at ca. 36 ky BP on the southern coast of the İzmit Gulf (Çağatay et al., 2003) suggest that the Marmara basin was linked to the Mediterranean Sea during MIS-3 period. Later, Çağatay et al. (2009) denote that the Marmara Sea isolated from the Mediterranean Sea from early MIS-4 to early MIS-1. In the Black Sea, MIS-3 corresponds to a highstand (The Surozh transgression), with water level 25 m lower than today (Yanina, 2014).

In this study, the faunal and floral contents (ostracods, foraminifera, molluscs and diatoms) and the numerical (radiocarbon and OSL) age (Fig. 2) data of drilling samples collected from the İzmit Gulf have been studied in detail in order to understand the water connections among the Black Sea - Marmara Sea - Mediterranean and their palaeoenvironmental changes.

MATERIALS AND METHODS

In 2010, a series of submarine drilling was carried out during the construction of a suspension bridge (Osmangazi Bridge) in the İzmit Gulf (Fig. 1 and Table 1). The material consisted of 73 sediment samples retrieved from seven drilling cores. The samples were collected at different intervals of the drilling cores (1-108 m in 10MB-201, 16.5-147 m in 10MB-203, 2-69 m in 10MB-204, 1.5-30 m in 10MB-205, 4.5-63 m in 10MB-206, 1-43 m in 10MB-207 and 1-37.5 m in 10MB-208).

Table 1 Location, water depth and sediment thickness of drillings

Exploration	Completion Depth (m)	Mudline Elevation (m)[1]	UTM, Zone 35N Easting[2]	UTM, Zone 35N Northing[2]	Project Co-ordinates Easting[3]	Project Co-ordinates Northing[3]
10MB-201	121	-40.4	712359.5	4515452.1	459125.3	4514325.3
10MB-203	161	-39.7	712459	4515342.3	459220.9	4514212.1
10MB-204	120	-42.1	712340.6	4515253	459099.6	4514127
10MB-205	117.2	-40.1	712539.6	4515233.4	459297.8	4514100.5
10MB-206	122	-35.0	712198.8	4513759.6	458906.8	4512639.4
10MB-207	120.9	-23.2	712397.2	4513740.4	459104.5	4512613.4
10MB-208	200	-18.3	712288.5	4513650.1	458992.8	4512526.9
[1] Elevation is based on TUDKA, meters						
[2] Coordinates are based on WGS84, UTM Zone 35, meters						
[3] Coordinates are based on WGS84, Gauss Kruger, Central Meridian 30 degrees East, scale factor 1.00, meters						

The drillings were made about 40 m of water depth in the northern part of the bridge in Dilovası region (10MB-201, 203, 204 and 205) and about 18-35 m water depths in the southern part of the bridge in Hersek region (10MB-206, 207 and 208). The lithology of the core sediments (Fig. 3) consists mainly of fine to coarse sand with shell fragments, brownish-green colored hard mud with interfingering sand and gravel and homogeneous, plastic, greenish mud. Large mollusc shells are also observed at different levels of drillings.

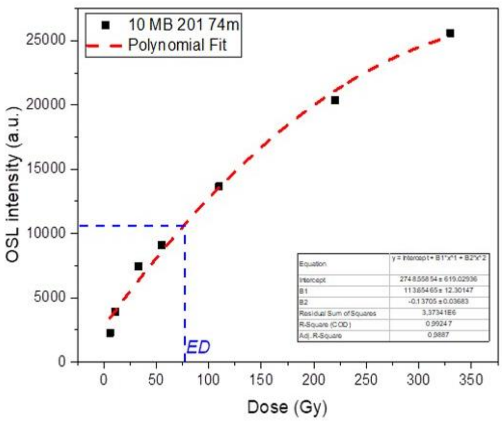

Fig. 2 Growth curve used in determination of ED for sample 10MB-201 74 m by using regenerative procedure.

Sample Preparation for fauna and flora

For faunal analyzes (foraminifera, ostracods, bivalvs and gastropods) and determination of grain-size distributions, sediment samples were dried in an oven at 45ºC. 10 g subsamples of dry sediment were moistened with tap water for ca. 24 hours and washed to pass a 63 µm sieve. These residues were dried and weighed again. The ratio between the initial subsample and residue weight was used as a measure of the sand content of the sediment. Residues (>63 µm) were analyzed using a stereomicroscope. Ostracods and molluscs were examined from >125 µm fraction. The descriptions and counts of foraminifera were performed on >63 µm fraction. Where foraminiferal fauna was abundant, the >63 µm fraction was separated into equal aliquots with a microsplitter until an aliquot containing at least 300 specimens was obtained. In low density samples, the whole >63 µm fraction was analyzed. Foraminifera taxa identifications were made based on Yanko and Troitskaja (1987), Yanko (1989), Cimerman and Langer (1991), Sgarrella and Moncharmont-Zei (1993), Kaminski et al. (2002) and Meriç et al. (2004). Taxonomic concepts of Van Morkhoven (1963), Hartmann and Puri (1974), Bonaduce et al. (1975), Breman (1975), Olteanu (1978), Yassinsi (1979), Guillaume et al. (1985), Athersuch et al. (1989), Zangger and Malz (1989), Tunoğlu (1999, 2002, 2003), Boomer et al. (2005, 2010), Mostafawi and Matzke-Karasz (2006), Joachim and Langer (2008), Oprenau (2008), Schornikov (2011), Briceag et al. (2012), Zenina et al. (2017), Javadova (2019) and "MarBEF Data System" (http://www.marbef.org/data/) were followed for identifications of ostracods. Determinations of mollusc species were made by using the studies of Neveskaja (1963), Poppe and Goto (1991, 1993), Çetin et al. (1995), Kapan Yeşilyurt (1997), İslamoğlu and Tchepaliga (1998), Kerey et al. (2004), Meriç et al. (2000, 2005). Selected specimens of foraminifera and ostracod species were photographed using a Quorum (Q150R ES) and Quanta 650 Field Emission scanning electron micrographs at the Central Research Laboratory of Çukurova University (ÇÜMERLAB).

Diatom examination was performed on three samples collected from at 143.5 m, 140 m and 95 m of drilling 10MB-203. Sediment samples for diatoms analyzes were cleaned with 10% HCl and then fixed onto a lam by entellan and a lamella. Diatom flora was identified and photographed under Leica DM 2500 P polarizing microscope at the Geological Enginering Laboratory of the Aksaray University. The taxonomic descriptions and ecological features of the taxa were performed using

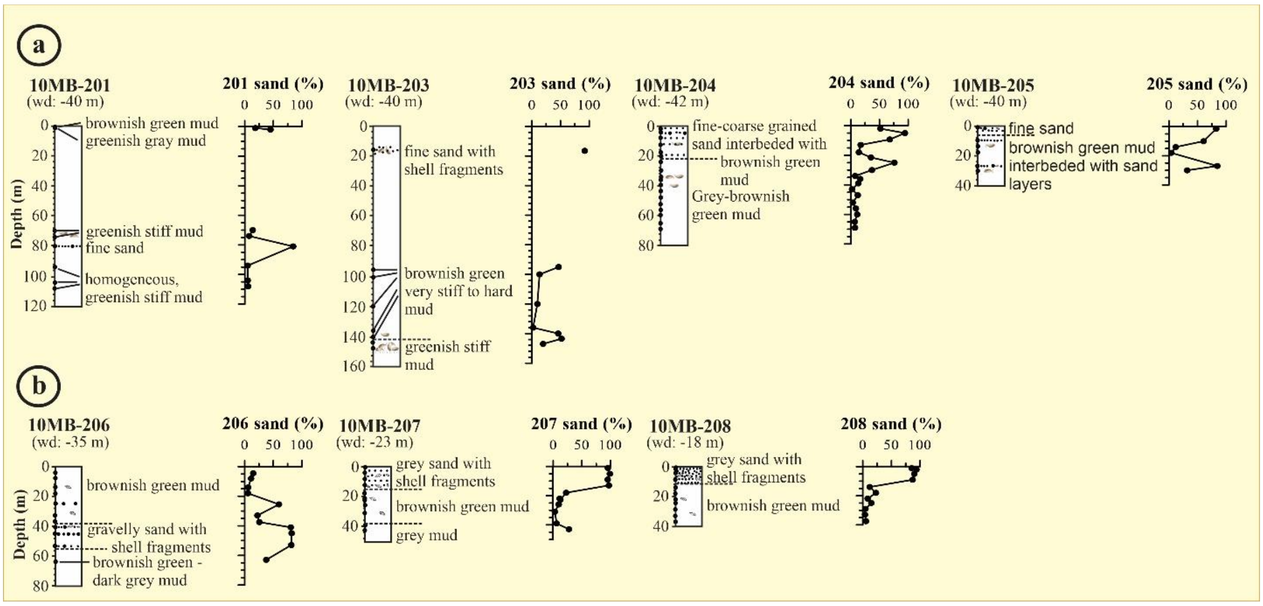

Fig. 3 Lithological features and sand distributions of collected sediment samples **a.** Dilovası, **b.** Hersek Burnu. The lower intervals of drillings 10MB-204 (120-80 m), 10MB-205 (117.2-40 m), 10MB-206 (122-80 m), 10MB-207 (120.9-50 m) and 10MB-208 (200-40 m) are not shown due to absence of sample.

studies of Wetzel (1983), Round (1956, 1984), Krammer and Lange-Bertalot (1986a, 1986b, 1988, 1991), Van Dam et al. (1994), Trojanowski et al. (2001), Pala (Toprak) and Çağlar (2006), Round et al. (2007), Taş and Gönülol (2007), Zaim (2007), Sivaci et al. (2007, 2008, 2013), Kistenich et al. (2014), Varol and Şen (2014), URL-1 – 11.

Radiocarbon Dating

Conventional radiocarbon dates (^{14}C) were performed at the Poznan Radiocarbon Laboratory, Poland and Earth and Marine Sciences Institute of TÜBİTAK Marmara Research Center, Turkey. The mollusc shells (20-180 mg) were used for ^{14}C dating materials. The dates are expressed as uncalibrated.

Optically Stimulated Luminescence (OSL) dating

The quartz and feldspar minerals, which are the main constituents of sediments, are continually under the exposure of ionizing radiation. The absorbed dose by these crystals is the stored energy in the crystal structure of the mineral, and is a measure for the amount of ionizing radiation received by the mineral grain since its last exposure to daylight. An exposure to sunlight is needed to reset the luminescence signal in depositional environments. OSL provides an age estimation for the current sediment was exposed to sunlight which resets the luminescence signal (Huntley et al., 1985). In this study, optically stimulated luminescence (OSL) dating is applied to sediment samples to obtain depositional ages. In order to prevent OSL signal loss, the sample preparation method was carried out at the laboratory under red light. The sieved samples are first soaked in 1N (normality) HCL to remove carbonate compositions. Secondly, 30% H_2O_2 solution is added to the sample in a beaker and mixed for ~ 30 minutes to extract the sample from organic compounds. The sample is sieved to obtain the 90-150 μm grain size fractions. In the third step, 40% HF solution is added to the sample in a beaker to remove the external alpha additive and dissolve the feldspar, and waited for 60-80 minutes by mixing. Finally, 12N HCL solution is added and kept in this solution to remove possible remnant carbonate particles for ~ 30 minutes (Juyal et al., 2006; Bernt et al., 2018). Samples are washed three times with distilled water at the end of all acid washing processes. All minerals in the samples that are washed with distilled water consist of only quartz minerals. The etched quartz grains were dried at 50 ºC in incubator, 25 mg grains were scattered over a 8 mm diameter stainless steel disc with a silicon spray for OSL measurements Multi-grained aliquots are tested with the IRSL (infrared stimulated luminescence) signal to prevent feldspar contamination. In this study, any detectable IR signal was not observed. OSL measurements were carried out at 110°C trap combined with thermoluminescence trap and at 125°C to prevent re-trapping (Murray and Wintle, 1998). CW-OSL (continuous wave optically stimulated luminescence) measurements were carried out with the Lexsyg Smart TL / OSL reader at the Luminescence Dating Laboratory, Physics Department, Çukurova University.

The following dating equation (Equation 1) was used to calculate the age with luminescence method (Huntley, 1985).

Age = Equivalent Dose (ED) / Annual Dose (AD) (Equation 1)

A single sample shows the change of OSL signal values obtained as a result of exposure to the artificial irradiation in the laboratory after the measurement of the natural OSL signal is given regarding the age of Equivalent Dose value with Regenerative Method (Aitken, 1998) (Fig. 2). In this study, each equivalent dose value was calculated by using the average of 3 aliquots. Besides, annual dose value was taken as 2.1 mGy/a considering the similar studies conducted in the region (Şahiner et al., 2013; Dogan et al., 2015).

RESULTS

Lithology and Chronology

The top two meters of drilling 10MB-201 consists of brownish-green and greenish-grey loose mud (Fig. 3a). The sediments of lower part consist of greenish stiff mud except for 81 m with 84.5% sand content. In drillings 10MB-203, 10MB-204 and 10MB-205, fine-coarse grained sands with shell and shell fragments interbedded with brownish green mud at the upper parts pass down to brownish green stiff muds. The lithology of drilling 10MB-206 is composed mainly of coarse-grained materials. Gravelly sand and shell fragments represent the interval between 40 - 55 m (Fig. 3b). The uppermost 10-15 m of drillings 10MB-207 and 10MB-208 is composed predominantly of grey sand with shell fragments. The sand content sharply decrease at the lower parts of the drillings and are limited between 27.5% and 2.9%. These levels are represented by brownish green muds.

10MB-205/10 m were analyzed with ^{14}C method in two different laboratories and the results yielded 49.0 ky and 43.2 ky of age (Table 2). According to the numerical age data results, the drilling sediments include the sedimentary records of MIS-5, MIS-3 and MIS-1.

Benthic Foraminifera

A total of 128 benthic foraminiferal species belonging to 75 genera were identified (Appendix 1, Figs. 4-9). The species richness was the highest in the samples from the Hersek Burnu drillings and ranged between 71 and 97 species/drilling. Dilovası drillings contain slightly fewer foraminifera compared with the Hersek Burnu drillings. Species of *Bolivina*, *Elphidium*, *Bulimina* and *Ammonia* are the dominant taxa in all analyzed samples.

In the Dilovası drillings, most of the levels are either barren of foraminifera (14 levels) or contain rare foraminifera (13 levels). The highest foraminiferal abundances (3328, 2900 and 1023 individuals/10 g dry sediment) are recorded at 10MB-205/1.5 m, 10MB-201/1 m and 81 m, respectively (Table 3, Fig. 10a). 10MB-201/81 m has low species richness (39 species). The microfaunistic assemblage is characterized by the abundance of *Bulimina aculeata*, *Bolivina ordinaria*, *Aubignyna perlucida*, *Bulimina marginata*, *Bulimina elongata*, *Ammonia tepida* and *Nonionoides turgidus*. Poor foraminiferal density (43 individuals/10 g dry sediment) and species richness (15 species) are observed at 74 m. The assemblage is composed of species of the genera *Haynesina*, *Ammonia*, *Elphidium* and *Cribroelphidium.* The uppermost 1 m has the highest species richness (79 species), and is represented mainly by *Cassidulina carinata*, *Bolivina ordinaria*, *Discorbinella bertheloti*, *Bulimina aculeata*, *Neoconorbina terquemi*, *Cibicides* sp., *Gavelinopsis praegeri*, *Bolivina dilatata* and *Cibicidoides lobatulus*, in order of abundances. Foraminifera are completely absent in drilling 10MB-203, except for few specimens at 95 and 100 m. Foraminiferal fauna at the lower parts of 10MB-204 have sporadic occurrences with very low abundance, except for the bottom 69 m, which contained *Bolivina dilatata*, *B. spathulata* and *B. ordinaria*. The uppermost 21.5 m are generally characterized by low foraminiferal density and species richness (maximum 220 individuals/10 g dry sediment and 28 species). The fauna includes *Ammonia compacta*, *A. parkinsoniana*, *A. tepida*, *Ammonia* spp., *Asterigernata mamilla*, *Aubignyna perlucida*, *Bolivina. dilatata*, *B. ordinaria*, *B. spathulata*, *B. striatula*, *Bolivina* spp., *Bulimina. aculeata*, *B. elongata*, *Cassidulina carinata*, *Discorbinella bertheloti*, *Elphidium macellum*, *E. pulvereum*, *Elphidium* spp. and *Haynesina depressula.* Both foraminiferal density (9-113 individuals/10 g dry sediment) and species richness (8-31 species) are low between 18 - 10 m of 10MB-205. The main components of the assemblages are represented by *Bo. dilatata*, *Bo. ordinaria*, *C. carinata*, *Elphidium* spp., *H. depressula*, *Bo. spathulata*, *Bo. striatula*, *Fursenkoina complanata*, *A. parkinsoniana* and *P. subgranosus*. High species richness (64 species) is recorded at 1.5 m and *As. mamilla*, *D. bertheloti*, *C. carinata*, *Bo. dilatata*, *N. terquemi* and *E. macellum* display significant abundances.

Hersek Burnu drillings have a rich and diverse foraminiferal fauna (Table 4, Fig. 10b). Benthic foraminiferal assemblages consisting of *Bo. dilatata*, *Bo. spathulata*, *C. carinata*, *Elphidium* spp., *H. depressula*, *B. aculeata*, *Bo. ordinaria*, *Au. perlucida* and *Ammonia* spp. occur at lower most 63 m of 10MB-206, in order of abundances. Despite the lack of foraminifera at the upper 53 and 45 m, the dominance of *Elphidium* and *Ammonia* genera together with subordinately number of *B. aculeata*, *C. carinata*, *H. depressula*, *Bo. dilatata* and *As. mamilla* is conspicuous between 41 - 25.5 m. *B. aculeata* (21.2-47.8%) and *Bo. ordinaria* (6.0-35.4%) together with subordinately number of *Bo. dilatata*, *N. turgidus*, *Bo. spathulata*, *Au. perlucida* and *B. marginata* are consistently present towards the top part of the drilling. Benthic foraminiferal assemblages display two significant peaks in 10MB-207. *Au. perlucida*, *A. tepida*, *A. parkinsoniana*, *Ammonia* spp., *H. depressula*, *P. subgranosus* and *Elphidium* spp. are dominant in the first increment at 31 m, whereas second peak at 18 m is characterized by high abundances of *Bo. ordinaria*, *B. aculeata*, *A. tepida*, *N. turgidus* and *Bo. dilatata*, reaching to 65% in Total Benthic Foraminifera (TBF). A distinct faunal change appears at the upper parts of the drilling with the domination of *Ammonia*, *Elphidium*, *Rosalina* and *Neoconorbina* genera. In 10MB-208, TBF and species

Table 2 Radiocarbon (uncalibrated) and OSL ages of selected levels from the İzmit Gulf drillings

Drilling	Depth (m)	Dated material	Laboratory number	Method	Date
10MB-201	74	Sediment		OSL	38 170±3225
10MB-201	94	Sediment		OSL	54 361±4897
10MB-203	120	Sediment		OSL	87 820±7974
10MB-203	136	Sediment		OSL	110 500±16000
10MB-204	18	Mollusc shell	Poz-95936	C-14	>46 000
10MB-205	10	Mollusc shell	Poz-95937	C-14	49 000±3000
10MB-205	10	Mollusc shell	TÜBİTAK-378	C-14	43 191±396
10MB-205	14	Mollusc shell	Poz-95938	C-14	>46 000
10MB-206	8	Sediment		OSL	6195±480
10MB-206	18	Mollusc shell	Poz-95939	C-14	8360±50
10MB-206	25.5	Mollusc shell	Poz-95940	C-14	46 000±2000
10MB-206	33	Mollusc shell	TÜBİTAK-379	C-14	48 443±639
10MB-206	45	Sediment		OSL	51 504±3399
10MB-207	31	Mollusc shell	Poz-95942	C-14	9230±50
10MB-207	39	Sediment		OSL	40 000±1824
10MB-207	43	Sediment		OSL	41 700±3515
10MB-208	14	Mollusc shell	TÜBİTAK-380	C-14	6586±38

richness show an increasing trend from bottom to top. The high abundances of *Au. perlucida* (57.4%), *A. tepida* (9.9%) and *Ammonia* spp. (27.0%) at the bottom 37.5 m accompanied by *B. aculeata*, *B. elongata*, *N. turgidus*, *Bo. ordinaria* and *H. depressula* towards the upper parts. *A. compacta*, *A. parkinsoniana*, *A. tepida*, *Ammonia* spp., *C. advenum*, *Cr. gerthi*, *Cribroelphidium poeyanum* and *Elphidium* spp. are the main abundant species at the top 9 m.

Ostracods

The ostracod assemblages (74 species belonging to 45 genera) were identified in the seven drillings samples from Dilovasi (10MB-201, 203, 204, 205) and Hersek Burnu (10MB-206, 207, 208).

Scanning electron microscopy images of selected ostracods species, Ponto-Caspian originated species (Figs. 11-13) and Mediterranean originated species (Figs. 14-17) were determined Ponto-Caspian ostracod species are belong to genera *Bacunella*, *Amnicythere*, *Euxinocythere*, *Tyrrenocythere*, *Loxoconcha*, *Loxocaspia* and *Cytherissa* (Table 5 & 6), and indicate low salinity (fresh and brackish waters) from littoral to marine environments. (e.g. Olteanu, 1978, 2003-2004; Opreanu, 2008; Boomer et al., 2010; Schornikov, 2011; Ivanova et al., 2015; Zenina et al., 2017; Williams et al., 2018; Javadova, 2019). The species of *Acanthocythereis*, *Aurila*, *Bosquetina*, *Bythocythere*, *Callistocythere*, *Costa*, *Cytheridea*, *Hiltermannicythere*, *Neonesidea*, *Paracytheridea*, *Pseudocytherura*, *Pseudopsammocythere*, *Pterygocythereis*, *Semicytherura* and *Urocythereis* genera (Table 5 & 6) consist of the Mediterranean assemblage (e.g. Bonaduce et al., 1975; Breman, 1975; Yassini, 1979; Mostafawi and Matzke-Karasz, 2006; Joachim and Langer, 2008).

The units in the northern part (Dilovası) of the studied area consist of more thicker and older than the southern parts (Hersek Burnu) according to fauna, numerical and lithological data. The ostracod assemblages of drilling 10MB-201 point out the Ponto-Caspian origin ostracods (e.g. *Candona schweyeri*, *Trapezicandona* sp., *Amnicythere reticulata*, *Euxinocythere* (*Maetocythere*) *lopatici*, *Amnicythere quinquetuberculata*, *Euxinocythere bacuana*, *Euxinocythere relicta* and *Loxoconcha immodulata*) at 108 m, 104 m, 74 m and 70 m; mixed group (Ponto-Caspian and Mediterranean originated) at 94 m and 81m. Mediterranean origin ostracods (e.g. *Acantocythereis hystrix*, *Bosquetina carinella*, *Bythocythere minima*, *Callistocythere intricatoides*, *Cytheridea acuminata*, *Paracytheridea parallia* and *Semicytherura inversa*) at the uppermost 1 m.

Ponto-Caspian fauna at 147 m, 143.5 m and 120 m, mixed fauna at 140 m, 95 m and 16.5 m, and Mediterranean originated fauna at 100 m were found in drilling 10MB-203.

A thick sedimentary sequence containing Ponto-Caspian ostracods between 69 m and 5 m is observed in the drilling core 10MB-204, except for 13 m, 9.3 m and 2 m which have a mixed or Mediterranean origin fauna (Table 5).

In the drilling core 10MB-205, the fauna includes Ponto-Caspian ostracods between 30 m and 14 m, and relatively abundant Ponto-Caspian species together with

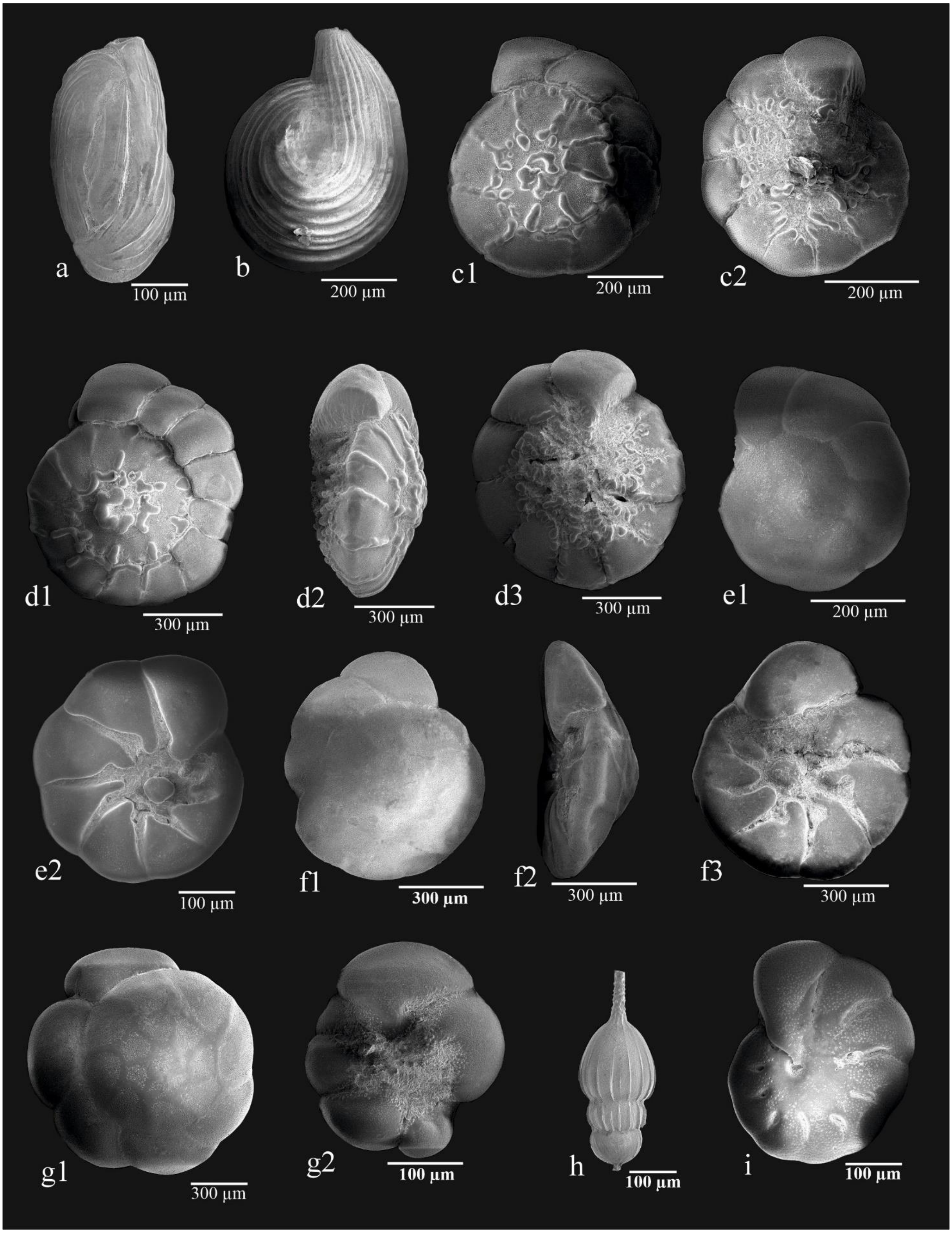

Fig. 4 Scanning electron micrographs of selected benthic foraminiferal species identified from the İzmit Gulf drilling cores. **a.** *Adelosina carinatastriata*, 208/5 m. **b.** *Adelosina mediterranensis*, 201/1 m. **c.** *Ammonia compacta*, 207/31 m: c1, spiral view; c2, umbilical view. **d.** *Ammonia compacta*, 208/1 m: d1, spiral view; d2, peripheral view; d3, umbilical view. **e.** *Ammonia parkinsoniana*, 206/37.5 m: e1, spiral view; e2, umbilical view. **f.** *Ammonia parkinsoniana*, 208/1 m: f1, spiral view; f2, peripheral view; f3, umbilical view. **g.** Ammonia tepida, 208/5 m: g1, spiral view; g2, umbilical view. **h.** *Amphicoryna scalaris*, 206/4.5 m. **i.** *Astrononion stelligerum*, 205/1.5 m.

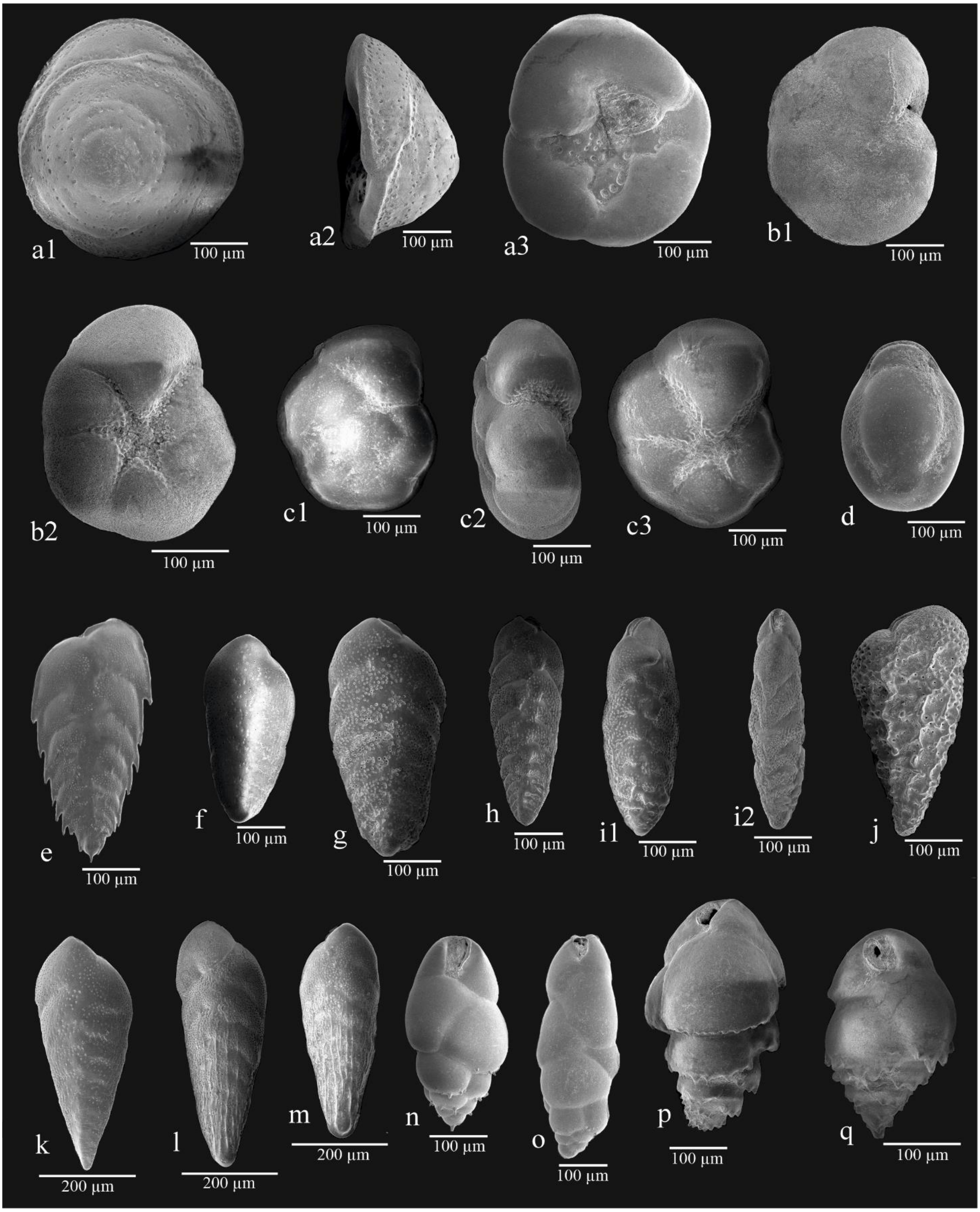

Fig. 5 Scanning electron micrographs of selected benthic foraminiferal species identified from the İzmit Gulf drilling cores. **a**. *Asterigerinata mamilla*, 206/37.5 m: a1, spiral view; a2, peripheral view; a3, umbilical view. **b.** *Aubignyna perlucida*, 208/37.5 m: b1, spiral view; b2, umbilical view. **c.** *Aubignyna perlucida*, 207/31 m: c1, spiral view; c2, peripheral view; c3, umbilical view. **d.** *Biloculinella labiata*, 204/13 m. **e.** *Bolivina alata*, 207/22 m. **f.** *Bolivina dilatata*, 206/37.5 m. **g.** *Bolivina dilatata*, 208/18 m. **h.** *Bolivina ordinaria*, 207/22.75 m. **i.** *Bolivina ordinaria*, 206/8 m: i1, side view; i2, apertural edge view. **j.** *Bolivina pseudoplicata*, 206/37.5 m. **k.** *Bolivina spathulata*, 206/37.5 m. **l.** *Bolivina striatula*, 206/14 m. **m.** *Bolivina striatula*, 208/25 m. **n.** *Bulimina aculeata*, 208/33 m. **o.** *Bulimina elongata*, 208/18 m. **p.** *Bulimina marginata*, 207/18 m. **q.** *Bulimina marginata*, 207/22.75 m.

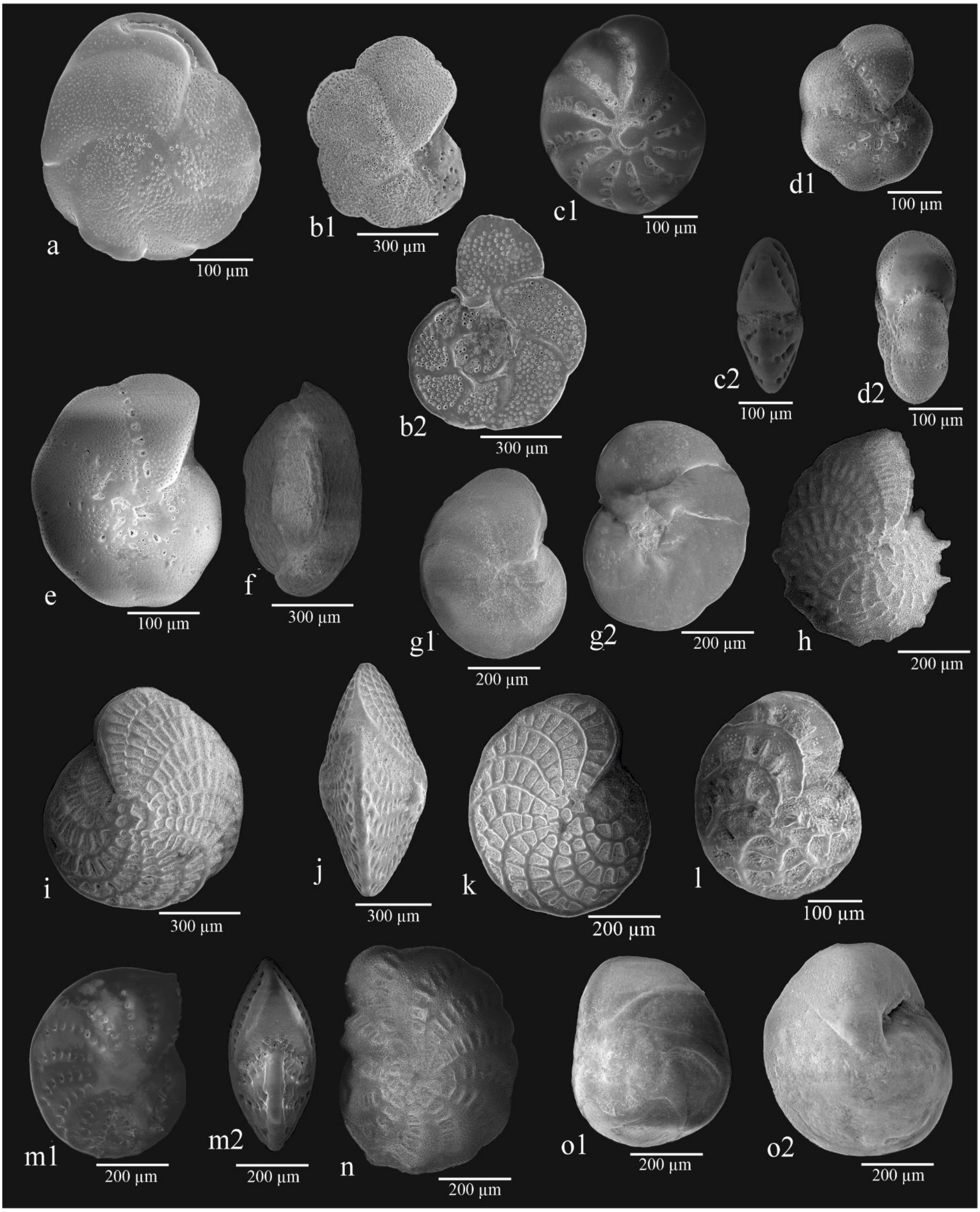

Fig. 6 Scanning electron micrographs of selected benthic foraminiferal species identified from the İzmit Gulf drilling cores. **a.** *Cassidulina carinata*, 206/33 m. **b.** *Cibicidoides lobatulus*, 206/37.5 m: b1, spiral view; b2, umbilical view. **c.** *Cribroelphidium gerthi*, 208/1 m: c1, side view; c2, apertural edge view. **d.** *Cribroelphidium poeyanum*, 207/31 m: d1, side view; d2, apertural edge view. **e.** *Cribroelphidium poeyanum*, 208/9 m. **f.** *Cycloforina villafranca*, 208/1 m. **g.** *Discorbinella bertheloti*, 205/1.5 m: g1, spiral view; g2, umbilical view. **h.** *Elphidium aculeatum*, 208/18 m. **i.** *Elphidium crispum*, 208/1 m. **j.** *Elphidium crispum*, 206/41 m. **k.** *Elphidium macellum*, 207/22.75 m. **l.** *Elphidium macellum*, 206/41 m. **m.** *Elphidium punctatum*, 208/1 m: m1, side view; m2, apertural edge view. **n.** *Elphidium* sp. 208/1 m. **o.** *Eponides concameratus*, 206/41 m: o1, spiral view; o2, umbilical view.

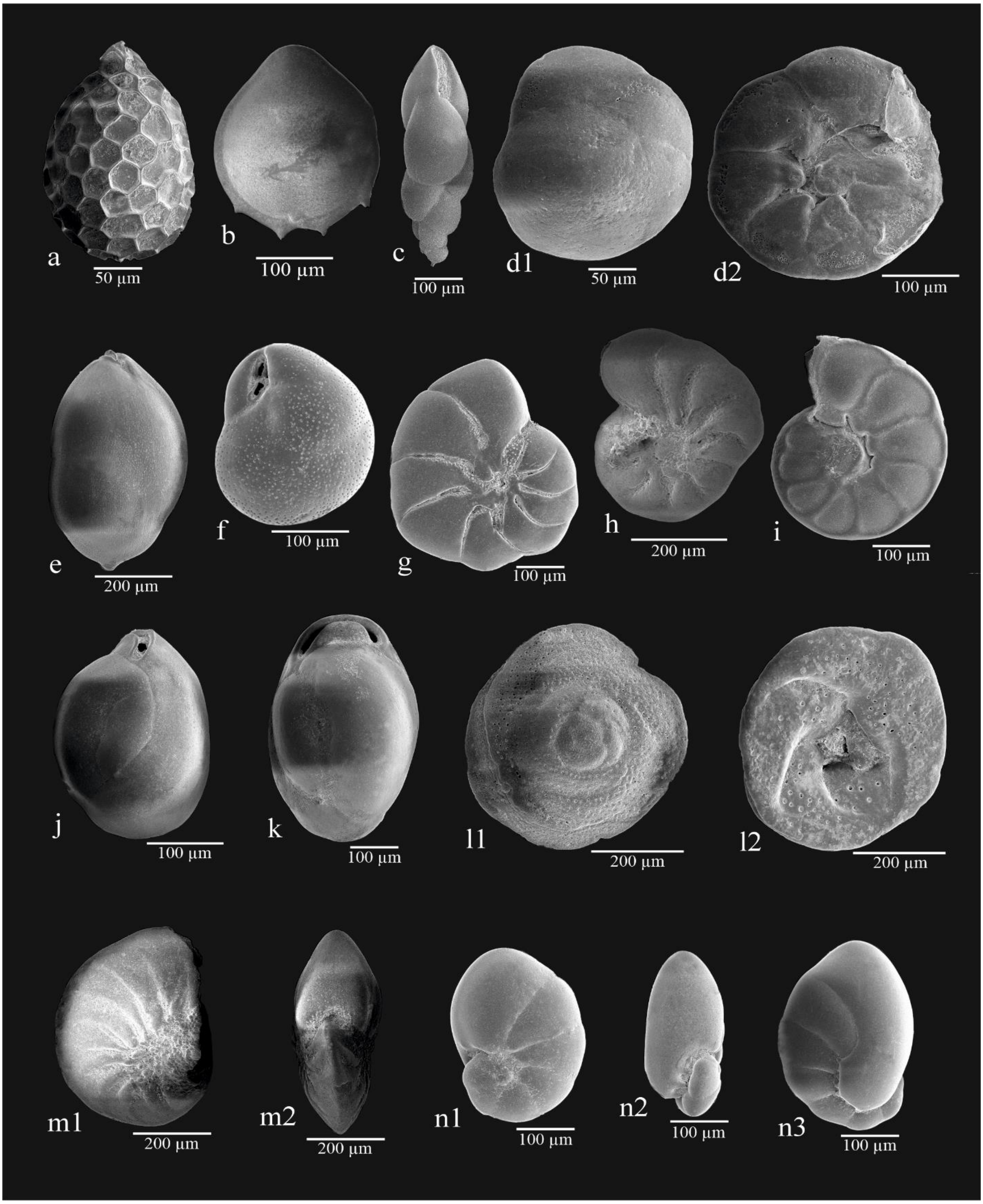

Fig. 7 Scanning electron micrographs of selected benthic foraminiferal species identified from the İzmit Gulf drilling cores. **a.** *Favulina hexagona*, 206/37.5 m. **b.** *Fissurina staphyllearia*, 206/37.5 m. **c.** *Fursenkoina complanata*, 206/14 m. **d.** *Gavelinopsis praegeri*, 206/37.5 m: d1, spiral view; d2, umbilical view. **e.** *Globobulimina affinis*, 201/1 m. **f.** *Globocassidulina subglobosa*, 201/1 m. **g.** *Haynesina depressula*, 206/33 m. **h.** *Haynesina* sp., 208/1 m. **i.** *Hyalinea balthica*, 206/33 m. **j**. *Miliolinella subrotunda*, 208/5 m. **k.** *Miliolinella subrotunda*, 208/9 m. **l.** *Neoconorbina terquemi*, 208/5 m: l1, spiral view; l2, umbilical view. **m.** *Nonion subturgidum*, 206/41 m: m1, side view; m2, apertural edge view. **n.** *Nonionoides turgidus*, 208/33 m: n1, spiral view; n2, peripheral view; n3, umbilical view.

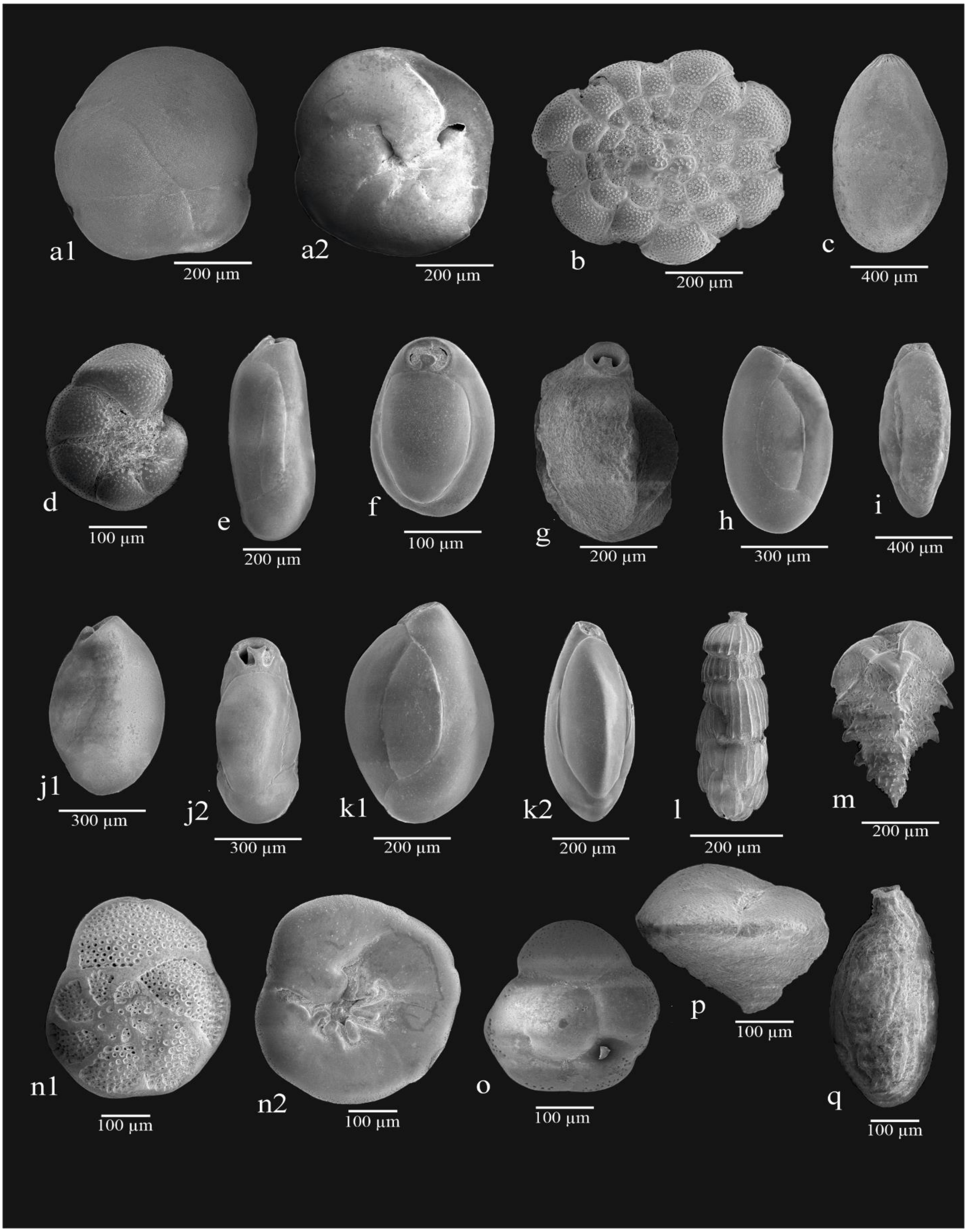

Fig. 8 Scanning electron micrographs of selected benthic foraminiferal species identified from the İzmit Gulf drilling cores. **a.** *Planodiscorbis* sp., 205/1.5 m: a1, spiral view; a2, umbilical view. **b.** *Planorbulina mediterranensis*, 201/1 m. **c.** *Polymorphina* sp., 206/41 m. **d.** *Porosononion subgranosus*, 207/31 m. **e.** *Pseudotriloculina lecalvezae*, 207/1 m. **f.** *Pyrgo elongata*, 201/1 m. **g.** *Quinqueloculina berthelotiana*, 208/1 m. **k.** *Quinqueloculina laevigata*, 208/9 m. **i.** *Quinqueloculina laevigata*, 208/2 m. **j.** *Quinqueloculina parvula*, 208/5 m: j1, side view; j2, apertural edge view. **k.** *Quinqueloculina seminula*, 201/1 m: k1, side view; k2, apertural edge view. **l.** *Rectuvigerina phlegeri*, 205/1.5 m. **m.** *Reusella spinulosa*, 201/1 m. **n.** *Rosalina bradyi*, 208/5 m: n1, spiral view; n2, umbilical view. **o.** *Rosalina globularis*, 208/1 m. **p.** *Sahulia conica*, 201/1 m. **q.** *Sigmoilina costata*, 208/5 m.

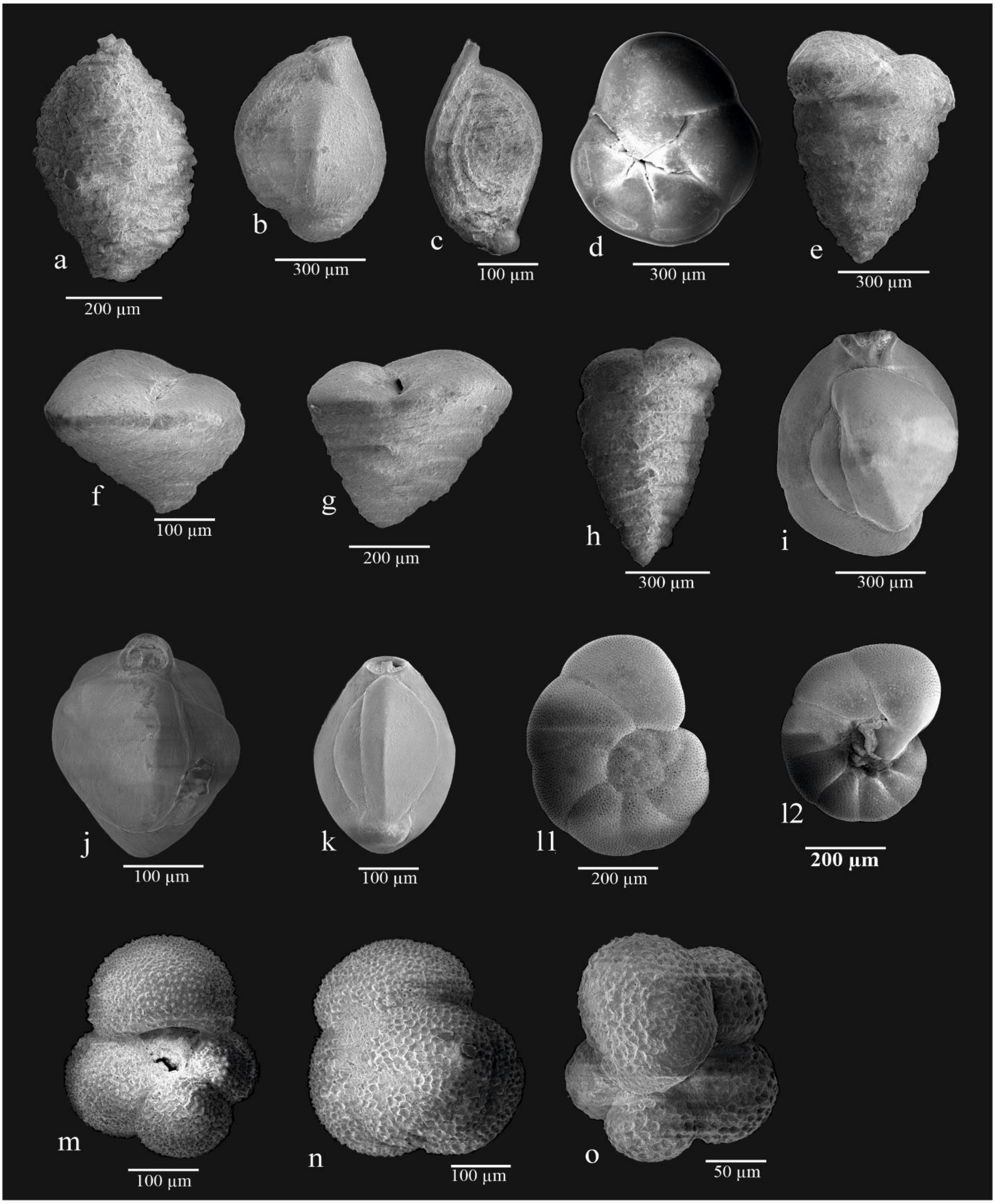

Fig. 9 Scanning electron micrographs of selected benthic foraminiferal species identified from the İzmit Gulf drilling cores. Three planktic species rarely observed in the drillings are illustrated in **m**, **n** and **o**. **a.** *Sigmoilopsis schlumbergeri*, 201/1 m. **b.** *Siphonaperta* sp., 208/5. **c.** *Spirophthalmidium tenuiseptatum*, 201/1 m. **d.** *Stomatorbina concentrica*, 207/5 m. **e.** *Textularia aglutinans*, 208/9 m. **f.** *Textularia calva*, 201/1 m. **g.** *Textularia pala*, 205/1.5 m. **h.** *Textularia sagittula*, 201/1 m. **i.** *Triloculina marioni*, 207/1 m. **j.** *Triloculina plicata*, 208/1 m. **k.** *Triloculina tricarinata*, 205/1.5 m. **l.** *Valvulineria bradyana*, 206/37.5 m: l1, spiral view; l2, umbilical view. **m.** *Globigerina bulloides*, 207/22 m. **n.** *Globigerinoides ruber*, 201/1 m. **o.** *Turborotalita quinqueloba*, 201/1 m.

Table 3 Percentage composition of representative species in the Dilovasi drillings. Species having ≥3% abundance were accepted as environmentally representative species and were shaded in gray color on the table. Number of specimens are presented as numbers per 10 g dry sediment. Drilling 10MB-203 is not shown due to absence of a representative foraminiferal fauna.

DRILLING NO.	10MB-201								10MB-204																		10MB-205					
Depth (m)	1	2	70	74	81	94	104	108	2	5	9.3	13	18	21.5	25	30	34	36	39	43	47	52	56	60	65	69	1.5	10	14	18	27	30
Number of specimens	2900	0	0	43	1023	0	6	2	172	16	220	122	42	148	0	0	2	4	6	12	4	0	28	8	4	120	3328	113	43	9	0	0
Ammonia compacta	2.1			2.3	3.3				8.1		12.7	1.6		16.2													2.3	3.5				
Ammonia parkinsoniana	0.2			4.7	1.2				3.5		6.4			2.7									7.1				1.9	5.3				
Ammonia tepida	0.2			11.6	6.3				11.6		7.3			1.4									7.1				2.2	3.5				
Ammonia sp.				4.7	2.1							4.9		1.4																		
Ammonia spp.									15.1		6.4																2.0					
Asterigerinata mamilla									2.3		4.5			5.4													15.5	4.4				
Asterigerinata sp.				4.7																												
Aubignyna perlucida	0.1				10.5				4.7			8.2	4.8														1.8	3.5				
Bolivina dilatata	2.8				1.2				1.2		3.6	8.2	23.8										14.3			38.3	6.3	12.4	27.9			
Bolivina ordinaria	9.9			4.7	14.5							9.8	4.8													20.0	1.4		16.3			
Bolivina spathulata											1.8	8.2	19.0										14.3			33.3	3.0	7.1	4.7			
Bolivina striatula											0.9	4.9	14.3										14.3			1.7		0.9	7.0			
Bolivina sp.													14.3																			
Bolivina spp.												4.9																				
Bulimina aculeata	6.2			2.3	23.5				3.5		2.7	4.9																				
Bulimina elongata	0.1				7.1						0.9	4.9																				
Bulimina marginata	0.1				7.3																											
Cassidulina carinata	12.6			2.3	0.5				2.3		5.5	4.9											7.1			1.7	6.7	13.3	2.3			
Cibicides advenum																											3.2	1.8				
Cibicides sp.	3.8				0.2						3.6	1.6		1.4													4.0	4.4				
Cibicidoides lobatulus	2.7				0.2																											
Cribroelphidium gerthi	0.2			4.7					3.5																							
Cribroelphidium poeyanum	0.5			4.7	3.1																											
Discorbinella bertheloti	7.4				0.1						0.9		4.8														8.8	0.9				
Elphidium macellum									14.0		3.6			31.1													3.7	0.9				
Elphidium pulvereum									4.7		0.9			12.2																		
Elphidium punctatum				4.7																												
Elphidium sp.																											1.9	9.7				
Elphidium spp.	0.6			9.3					5.8		15.5	6.6																				
Fursenkoina complanata																							28.6			1.7			7.0			
Gavelinopsis praegeri	3.2																															
Globocassidulina crassa																													4.7			
Haynesina depressula	0.3			32.6	2.0				8.1		5.5	14.8	9.5										7.1				1.1	3.5	9.3			
Neoconorbina terquemi	4.7																										3.8	0.9				
Nonionoides turgidus	1.2				3.6				1.2			3.3															0.6		4.7			
Patellina corrugata																											0.2		4.7			
Porosononion subgranosus	0.3				2.7				1.2		3.6																0.6	5.3				
Valvulineria bradyana												1.6		4.1																		
Valvulineria sp.													4.8																			

Table 4 Percentage composition of species in the Hersek Burnu drillings, showing relative abundances ≥3%. Species having ≥3% abundance were accepted as environmentally representative species and were shaded in gray color on the table. Number of specimens are presented as numbers per 10 g dry sediment.

DRILLING NO.	**10MB-206**											**10MB-207**											**10MB-208**										
Depth (m)	**4.5**	**8**	**14**	**18**	**25.5**	**33**	**37.5**	**41**	**45**	**53**	**63**	**1**	**5**	**9**	**13**	**18**	**22**	**22.75**	**26**	**31**	**39**	**43**	**1**	**2**	**5**	**9**	**14**	**18**	**22**	**25**	**29**	**33**	**37.5**
Number of specimens	**1078**	**622**	**890**	**1312**	**79**	**982**	**1635**	**489**	**0**	**0**	**101**	**706**	**136**	**42**	**49**	**1042**	**594**	**749**	**5**	**1818**	**10**	**33**	**1766**	**1530**	**564**	**1736**	**106**	**620**	**117**	**218**	**60**	**541**	**719**
Ammonia compacta	0.7	3.5	0.7	2.7	2.5	2.1	5.5	18.6				18.7	1.5	9.5	65.3	1.9	1.3	1.2		4.0			24.0	12.9	7.4	8.5		1.5		7.3		3.3	0.4
Ammonia parkinsoniana		0.3	0.6	1.1	1.3	6.3	2.3	5.3				23.7	2.2	4.8	2.0	0.2	0.5	0.5		11.2			11.6	45.5	13.7	1.8	0.9	0.2		0.5			
Ammonia tepida	2.5	1.9	3.1	1.9	1.3	4.9	4.6	5.5			2.0	6.2	1.5	4.8		9.9	6.9	3.7		15.6		45.5	12.0	9.3	3.5	4.4	17.9	10.6	7.7	10.1	8.3	2.8	9.9
Ammonia sp.													0.7									3.0											
Ammonia spp.	1.2		1.9	1.3		3.2	1.1	2.2			4.0	1.4	0.0			2.4	2.5	0.9		10.0			15.5	3.9	2.8	5.5	9.4	6.3		6.4		3.9	27.0
Asterigerinata mamilla	0.1					0.2	5.6	2.0				1.0	4.4			0.1		0.7		0.2													
Aubignyna perlucida	0.5	0.6	1.9	7.9	1.3	3.9	2.0	3.1			5.0	1.0				4.2	1.5	1.5		25.9		3.0	0.5			0.2	1.9	1.1	0.9	1.4	31.7	11.5	57.4
Bolivina dilatata	24.3	12.7	1.6	0.2	36.7	4.9	6.2	0.4			26.7					5.7	7.7	5.7					0.1	0.3	0.2	0.9	5.7	2.9	1.7	4.1	5.0		
Bolivina ordinaria	28.5	35.4	6.0	14.6		1.0		0.2			5.0	0.3	1.5			28.1	10.4	36.7		0.1			0.2		0.2	1.8	2.8	2.4	23.1	4.6	3.3	9.6	
Bolivina spathulata	5.4	4.0	1.7	0.1	12.7	2.4	2.3				10.9					2.9	3.0	4.8					0.3	0.1	0.5	0.5	3.8	2.7	12.0	17.0	10.0	0.4	
Bolivina striatula																										0.2		0.2	0.9	4.6	3.3		
? *Buccella* sp.															4.1																		
Bulimina aculeata	21.2	21.7	47.8	41.7		0.6	15.3	3.5			5.9	0.4				14.5	18.7	17.8		0.1			0.2	0.3		4.4		33.5	9.4	16.5		25.1	
Bulimina elongata	0.4	1.4	1.6	3.4		0.2	0.9	0.4			2.0					3.4	2.9	2.3		0.2			0.3					1.5	0.9	4.6	5.0	12.8	0.1
Bulimina marginata	0.8	1.1	7.0	1.8	3.8	4.2	0.7	0.2																			0.9	1.8		1.4	3.3	1.1	
Cassidulina carinata	1.7	2.3	0.8	0.4	19.0	15.1	7.6	2.0			9.9		0.7			3.3	5.1	3.6		0.1		3.0			0.4		3.8	1.6	5.1	6.0	1.7	0.2	
Cibicides advenum																							0.5	0.1	4.6	2.8						0	
Cibicidoides lobatulus			0.1	0.1	2.5	0.8	4.7	2.0																									
Cribroelphidium gerthi	0.2	0.2				4.6	1.2	4.5			2.0												1.4	3.0	2.8	5.3		1.3	0.9			0	
Cribroelphidium poeyanum												0.4				3.0	1.3	0.7		4.6			4.0	1.3	2.0	5.3	10.4	4.2	1.7	1.8	1.7	1.7	0.7
Cycloforina contorta												1.7	3.7	4.8			0.5						0.2	0.3	3.0	0.2	0.9						
Elphidium crispum		0.2		0.1			0.1	4.1				0.7		2.4	4.1		0.2						3.4	1.0	0.9	0.5	0.9						0.1
Elphidium macellum	0.4	2.1		1.1	1.3	4.6	6.2	13.1			5.0	3.3	1.5	7.1		0.7	1.5	1.3		0.9		6.1	2.3	1.4	1.8	2.5		2.7	1.7	1.4		4.3	
Elphidium sp.												0.6	0.7	4.8		0.1																	
Elphidium spp.	1.2		0.3	0.9	7.6	9.8	4.3	8.8			8.9	2.3				1.9	1.0	2.1		7.5		21.2	5.3	4.4	3.4	6.2	6.6				8.3	0.6	0.8
Haynesina depressula	0.9	0.5	2.4	3.7	2.5	11.5	3.4	3.1			5.9	1.3		2.4		2.1	0.8	1.2		11.3		9.1	1.6	0.9	1.8	2.8	6.6	4.8		2.3	5.0	5.7	1.1
Miliolinella subrotunda																							0.2	1.6	3.4	4.8		1.9	0.9			0.2	
Neoconorbina terquemi												3.8	8.1										0.1	0.3	5.1	0.7							
Nonionoides turgidus	2.2	2.3	15.2	10.7	2.5	4.9	4.5									6.7	21.0	2.5		0.2			0.1		0.2	0.2		5.5	9.4	2.3		10.2	
Porosononion subgranosus	0.9	0.5	1.0	1.1	1.3	5.4	0.8	1.0				1.8	1.5	4.8		4.0	1.0	2.7		7.6		9.1	1.1	1.4	1.1	1.4	19.8	3.2		1.8	3.3	3.1	1.9
Quinqueloculina seminula	0.2	0.8	0.6	0.3		0.5	0.1	4.1				1.8	1.5	4.8		0.4	0.8	0.4		0.1			0.6	0.4	1.1	3.7		3.1	3.4	2.3		0.2	
Rosalina bradyi												4.2	8.1	19.0									0.2		3.4	1.8							
Rosalina floridensis																							0.9	0.8	3.7	0.7							
Sigmoilina costata																							0.2	0.1	3.0	0.9							
Siphonaperta aspera												1.1			14.3																		
Siphonaperta sp.														4.8																			
Textularia pala													3.7	2.4			0.5																
Valvulineria bradyana		0.3	0.1	0.1			4.9	0.6																									

Mediterranean species at 10 m (Table 5). Mediterranean origin ostracod species were found at the uppermost 1.5 m. After the reconnection of Mediterranean and The Marmara Sea via the Strait of Dardanelles during the early Holocene (Aksu et al., 1999), the ostracods of the southern drillings (Hersek Burnu, Table 6) is mainly represented by the Mediterranean origin species and a few relict Ponto-Caspian fauna. The ostracod fauna of Ponto-Caspian origin are represented by a few species at different levels of 10MB-206, 10MB-207 and 10MB-208 drillings while the highest species diversity of them is recorded at 63 m (Table 6).

Molluscs

In this study, 21 genera and 21 species belonging to the Gastropoda class, 12 genera and 14 species belonging to the Bivalvia class of the Mollusca were identified (Table 7 and Figs. 18-20). A large part of the identified gastropod and bivalv samples were probably broken up during drilling while coring, and were not well preserved. They are also smaller than they should be and are in juvenile forms. The identification was made by considering the observable features as much as possible. Black Sea origin species such as *Pirenella conica*, *Bythinella pannonica* (Meriç et al., 2005) and Mediterranean origin species such as *Lucinella divaricata, Parvicardium exigium, Spisula subtruncata* (Kerey et al., 2004) were detected together at 1 m and 81 m of the 10MB-201 drilling. Black Sea origin species such as *Dreissena rostriformis distincta*, *Dreissena rostriformis tschuadae* (Neveskaja, 1963) were identified between 16.5 - 95 m of 10MB-203 borehole and 13 -69 m between 10MB-204 borehole. The fauna of Mediterranean and Black Sea origin was observed together between 2 - 9.5 m in the 10MB-204 borehole and at 1.5 - 14 m in the 10MB-205 borehole. Bivalvia at 18 - 30 meters of the 10MB-205 borehole are of Black Sea origin. In the 10MB-206 drill, a single Black Sea origin genus at 25.5 m, Black Sea and Mediterranean species together at 41 m and Black Sea origin *Dreissena* sp. was found at 63 m. Both Mediterranean and Black Sea origin gastropods and bivalvs were found together between 1 - 26 m of 10MB-207 borehole and 1-22 m of 10MB-208 borehole; Mediterranean species were relatively dominant.

Diatoms

The diatom flora consist in 15 species assigned to 10 genera in the three samples of drilling 10MB-203 (143.5 m, 140 m and 95 m, Table 8, Fig. 21). All of the taxa were recorded in low densities. Sample from 143.5 m has four pennate diatom form (*Amphora libyca*, *Diploneis parma*, *Epithemia turgida* var. *westermannii* and *Fragilaria lancettula* and two centric forms (*Cyclotella comensis* and *Stephanodiscus lucens*). Only one pennate diatom (*Amphipleura pellucida*) was identified in 95 m. Relatively high species richness is observed at 95 m, consisting of six pennate diatom forms (*Amphipleura pellucida, Cocconeis disculus*, *Diploneis elliptica*, *Diploneis parma*, *Fragilaria* sp., *Stenopterobia sigmatella*) and six centric diatom forms (*Actinocyclus normanii*, *Stephanodiscus aegyptiacus*, *S. alpinus*, *S. lucens*, *S. medius* and *S. niagarae*).

DISCUSSION AND CONCLUSIONS

Global climatic changes in the form of glacial and interglacial cycles occur during the Quaternary (Lowe and Walker, 1984). Remarkable expansion and contraction of glacial masses were recorded in the Northern Hemisphere during glacial and interglacial periods. Depending on these events, the hydrodynamic regimes of water systems (rivers, lakes, seas etc.) have changed due to the vertical oscillations resulted from the rises or drops in the water levels.

The fluctuating sea level caused connections or disconnections between basins and hence the formation of different environmental settings. One of the most important area, the Marmara Sea, which provides the only connection of Ponto-Caspic basins (Black Sea, Azov Sea and Caspian Sea) with the open sea (Mediterranean) (Stanley and Blanpeid, 1980).

According to the age data of this research, the sediments are Late Pleistocene-Holocene aged and correspond to the marine isotope stage MIS-5, MIS-3 and MIS-1 (Fig. 22). The unconformity between MIS-3 and MIS-1 is clearly observed based on the numerical age data. The lack of records for MIS-4 and MIS-2 can be explained by the fact that this region was affected by the North Anatolian Fault, because it may be exposed to subaerial erosion in low-water levels during the glacial period or the sampling frequency was inadequate. It is also important to keep in mind that the sediment gaps from the drillings have restricted a high-resolution sampling.

Pleistocene / MIS-5 Interval

The thickest sequence from drilling 10MB-203, recovered from -40 m in Northern Dilovası, and had the oldest sedimentary records extending back to MIS-5 (Fig. 22). MIS-5 stage is characterized by the Ponto-Caspian ostracod fauna such as *Camptocypria acronasuta*, *Bacunella dorsoarcuta*, *Candona parallela pannonica*, *Amnicythere olivia*, *Amnicythere. reticulata*, *Loxocaspia lepida*, *Xestoleberis chanakovi*, *Candona schweyeri*, *Amnicythere pediformis*, *A. postbissinuata*, *Euxinocythere (Maetocythere) lopatici*, *Euxinocythere bacuana*, *Tyrrenocythere amnicola donetziensis* and *Loxoconcha immodulata*, except for 140 m which had a mixed ostracod fauna originated from the Ponto-Caspian and Mediterranean. The diatom flora includes some fresh water and cosmopolitan species consisting of *Amphora libyca*, *Cyclotella comensis*, *Epithemia turgida* var. *westermannii*, *Fragilaria lancettula* and *Amphipleura pellucida*. Foraminifera are completely absent in the sediments deposited during MIS-5.

Table 5 Distribution of Ponto-Caspian and Mediterranean origin and cosmopolitan ostracods in Dilovasi drillings.

10MB-205						10MB-204															10MB-203							10MB-201							DRILLING NO	
30	27	18	14	10	1.5	69	65	60	56	47	43	39	36	34	21.5	18	13	9.3	5	2	147	143.5	140	120	100	95	16.5	108	104	94	81	74	70	1	Depth (m)	
																	*	*								*									_Candona neglecta_ Sars, 1987	PONTO-CASPIAN ORIGIN
			*	*			*		*		*				*			*			*	*				*							*		_Candona parallela pannonica_ Zalanyi, 1959	
		*	*											*		*					*						*			*					_Candona schweyeri_ Schornikov, 1964	
																												*	*						_Trapezicandona_ sp. sensu Schornikov and Syrtlanova, 2008	
*	*					*	*	*	*	*			*	*							*	*	*	*		*			*	*		*	*		_Camptocypria acronasuta_ (Livental, 1929)	
																													*			*	*		_Pseudocandona_ sp.	
							*	*			*						*				*	*	*	*						*		*			_Bacunella dorsoarcuta_ (Zalanyi, 1929)	
		*		*													*	*																	_Amnicythere bendovanica_ (Livental, 1935)	
									*																								*		_Amnicythere hilda_ (Stepanaitys,1960)	
				*														*																	_Amnicythere longa_ (Negadaev, 1955)	
		*	*	*			*		*					*		*	*				*	*				*				*			*		_Amnicythere olivia_ (Livental, 1938)	
			*	*			*	*	*		*						*	*			*														_Amnicythere pediformis_ (Schornikov, 1966)	
																						*													_Amnicyhter postbissinuata_ (Negadaev, 1955)	
																																*			_Amnicythere quinquetuberculata_ (Schweyer, 1949)	
																					*	*							*			*			_Amnicythere reticulata_ (Schornikov, 1966)	
		*	*	*						*			*		*	*										*								_Amnicythere striatacostata_ (Schweyer, 1949)	
	*												*									*				*						*			_Euxinocythere bacuana_ (Livental, 1938)	
																						*													_Euxinocythere bosqueti (Liventai, 1929)_	
																						*													_Euxinocythere_ ex. gr. _bosqueti_ (Livental, 1929)	
			*	*			*							*																*	*			_Euxinocythere relicta_ (Schornikov, 1964)	
*	*	*		*			*		*		*			*		*	*	*						*		*	*		*			*			_Euxinocythere (Maetocythere) lopatici_ (Schornikov, 1964)	
																																	*	_Hemicytherura bulgarica_ Klie, 1937	
	*	*	*	*							*	*		*	*	*	*	*			*				*									_Tyrrenocythere amnicola_ (Sars, 1888)	
																																	*	_Loxocorniculina djaffarovi_ (Schneider, 1956)	
		*	*	*			*				*					*	*	*						*			*	*	*	*		*	*		_Loxoconcha immodulata_ Stepanaitys, 1958	
	*		*	*		*	*	*	*		*	*		*			*				*	*				*	*			*					_Loxocaspia lepida_ (Stepanaitys,1962)	
																*		*			*	*													_Xestoleberis chanakovi_ Livental, 1949	
							*	*			*			*												*						*			_Cytherissa bogatschovi_ (Livental, 1929)	
																													*					_Ilyocypris gibba_ Ramdohr, 1808	Cosmopolitan
				*																		*	*		*									*	_Cyprideis torosa_ Jones, 1850	
					*																												*	_Acantocythereis hystrix_ (Reuss, 1850)	MEDITERRANEAN ORIGIN
				*	*																*	*				*							*	_Aurila convexa_ (Baird, 1850)	
					*															*			*												_Aurila interpretis_ Uliczny, 1969	
					*																												*	_Bosquetina carinella_ (Reuss, 1850)	
																																	*	_Bythocythere minima_ Bonaduce, Ciampo & Masoli, 1976	
					*													*								*							*	_Callistocythere intricatoides_ Ruggieri, 1953	
					*													*		*														*	_Callistocythere pallida_ (Mueller, 1894)	
					*																									*			*	_Carinocythereis carinata_ (Roemer, 1838)	
					*																									*			*	_Carinocythereis rhombica_ Stambolidis, 1982	
					*																												*	_Costa edwardsii_ (Roemer, 1838)	
					*																												*	_Costa tricostata_ (Reuss, 1850)	
																																		Cuhmanidea elongata (Brady, 1868)	
				*	*																									*				_Ponyocythere turbida_ (Mueller, 1894)	
					*																											*	*	_Cytherois_ sp.	
																													*	*			*	_Cytheridea acuminata_ (Bosquet, 1852)	
																																	*	_Cytheropteron rotundatum_ Mueller, 1894	
					*																													_Hiltermannicythere rubra_ (Mueller, 1894)	
																																		Hiltermannicythere turbida (Mueller, 1894)	
					*																					*				*			*	_Leptocythere bacescoi_ (Rome, 1942)	
																														*				_Leptocythere bituberculata_ Bonaduce, Ciampo & Masoli, 1976	
					*												*																*	_Loxoconcha gibberosa_ Terquem, 1878	
					*																													_Neonesidea frequens_ (Mueller, 1894)	
				*	*																													_Neonesidea inflata_ (Norman, 1862)	
					*																													_Tetracytherura irregularis_ Terquem, 1978	
					*																												*	_Microcytherura nigrescens_ Mueller, 1894	
																														*			*	_Palmoconcha agilis_ (Ruggieri, 1967)	
					*													*															*	_Paracytheridea parallia_ Barbeito-Gonzalez, 1971	
																																	*	_Paradoxostoma triste_ Mueller, 1894	
					*												*																*	_Pontocypris rara_ (Mueller, 1894)	
					*																												*	_Pseudopsammocythere reniformis_ (Brady, 1868)	
																																		Pseudocytherura calcarata (Seguenza, 1880)	
																																	*	_Pterygocythereis jonesii_ (Baird, 1850)	
																		*															*	_Sagmatocythere versicolor_ (Mueller, 1894)	
																								*										_Loxoconcha minima_ Mueller, 1894	
																																		Schlerochilus contortus (Norman, 1861)	
																																		Semicytherura acuminata (Mueller, 1894)	
																																		Semicytherura incongruens (Mueller, 1894)	
					*																												*	_Semicytherura inversa_ (Seguenza, 1880)	
																																	*	_Semicytherura paradoxa_ (Mueller, 1894)	
					*												*	*												*			*	_Semicytherura punctata_ (Mueller, 1894)	
					*																				*									_Semicytherura sulcata_ (Mueller, 1894)	
					*													*																_Urocythereis crenulosa_ (Terquem, 1878)	
																							*		*						*				_Xestoleberis_ sp.	
																																		Xestoleberis communis Mueller, 1894	
																		*		*															_Xestoleberis depressa_ Sars, 1866	

Table 6 Distribution of Ponto-Caspian and Mediterranean origin and cosmopolitan ostracods in Hersek Burnu drillings.

10MB-208									10MB-207								10MB-206										DRILLING NO	
33	25	22	18	14	9	5	2	1	39	26	22.75	22	18	9	5	1	63	53	41	37.5	33	25.5	18	14	8	4.5	**Depth (m)**	
																	*										*Candona parallela pannonica* Zalanyi, 1959	**PONTO-CASPIAN ORIGIN**
		*			*							*	*												*	*	*Camptocypria acronasuta* (Livental, 1929)	
	*			*																*		*			*	*	*Bacunella dorsoarcuta* (Zalanyi, 1929)	
																	*										*Amnicythere bendovanica* (Livental, 1935)	
																	*										*Amnicythere hilda* (Stepanaitys,1960)	
																	*					*					*Amnicythere olivia* (Livental, 1938)	
																	*	*									*Amnicyhtere postbissinuata* (Negadaev, 1955)	
	*																*										*Amnicythere quinquetuberculata* (Schweyer, 1949)	
												*					*										*Euxinocythere bacuana* (Livental, 1938)	
	*											*															*Euxinocythere relicta* (Schornikov, 1964)	
																	*										*Euxinocythere (Maetocythere) lopatici* (Schornikov, 1964)	
	*			*																							*Hemicytherura bulgarica* Klie, 1937	
						*			*	*							*										*Tyrrenocythere amnicola* (Sars, 1888)	
											*	*													*		*Loxocorniculina djafarovi* (Schneider, 1956)	
																	*									*	*Loxoconcha immodulata* Stepanaitys, 1958	
																	*									*	*Loxoconcha* sp.1 sensu Boomer, 2010	
																						*					*Loxocaspia lepida* (Stepanaitys,1962)	
		*								*								*									*Cytherissa bogatschovi* (Livental, 1929)	
					*		*	*	*											*							*Cyprideis torosa* Jones, 1850	Cosmo-politan
																			*								*Acantocythereis hystrix* (Reuss, 1850)	**MEDITERRANEAN ORIGIN**
					*	*	*								*				*	*	*						*Aurila convexa* (Baird, 1850)	
					*	*	*							*													*Aurila interpretis* Uliczny, 1969	
																											Bosquetina carinella (Reuss, 1850)	
																											Bythocythere minima Bonaduce, Ciampo & Masoli, 1976	
*					*	*	*						*		*				*	*	*		*				*Callistocythere intricatoides* Ruggieri, 1953	
			*		*		*	*								*			*							*	*Callistocythere pallida* (Mueller, 1894)	
*	*		*	*	*		*	*				*	*			*			*	*			*	*	*		*Carinocythereis carinata* (Roemer, 1838)	
*	*		*					*			*		*			*					*		*		*	*	*Carinocythereis rhombica* Stambolidis, 1982	
											*		*							*					*	*	*Costa edwardsii* (Roemer, 1838)	
																							*			*	*Costa tricostata* (Reuss, 1850)	
	*	*						*						*	*					*							*Cusmanidea elongata* (Brady, 1868)	
			*	*	*	*	*	*			*	*			*	*				*	*		*	*	*	*	*Pontocythere turbida* (Mueller, 1894)	
	*				*														*								*Cytherois* sp.	
*			*								*	*	*														*Cytheridea acuminata* (Bosquet, 1852)	
																									*	*	*Cytheropteron rotundatum* Mueller, 1894	
								*								*					*						*Hiltermannicythere rubra* (Mueller, 1894)	
					*	*	*	*						*		*			*	*	*					*	*Hiltermannicythere turbida* (Mueller, 1894)	
	*	*	*	*							*	*	*						*	*	*			*	*	*	*Leptocythere bacescoi* (Rome, 1942)	
													*								*				*	*	*Leptocythere bituberculata* Bonaduce, Ciampo & Masoli, 1976	
			*	*		*	*					*			*					*	*					*	*Loxoconcha gibberosa* Terquem, 1878	
					*														*	*							*Neonesidea frequens* (Mueller, 1894)	
																											Neonesidea inflata (Norman, 1862)	
							*												*								*Microcytherura nigrescens* Mueller, 1894	
*	*		*					*			*	*	*						*	*	*		*	*	*	*	*Palmoconcha agilis* (Ruggieri, 1967)	
			*		*	*	*	*							*	*					*					*	*Paracytheridea parallia* Barbeito-Gonzalez, 1971	
			*		*							*															*Paradoxostoma triste* Mueller, 1894	
																											Pontocypris rara (Mueller, 1894)	
												*															*Pseudopsammocythere reniformis* (Brady, 1868)	
							*	*								*				*							*Pseudocytherura calcarata* (Seguenza, 1880)	
					*															*							*Pterygocythereis jonesii* (Baird, 1850)	
													*							*	*						*Sagmatocythere versicolor* (Mueller, 1894)	
																											Loxoconcha minima Mueller, 1894	
				*																							*Schlerochilus contortus* (Norman, 1861)	
							*						*			*											*Semicytherura acuminata* (Mueller, 1894)	
							*																				*Semicytherura incongruens* (Mueller, 1894)	
*	*				*	*	*				*				*	*				*	*			*		*	*Semicytherura inversa* (Seguenza, 1880)	
																				*							*Semicytherura paradoxa* (Mueller, 1894)	
			*		*															*	*						*Semicytherura punctata* (Mueller, 1894)	
			*		*	*	*					*														*	*Semicytherura sulcata* (Mueller, 1894)	
					*	*	*	*						*	*	*				*	*					*	*Urocythereis crenulosa* (Terquem, 1878)	
*			*												*	*					*					*	*Xestoleberis* sp.	
				*	*	*		*					*													*	*Xestoleberis communis* Mueller, 1894	
					*	*															*						*Xestoleberis depressa* Sars, 1866	

Table 7 Distribution of molluscs in all drillings.

		DRILLING HOLES	10MB-201		10MB-203		10MB-204							10MB-205					10MB-206			10MB-207						10MB-208					
		Depth (m)	1	81	16.5	95	2	9.5	13	18	39	65	69	1.5	10	14	18	30	25.5	41	63	1	5	9	13	22	26	1	2	5	9	18	22
GASTROPODA	MEDITERRANEAN	*Gibbula albida* (Gmelin)																					*		*								
GASTROPODA	MEDITERRANEAN	*Gibbula varia* (Linnaeus)																												*			
GASTROPODA	MEDITERRANEAN	*Gibbula* sp.																		*		*			*					*			
GASTROPODA	MEDITERRANEAN	*Tricolia pullus* (Linnaeus)																				*											
GASTROPODA	MEDITERRANEAN	*Omalogyra atomus* (Philippi)														*											*						
GASTROPODA	MEDITERRANEAN	*Caecum trachea* (Montagu)																						*	*			*		*	*		
GASTROPODA	MEDITERRANEAN	*Alvania abbysicola* (Forbes)	*												*																		
GASTROPODA	MEDITERRANEAN	Alvania cime* (Linnaeus)																		*													
GASTROPODA	MEDITERRANEAN	*Alvania* sp.						*						*		*				*			*										
GASTROPODA	MEDITERRANEAN	*Cingula* sp.														*														*			
GASTROPODA	MEDITERRANEAN	*Manzonia crassa* (Kanmacher)																				*											
GASTROPODA	MEDITERRANEAN	*Rissoa marginata* Michaud																				*	*		*						*	*	
GASTROPODA	MEDITERRANEAN	*Rissoa pulchella* Philippi																		*		*		*	*	*		*		*			*
GASTROPODA	MEDITERRANEAN	*Turritella* sp.	*											*										*									
GASTROPODA	MEDITERRANEAN	*Natica rizzae* (Philippi)																		*													
GASTROPODA	MEDITERRANEAN	*Trophon* sp.												*									*										
GASTROPODA	MEDITERRANEAN	*Nassarius* sp.												*						*				*	*								
GASTROPODA	MEDITERRANEAN	*Opalia crenata* (Linnaeus)																							*								
GASTROPODA	MEDITERRANEAN	*Retusa umbilicata* (Montagu)																				*		*				*	*	*		*	
GASTROPODA	MEDITERRANEAN	*Chrysallida obtusa* (Braun)																							*								
GASTROPODA	MEDITERRANEAN	*Turbonilla lactea* Linnaeus												*								*	*		*					*			
GASTROPODA	MEDITERRANEAN	*Creseis virguna* Rang																												*			
GASTROPODA	BLACK SEA	*Pirenella conica* (Blainville)	*											*						*			*	*	*					*			
GASTROPODA	BLACK SEA	*Bittium latreilli* (Payraudeau)		*										*						*		*	*	*	*		*	*		*	*		
GASTROPODA	BLACK SEA	*Chrysalllida indistincta* (Montagu)					*															*		*						*			
GASTROPODA	BLACK SEA	*Odostomia acuta* Jeffreys												*						*		*	*									*	
GASTROPODA	BLACK SEA	*Odostomia* sp.	*		*																			*	*		*						
GASTROPODA	BLACK SEA	*Bythinella pannonica* (Fraunfeld)		*																													
BIVALVIA	MEDITERRANEAN	*Nucula nucleus* (Linnaeus)																										*					
BIVALVIA	MEDITERRANEAN	*Anadara diluvi* (Lamarck)																						*			*						
BIVALVIA	MEDITERRANEAN	*Chlamys glabr* a (Linaaeus)																													*		
BIVALVIA	MEDITERRANEAN	*Lucinella divaricata* (Linnaeus)	*				*								*							*						*	*	*	*		
BIVALVIA	MEDITERRANEAN	Parvicardium e*igium (Gmelin)	*																			*			*			*	*	*	*		
BIVALVIA	MEDITERRANEAN	*Spisula subtruncata* (da Costa)	*																			*			*	*		*					
BIVALVIA	MEDITERRANEAN	*Lentidium mediterranea* da Costa		*				*						*								*	*		*	*		*	*	*	*	*	
BIVALVIA	MEDITERRANEAN	*Timoclea ovata* (Pennant)												*																			
BIVALVIA	MEDITERRANEAN	*Clausinella fasciata* (da Costa)																										*					
BIVALVIA	MEDITERRANEAN	*Clausinella* sp.																				*											
BIVALVIA	MEDITERRANEAN	*Gouldia minima* (Montagu)	*											*								*						*		*	*		
BIVALVIA	BLACK SEA	*Dreissena rostriformis distincta* (Andrussow)			*	*		*	*	*					*	*											*						
BIVALVIA	BLACK SEA	*Dreissena rostriformis pontocaspia* (Andrussow)			*						*			*																			
BIVALVIA	BLACK SEA	*Dreissena rostriformis tschuadae* (Andrussow)			*	*			*	*																							
BIVALVIA	BLACK SEA	*Dreissena* sp.							*			*	*	*			*	*	*		*										*		*
BIVALVIA	BLACK SEA	*Corbula (Varicorbula) gibba* (Olivi)		*										*							*	*						*					

Table 8 Distribution of diatoms in drilling 10MB-203 (ecological characteristics of the identified taxa from studies of Wetzel (1983), Round (1956, 1984), Krammer and Lange-Bertalot (1986a, 1986b, 1988, 1991), Van Dam et al. (1994), Trojanowski et al. (2001), Pala (Toprak) and Çağlar (2006), Round et al. (2007), Taş and Gönülol (2007), Zaim (2007), Sivaci et al. (2007, 2008, 2013), Kistenich et al. (2014), Varol and Şen (2014), URL-1 – 11).

DRILLING NO	Depth (m)	DIATOM SPECIES	ECOLOGICAL FEATURES: Life Style						Salinity				Temperature			Food			pH			Depth		
			Episammic	Epipelic	Epiphytic	Epilitic	Benthic	Planktonic	Brackish	Freshwater	Saltwater	Cosmopolitan	Eutrophic	Mesotrophic	Oligotrophic	Eurysaproph	Mesosaphroph	Oligosaphroph	< 7	7	> 7	Littoral	Pennate	Centric
10MB-203	95	*Actinocyclus normanii* (Gregory ex Graville) Hustedt						*	*	*	*	*	*			*						*		*
		Amphipleura pellucida (Kützing) Kützing		*		*	*	*	*	*	*	*		*	*		*				*	*	*	
		Cocconeis disculus Krammer and Lange-Bertalot		*	*	*				*		*											*	
		Diploneis elliptica (Kützing) Cleve	*	*	*				*	*	*	*											*	
		Diploneis parma Cleve			*								*	*	*	*			*		*		*	
		Fragilaria sp.,								*					*			*	*				*	
		Stenopterobia sigmatella (Gregory)		*			*			*													*	
		Stephanodiscus aegyptiacus Ehrenberg				*																		*
		Stephanodiscus alpinus Hustedt						*				*			*	*		*			*			*
		Stephanodiscus lucens Hustedt				*		*					*			*								*
		Stephanodiscus medius Hakanson						*					*			*								*
		Stephanodiscus niagarae Ehrenberg						*		*												*		*
	140	*Amphipleura pellucida* (Kützing) Kützing		*		*	*		*	*	*	*		*	*		*				*	*	*	
	143.5	*Amphora libyca* Ehrenberg						*	*	*	*												*	
		Cyclotella comensis Grunow		*	*	*	*	*		*			*		*	*		*			*			*
		Diploneis parma Cleve					*																*	
		Epithemia turgida var westermannii (Ehrenberg) Grunow								*													*	
		Fragilaria lancettula Schumann										*											*	
		Stephanodiscus lucens Hustedt				*		*					*			*								*

According to the global sea level curve (Chappell and Shackleton, 1986) and the data from the Ponto-Caspian basins (e.g., Sorokin, 2011; Yanina, 2014), there was a Mediterranean inflow into the Black Sea during MIS-5. The Çanakkale Strait was subaerially exposed at the peak of glacial oxygen isotopic stage 6 (Pleistocene), causing the Marmara Sea to become a lake. Even the low presence of marine elements and abundance of Ponto-Caspian ostracods together with fresh water and cosmopolitan diatom flora in our samples that the shallow water areas were still invaded by brackish waters.

Pleistocene / MIS-3 Interval

The sediments deposited during MIS-3 were observed in both northern and southern drillings (10MB-201, 203, 204, 205, 206 and 207; Fig. 22). The ostracods have three main assemblages consisting of Ponto-Caspian ostracods, Mediterranean ostracods and Ponto-Caspian and Mediterranean mixed fauna. The OSL numerical ages were obtained as 54.4 ky at 94 m of 10MB-201 and 38.2 ky at 74 m. In this age range, faunal groups (foraminifera, ostracod and mollusc) reflecting the Mediterranean influence was found. The older sediments at 108 m and 104 m and younger sediments at 70 m are barren of foraminifera and totally dominated by Ponto-Caspian ostracods, such as *Candona parallela pannonica*, *Trapezicandona* sp. sensu Schornikov et Syrtlanova, 2008, *Camptocypria acronasuta*, *Pseudocandona* sp., *Amnicythere hilda*, *A. olivia*, *A. reticulata*, *Euxinocythere (Maetocythere) lopatici* and *Loxoconcha immodulata*. Mediterranean influence is most noticeable at 81 m, where a rich and diverse foraminiferal fauna, mixed ostracods dominated by Mediterranean originated species (e.g., *Carinocythereis carinata*, *Carinocythereis rhombica*, *Pontocythere turbida*, *Cytheridea acuminata*, *Leptocythere bacescoi*, *L. bituberculata*, *Palmoconcha agilis*, *Semicytherura punctata* and *Xestoleberis* sp.) and Mediterranean originated bivalvia (*Lentidium mediterranea*) were recorded. Foraminifera fauna is represented by high numbers of *B. aculeata*, *Bo. ordinaria*, *Au. perlucida*, *B. marginata*, *B. elongata*, *A. tepida* and *N. turgidus*, reflecting marine influence. Ostracod fauna at 74 m consists entirely of Ponto Caspian species (*Caspiolla acronasuta*, *Pseudocandona* sp., *Bacunella dorsoarcuta*, *Amnicythere quinquetuberculata*, *A. reticulata*, *Euxinocythere relicta*, *Euxinocythere (Maetocythere) lopatici*, *Loxoconcha immodulata* and *Cytherissa bogatschovi*). The foraminiferal fauna its low density and species richness is mainly represented by *Haynesina*,

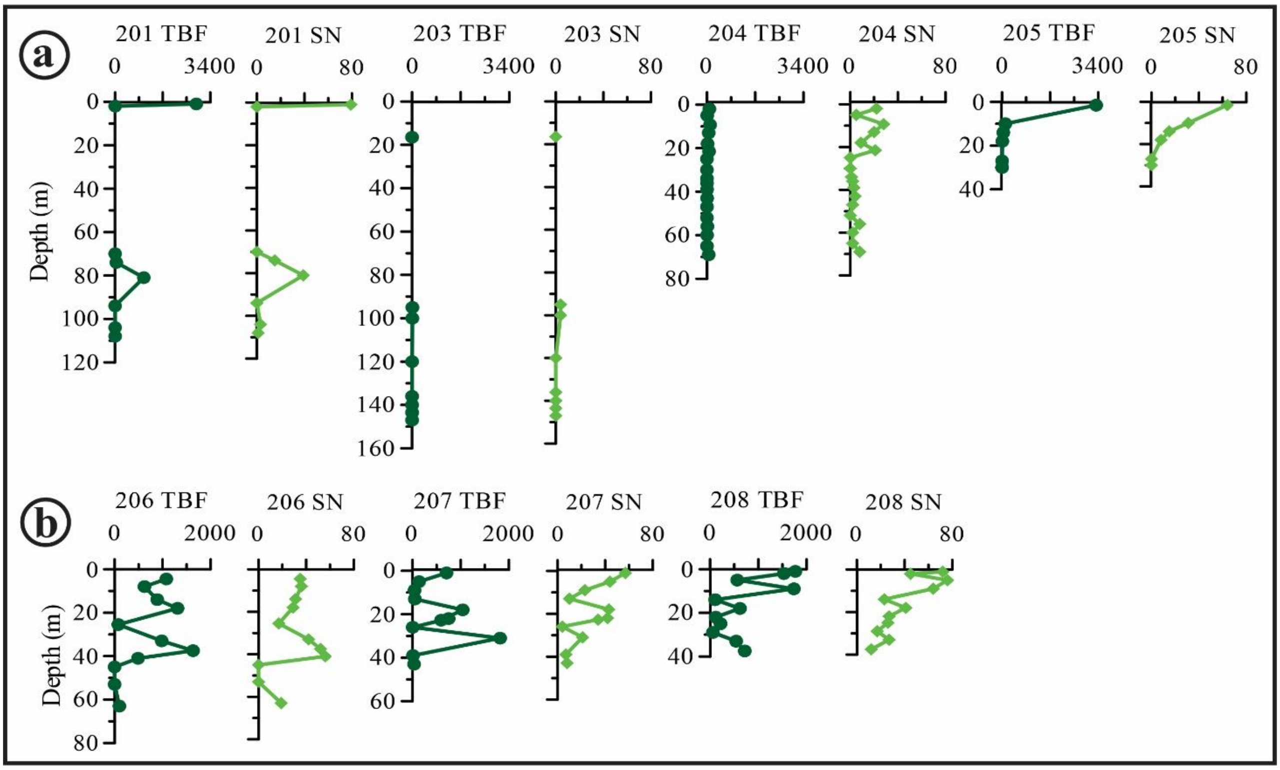

Fig. 10 Total Benthic Foraminifera (TBF) and Species Number (SN) in drillings **a.** Dilovası and **b.** Hersek Burnu. TBF indicates numbers of specimens per 10 g dry sediment. The lower intervals of drillings 10MB-204 (120-80 m), 10MB-205 (117.2-40 m), 10MB-206 (122-80 m), 10MB-207 (120.9-50 m) and 10MB-208 (200-40 m) are not shown due to absence of sample.

Elphidium and *Ammonia* which tolerates a wide range of euryhaline conditions (Murray, 1973 1991; Hayward et al., 1999). These findings are comparable with the faunal characteristics at 100 m and 95 m of 10MB-203. In addition, fresh water and cosmopolitan diatom flora (*Actinocyclus normanii*, *Amphipleura pellucida*, *Cocconeis disculus*, *Diploneis elliptica*, *Fragilaria* sp., *Stenopterobia sigmatella*, *Stephanodiscus alpinus*, and *S. niagarae*) occur at 95 m of 10MB-203.

Radiocarbon ages yielded >46.0 ky at both 18th m of drilling 10MB-204 and 14th m of 10MB-205 and at two different ages as 49.0 and 43.2 ky at 10th m of 10MB-205. In adition to the radiocarbon ages, OSL age is 28.5 ky at 56th m of 10MB-204. This age difference may be due to the transitions and transportations between clastic sedimentary layers, as well as the fact that the quartz samples used in all OSL measurements are based on the assumption that the fading (when exposed to light) properties are the same. Domination of Ponto-Caspian ostracods (*Candona parallela pannonica*, *C. schweyeri*, *Caspiolla acronasuta*, *Bacunella dorsoarcuta*, *Amnicythere bendovanica*, *A. hilda*, *A. olivia*, *A. pediformis*, *A. striatacostata*, *Euxinocythere (Maetocythere) lopatici*, *Euxinocythere bacuana*, *E. relicta*, *Tyrrenocythere amnicola donetziensis*, *Loxoconcha immodulata*, *Loxocaspia lepida*, *Xestoleberis chanakovi* and *Cytherissa bogatschovi*) and bivalvia (*Dreissena rostriformis distincta*, *D. rostriformis pontocaspia*, *D. rostriformis tschuadae* and *Dreissena* sp.) at lower parts of the both the drillings are related to the presence of Black Sea water body in the area. The occurrences of some normal marine and euryhaline benthic foraminiferal species at 69 m and 56 m of 10MB-204 and 14 m of 10MB-205 (e.g., *Bo. dilatata*, *Bo. ordinaria*, *Bo. spathulata*, *Bo. striatula*, *Bolivina* sp., *C. carinata*, *F. complanata*, *H. depressula*, *E. macellum*, *E. pulvereum*, *A. compacta*, *A. parkinsoniana*, *A. tepida*, *As. mamilla*, *Au. perlucida*, *D. bertheloti*, and *Valvulineria* sp.) may be associated with the fluctuations of water salinity resulted from the Mediterranean inflows. Ponto-Caspian and Mediterranean originated mixed ostracods together with foraminifera at 13 m and 9.3 m of 10MB-204 and 10 m of 10MB-205 indicate the increasing Mediterranean inflows.

When considering the radiocarbon and OSL dates from the southern drillings, it is noteworthy that the ages are clearly concentrated in the time interval between 40.0 - 52.0 ky BP. In this time interval, Ponto-Caspian ostracods and bivalves are represented by *Candona parallela pannonica*, *Amnicythere hilda*, *A. olivia*, *A. postbissinuata*, *A. quinquetuberculata*, *Euxinocythere (Maetocythere) lopatici*, *E. bacuana*, *T.e amnicola donetziensis*, *L. immodulata*, *Loxoconcha* sp 1 sensu Boomer, 2010, *Cytherissa bogatschovi*, *Bacuniella dorsoarcuta*, *Loxocaspia lepida* and *Dreissena* sp., *Corbula (Varicorbula) gibba*, respectively. Aditionally, low numbers and and poorly diverse foraminifera (e.g., *Bo. dilatata, Bo. spathulata, C. carinata, H. depressula, B. aculeata, Bo. ordinaria, Au. perlucida, Ammonia* spp. and *Elphidium* spp.) occur at some levels. At the interval

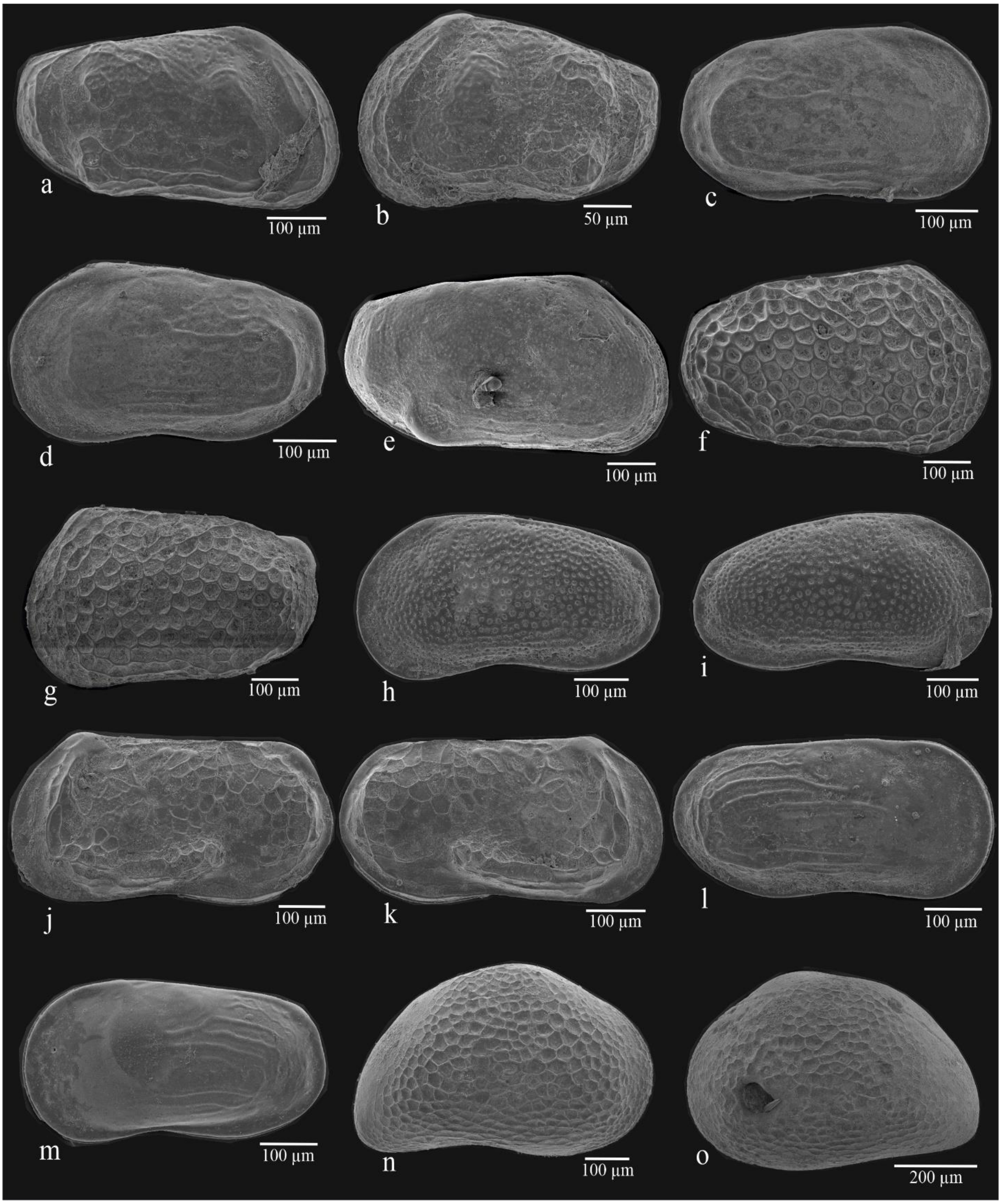

Fig. 11 Scanning electron micrographs of selected Ponto-Caspian origin ostracod species identified from the İzmit Gulf drilling cores. **a-b.** *Amnicythere bendovanica*; **a** right valve, 204/9.3 m, **b** left valve, 204/13 m; **c-d.** *Amnicythere hilda*; **c** right valve, **d** left valve, 204/56 m; **e.** *Amnicythere longa*; right valve, 204/9.3 m; **f-g.** *Amnicythere olivia*; **f** right valve, **g** left valve, 204/34 m; **h-i.** *Amnicythere pediformis*; **h** left valve, **i** right valve, 204/13 m; **j-k**. *Amnicythere quinquetuberculata*; **j** left valve, **k** right valve, 206/63 m; **l-m.** *Amnicythere striatacostata*; **l** right valve, 204/34 m; **m** left valve, 204/18 m; **n-o.** *Bacunella dorsoarcuata*; **n** right valve, **o** left valve 204/43 m.

Fig. 12 Scanning electron micrographs of selected Ponto-Caspian origin ostracod species identified from the İzmit Gulf drilling cores. **a-b.** *Camptocypria acronasuta*; **a** right valve, internal view, **b** right valve, 201/104 m; **c.** *Candona neglecta*; right valve, 204/9.3 m; **d.** *Candona parallela pannonica*; left valve, 204/9.3 m; **e-f.** *Candona schweyeri*; **e** left valve, 204/34 m, **f** right valve, internal view, 204/18 m; **g-h.** *Cryptocyprideis bogatschovi*; **g** left valve, **h** right valve, 204/43 m; **i-j.** *Euxinocythere bacuana*; **i** left valve, 203/95 m, **j** right valve, 206/63 m; **k-l.** *Euxinocythere bosqueti*; **k** right valve, 204/36 m, **l** right valve, 203/143.5 m; **m-n.** *Euxinocythere* ex gr. *bosqueti*; **m** left valve, 203/143.5 m; **n** left valve; **o-p.** *Euxinocythere relicta*; **o** left valve, **p** right valve, 201/74 m, 10 m; **q-r.** *Hemicytherura bulgarica*; **q** left valve, male 208/14 m, **r** right valve, female, 201/1 m.

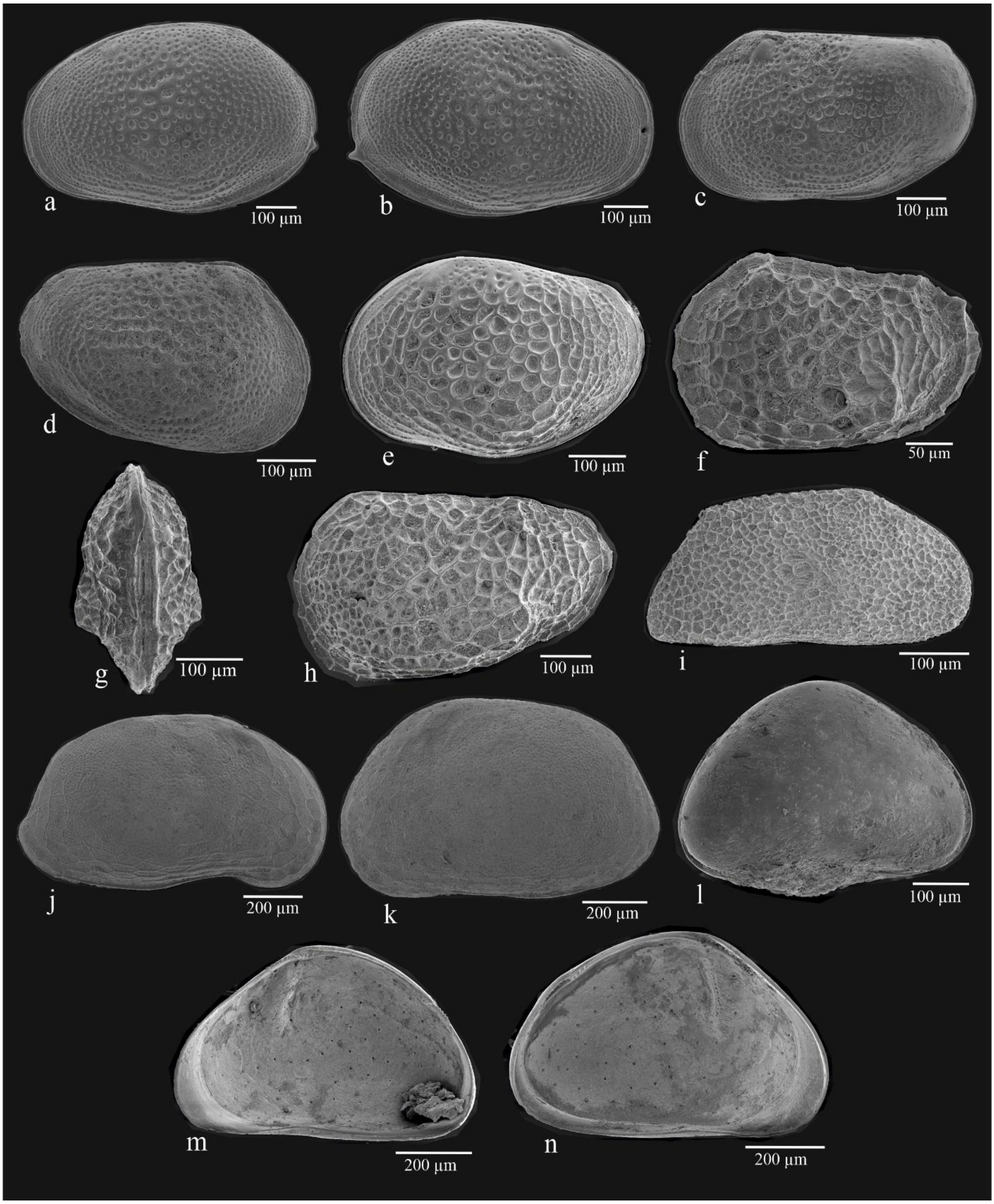

Fig. 13 Scanning electron micrographs of selected Ponto-Caspian origin ostracod species identified from the İzmit Gulf drilling cores. **a-b.** *Loxocaspia lepida*; **a** left valve, **b** right valve, 204/9.3 m; **c-d.** *Loxoconcha immodulata*; **c** left valve, male, **d** left valve, female, 204/9.3 m; **e.** *Loxoconcha* sp.; left valve, 206/63 m; **f-h.** *Loxocorniculina djaffarovi*; **f** left valve, 207/22.75 m, **g** dorsal view, 207/22.75 m, **h** left valve, 206/8 m; **i.** *Trapezicandona* sp.; right valve, 201/108 m; **j-k.** *Tyrrhenoythere amnicola donetziensis*; **j** right valve, **k** left valve, 204/9.3 m; **l-n.** *Xestoleberis chanakovi*; **l** right valve, 203/143.5 m; **m** right valve, internal view, 203/147 m; **n** left valve, internal view, 203/147 m.

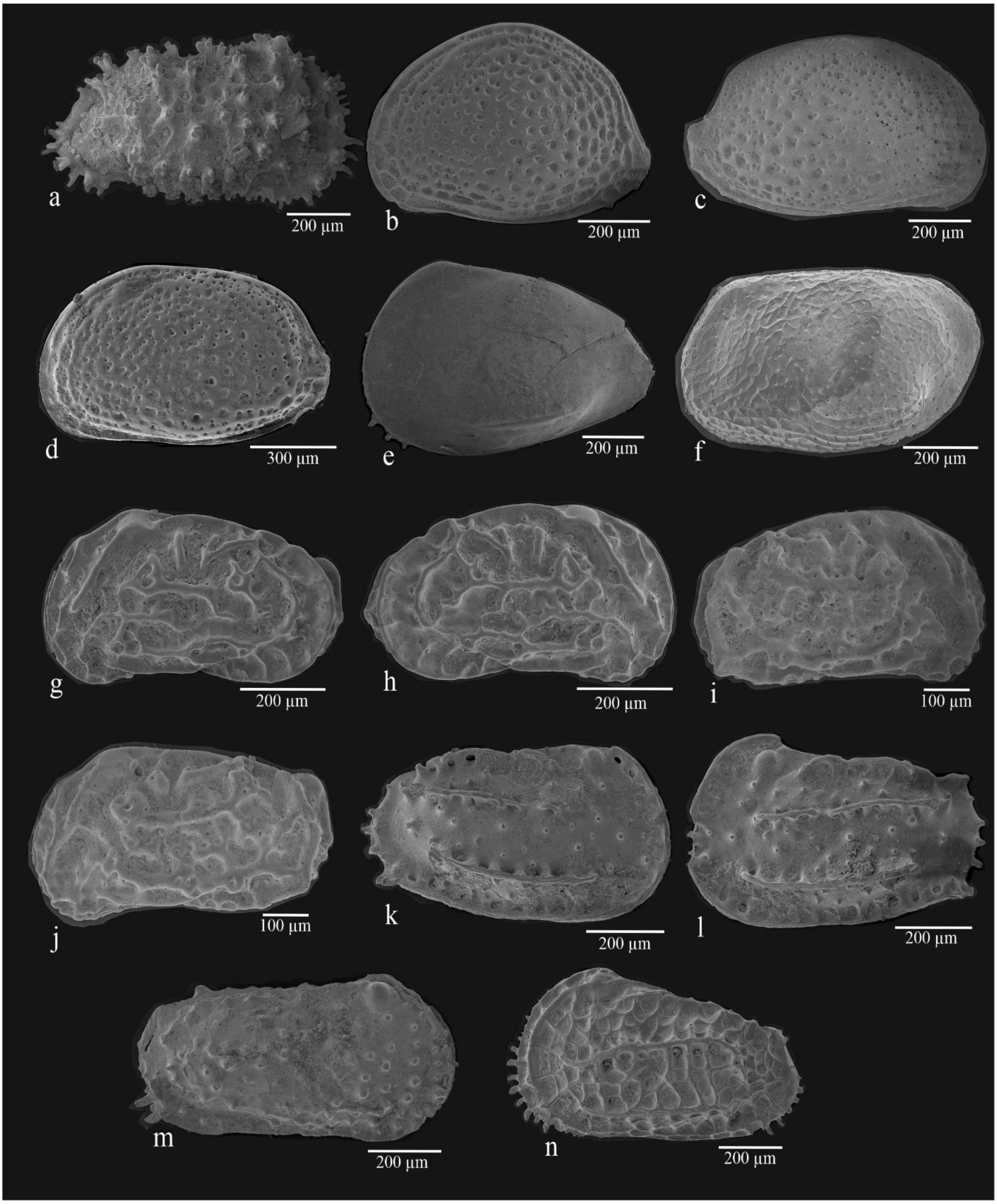

Fig. 14 Scanning electron micrographs of selected Mediterranean origin ostracod species identified from the İzmit Gulf drilling cores. **a.** *Acanthocythereis hystrix*; right valve, 205/1.5 m; **b-c.** *Aurila convexa*; **b** left valve, 205/1.5 m, **c** right valve, 208/5 m; **d.** *Aurila interpretis*; left valve, 205/1.5 m; **e.** *Bosquetina carinella*; left valve, 206/33 m; **f.** *Bythocythere minima*; left valve, 201/1 m; **g-h.** *Callistocythere intricatoides*; **g** left valve, **h** right valve, 206/37.5 m; **i-j.** *Callistocythere pallida*; **i** right valve, **j** left valve, 208/5 m; **k-l.** *Carinocythereis carinata*; **k** right valve, **l** left valve, 206/37.5 m; **m.** *Carinocythereis rhombica*; right valve, 206/4.5 m; **n.** *Costa edwardsii*; left valve, 206/37.5 m.

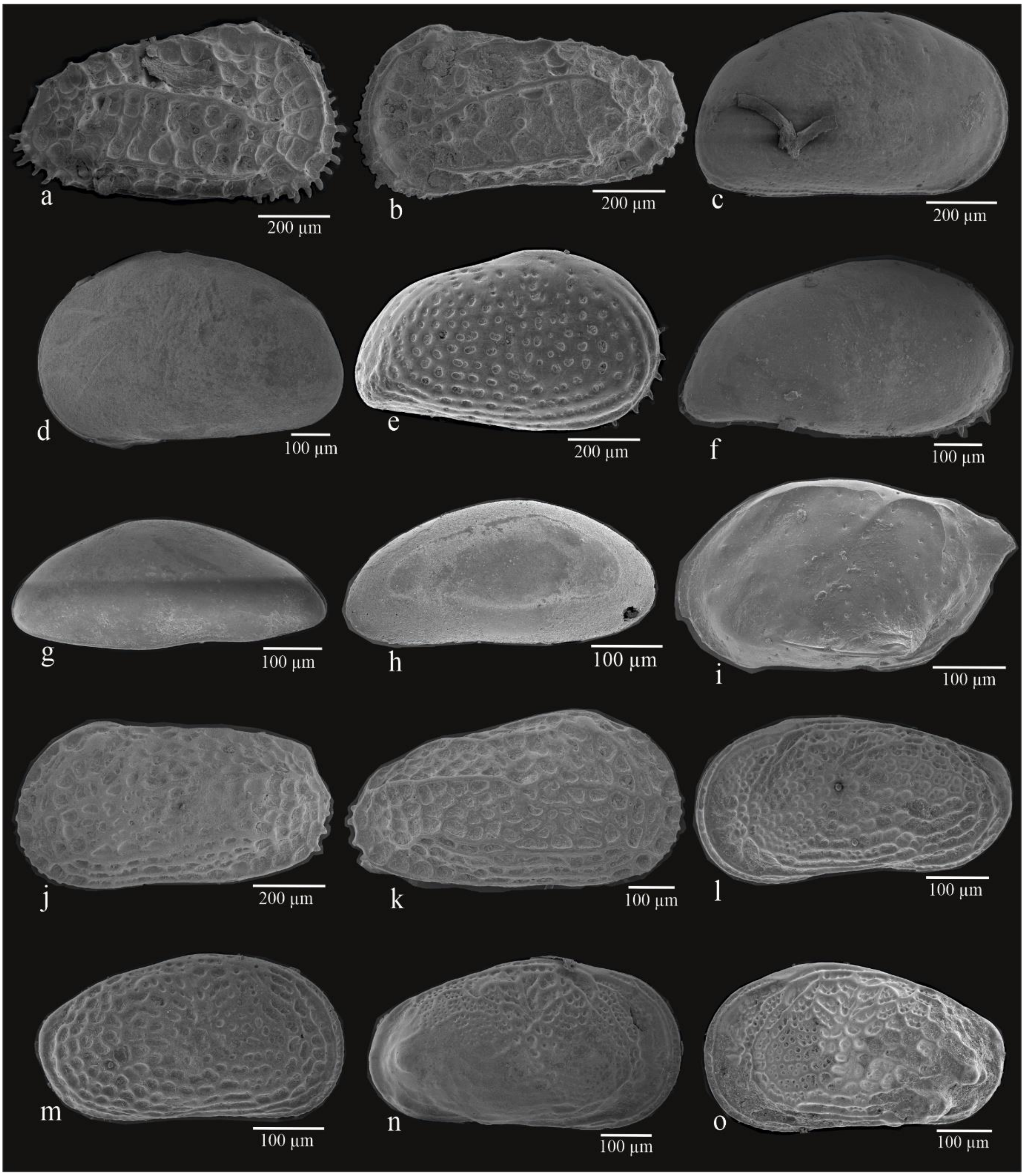

Fig. 15 Scanning electron micrographs of selected Mediterranean origin ostracod species identified from the İzmit Gulf drilling cores. **a.** *Costa edwardsii*; right valve, 206/37.5 m; **b**. *Costa tricostata*; left valve, 205/1.5 m; **c-d.** *Cyprideis torosa*; **c** right valve, 206/37.5 m, **d** left valve, 208/9 m; **e-f**. *Cytheridea acuminata*; e right valve, 208/33 m, **f** right valve, 207/18 m; **g-h**. *Cytherois* sp.; **g** right valve, 205/1.5 m. **h**. left valve, 201/1 m; **i**. *Cytheropteron rotundatum*, left valve, 201/1 m; **j-k**. *Hiltermanicythere rubra*; **j** left valve, 208/1 m; **k** right valve, 208/1 m; **l-m**. *Leptocythere bacescoi*, l left valve, **m** right valve, 206/33 m; **n-o**. *Leptocythere bituberculata*; **n** right valve, 206/37.5 m, **o** left valve, 207/18 m.

comprised between ca. 50.0 ky and 48.0 ky BP, the Mediterranean ostracods consisting of *Callistocythere pallida*, *Carinocythereis carinata*, *C. rhombica*, *Costa edwardsii*, *Cushmanidea elongata*, *Pontocythere turbida*, *Cytherois* sp., *Hiltermannicythere rubra*, *H. turbida*, *Leptocythere bacescoi*, *L. bituberculata*, *Loxoconcha gibberosa*, *Microcytherura nigrescens*, *Neonesidea frequens*, *Palmoconcha agilis*, *Paracytheridea parallia*, *Pseudocytherura calcarata*, *Pterygocythereis jonesii*, *Sagmatocythere versicolor*, *Semicytherura inversa*, *S. paradoxa*, *S. punctata*, *Urocythereis crenulasa* and *Xestoleberis* sp. and a rich and diverse benthic foraminifera microfauna represented by the dominance of *Elphidium* and *Ammonia* genera together with subordinately numbers of *B. aculeata, C. carinata, H. depressula, Bo. dilatata* and *As. mamilla* are steadially recorded.

When all fossil findings are evaluated at early parts of MIS-3 (ca. 52.0 - 40.0 ky BP), the Marmara Sea and the Izmit Gulf as part of the Marmara Sea are connected to the Black Sea and the Mediterranean Sea. This connection is supported by global sea level curve of Chappell and Shackleton (1986) and the Surozhian transgression in the Black Sea, where the water level rises from -100 to -25 m (Sorokin, 2011; Yanina, 2014). MIS-3 is an interstadial period between MIS-4 and MIS-2 glacial epochs and corresponds to regional Surozh transgression in the Black Sea and Early Khvalnian transgression in the Caspian Sea (Yanina, 2014). Faunal and floral data from the İznik Lake indicate that there was a connection with the Black Sea during the Surozhian period (30 ky-24 ky BP; Meriç et al., 2018). The incursion of the Mediterranean waters in the İzmit Gulf is stated by Meriç et al. (1995) based on the foraminifera fauna and numerical Electron Spin Resonance (ESR) ages in the time interval equivalent to MIS-3. Aksu et al. (2002) suggested that the deposition of M2 sapropel layer between 29.5 ky and 23.5 ky is associated with the two-layered water stratification indicating high sea level above the sill depth of the Çanakkale and İstanbul straits. The age findings obtained from the marine sediments in the south of Izmit Gulf is 36.0 ky (Çağatay et al., 2003). On the other hand, Çağatay et al. (2015) reported that there was no connection between the Marmara Sea and Mediterranean Sea from early MIS-4 to early MIS-1 or there could be a weak Mediterranean inflow limited to the deeper parts of the Marmara basin during MIS-3. Our data clearly denotes that the Izmit Gulf was connected with the Black Sea and the Mediterranean Sea at the beginning of MIS-3 and the shallow shelf areas were frequently affected by both fresh water discharges from the Black Sea and the marine inputs from the Mediterranean Sea.

Holocene / MIS-1 Interval

During MIS-2, Marmara Sea was completely isolated from the Mediterranean Sea and it is known that lacustrine environmental conditions were gone in Marmara Sea until ca. 12 ky BP (e.g., Stanley and Blanpied, 1980; Çağatay et al., 2000; Aksu et al., 2002; Yaltırak et al., 2002; Kırcı-Elmas et al., 2008; McHugh et al., 2008). Its permanent two-layered water structure, where the upper layer originated from the Black Sea and the lower layer formed from the Mediterranean Sea, has established during Holocene. A thin (2 m) Holocene sediment drape occurs in the northern Dilovası drillings, whereas a thick (35 m) Holocene sedimentary sequence is retrieved from the southern Hersek Burnu drillings. Radiocarbon dates provided as 9.2 ky at 31 m of 10MB-207, 8.4 ky at 18 m of 10MB-206 and 6.6 ky at 14 m of 10MB-208. OSL date is 6.2 ky at 8 m of 10MB-206 (Table 2). MIS-1 interval has the most diverse benthic foraminifera microfauna and the highest number of TBF. Three main benthic foraminiferal assemblages are defined within the Holocene sediments reflecting the variations in the water level. The first assemblage is dominated by *Au. perlucida*, *A. tepida* and *Ammonia* spp. and is recorded in the Early Holocene sediments from the base of 10MB-207 and 208. The second assemblage composed mainly of *Bo. ordinaria*, *Bolivina* spp., *B. aculeata*, *Bulimina* spp., *N. turgidus* and *A. tepida*. This relatively deeper assemblage occurs between 18 - 4.5 m of 10MB-206, 22.75 - 18 m of 10MB-207, 33 - 18 m of 10MB-208. *Ammonia* and *Elphidium* characterizes the third assemblage and is represented at the upper parts of 10MB-207 and 208. The assemblage compositions show similarity with the recent benthic foraminifera microfauna in the shelf areas of the Marmara Sea (Phipps et al., 2010; Kırcı-Elmas, 2013). In recent sediments of the Marmara Sea, *Ammonia* and *Elphidium* are commonly recorded at water depths >35 m and their distribution is associated with riverine organic-matter input, hydro-sedimentary processes, and the Black Sea surface inflow (Kırcı-Elmas, 2013). The *Bulimina aculeata - Bolivina ordinaria* (as *Bolivina variabilis* in Kırcı-Elmas (2013) assemblage, distributed between 28 - 50 m depths is influenced by the inflow of vertically mixed Black Sea waters. *Au. perlucida* has the highest abundance at 25 m, close to the mouth of Biga River, and is reported from slightly brackish and normal marine salinity shallow inner-shelf environments (Hayward et al., 1999). The studied ostracod and mollusc assemblages are characterized by the Mediterranean originated species. Although some Ponto-Caspian ostracods and molluscs species also appear, their occurrences in the Holocene sediments are sporadic and limited only within the Early-Middle Holocene. Absence or rare occurrences of the Ponto-Caspian ostracods, which are still living in the Azov Sea and the Caspian Sea, show that the water salinity in the Marmara Sea is no longer suitable for this community.

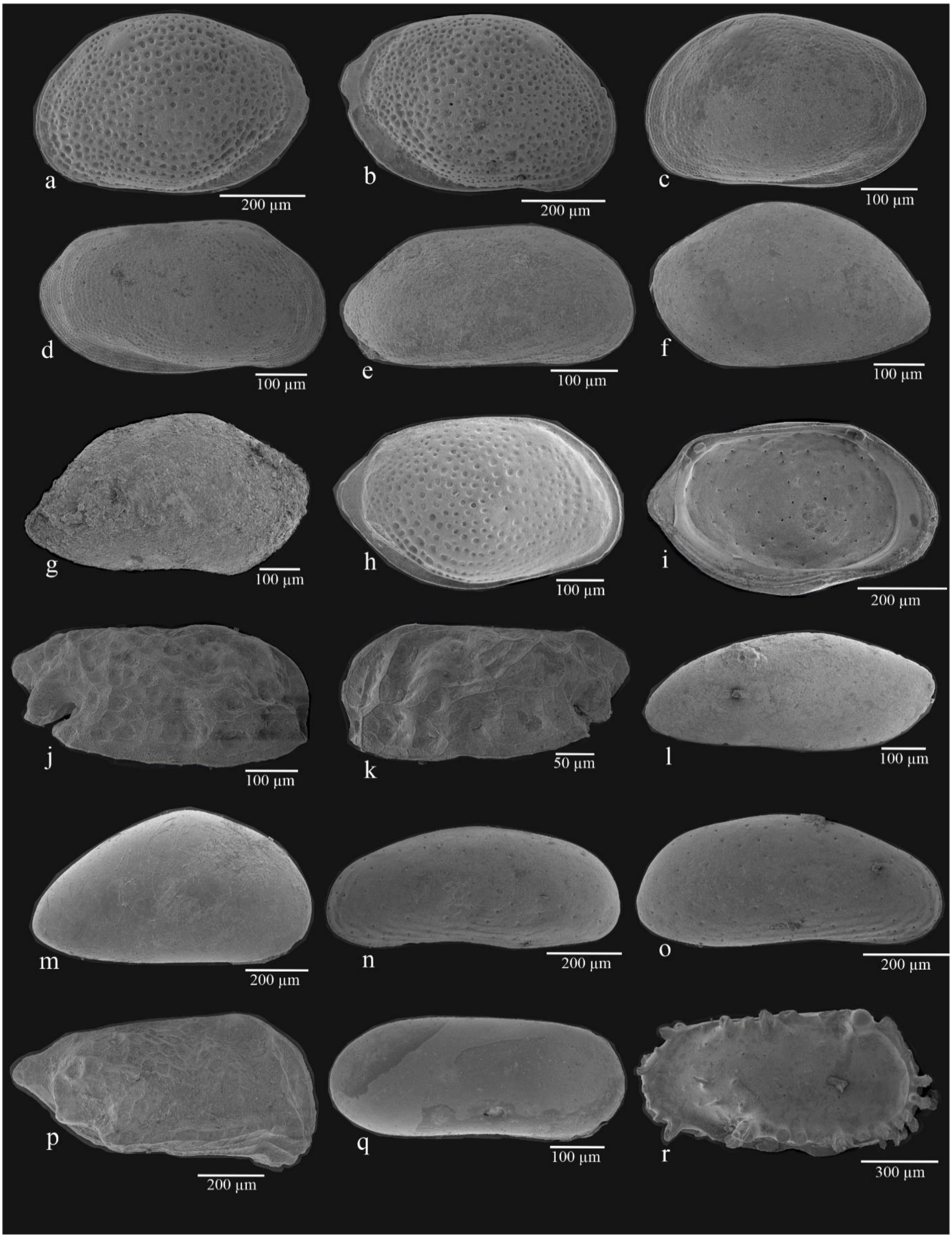

Fig. 16 Scanning electron micrographs of selected Mediterranean origin ostracod species identified from the İzmit Gulf drilling cores. **a-b.** *Loxoconcha gibberosa*; **a** left valve, **b** right valve, 206/33 m; **c-d.** *Loxoconcha minima*; **c** left valve, **d** right valve, 203/100 m; **e.** *Microcytherura nigrescens*; right valve, 208/2 m; **f.** *Neonesidea frequens*; left valve, 205/1.5 m; **g.** *Neonesidea inflata*; right valve, 205/10m; **h-i.** *Palmaconcha agilis*; **h** right valve, 206/33 m, **i** left valve internal view, 201/70 m; **j-k.** *Paracytherida parallia*; **j** right valve, 206/33 m, **k** left valve, 206/4.5 m; **l.** *Paradoxostoma trieste*, left valve, 201/1 m; **m.** *Pontocypris rara*; right valve, 201/1 m; **n-o.** *Pontocythere turbida*; **n** left valve, **o** right valve, 206/37.5 m; **p.** *Pseudocytherura calcarata*, right valve, 208/2 m; **q.** *Pseudopsammocythere reniformis*, right valve, 205/1.5 m; **r.** *Pterygocythereis jonesii*, right valve, 206/37.5 m.

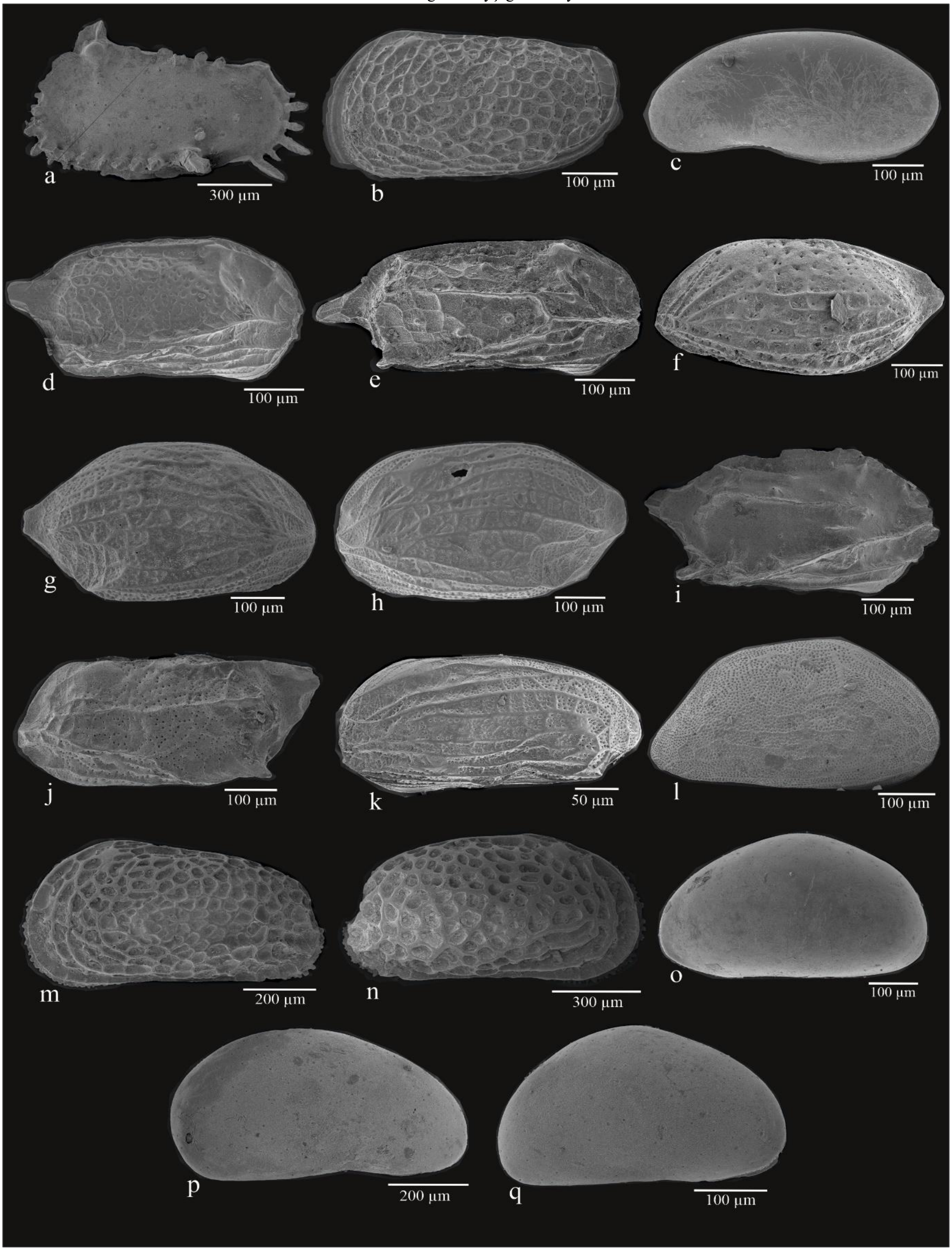

Fig. 17 Scanning electron micrographs of selected Mediterranean origin ostracod species identified from the İzmit Gulf drilling cores. **a.** *Pterygocythereis jonesii*; left valve, 208/2 m; **b.** *Sagmatocythere versicolor*; left valve, 206/33 m; **c.** S*clerochilus contortus*; left valve, 208/14 m; **d.** *Semicytherura alifera*; right valve, 201/1 m; **e.** *Semicytherura diafora*; right valve, 208/18 m; **f.** *Semicytherura incongruens*; left valve, 208/2 m**; g-h**. *Semicytherura inversa*; g right valve, 208/9 m, h left valve, 208/5 m; **i.** *Semicytherura paradoxa*; right valve, 206/37.5 m; **j.** *Semicytherura punctata*; left valve, 206/37.5m; **k.** *Semicytherura sulcata*; left valve, 203/100 m; **l**. *Tetracytherura irregularis*; right valve, 205/1.5 m; **m-n**. *Urocythereis crenulosa*; m left valve, n right valve, 206/33 m; **o-p.** *Xestoleberis depressa*; p left valve, q right valve, 206/33 m**; r.** *Xestoleberis communis*; right valve, 206/4.5 m.

Fig. 18 Photographs of selected gastropod species identified from the İzmit Gulf drillings. **a1, a2.** *Gibbula albida*, height: 2 mm, 207/5 m. **b1, b2.** *Gibbula varia*, height: 1 mm, 208/5 m. **c1, c2.** *Gibbula* sp., height: 3.5 mm, 208/5 m. **d1, d2.** *Tricolia pullus*, height: 2 mm, 207/1 m. **e1, e2.** *Omalogyra atomus*, height: 1 mm, 205/14 m. **f1, f2.** *Caecum trachea*, height: 2 mm, 207/13 m. **g1, g2.** *Alvania abbysicola*, height: 2 mm, 205/10 m. **h1, h2.** *Alvania cimex*, height: 2 mm, 206/41 m. **i1, i2.** *Alvania* sp., height: 1 mm, 206/41 m. **j1, j2.** *Cingula* sp., height: 3 mm, 205/14 m. **k1, k2.** *Monzonia crassa*, height: 3 mm, 207/1 m. **l1, l2**. *Rissoa marginata*, height: 5 mm, 207/13 m. **m1, m2.** *Rissoa pulchella*, height: 2.5 mm, 207/13 m. **n1, n2**. *Turritella* sp., height: 1.5 mm, 207/9 m. **o1, o2.** *Pirenella conica*, height: 3.5mm, 205/1.5 m. **p1, p2.** *Bittium latreilli*, height: 2mm, 207/13 m. **q1, q2.** *Natica rizzae*, height: 5 mm, 206/41 m. **r1, r2.** *Trophon* sp., height: 2mm, 207/5 m.

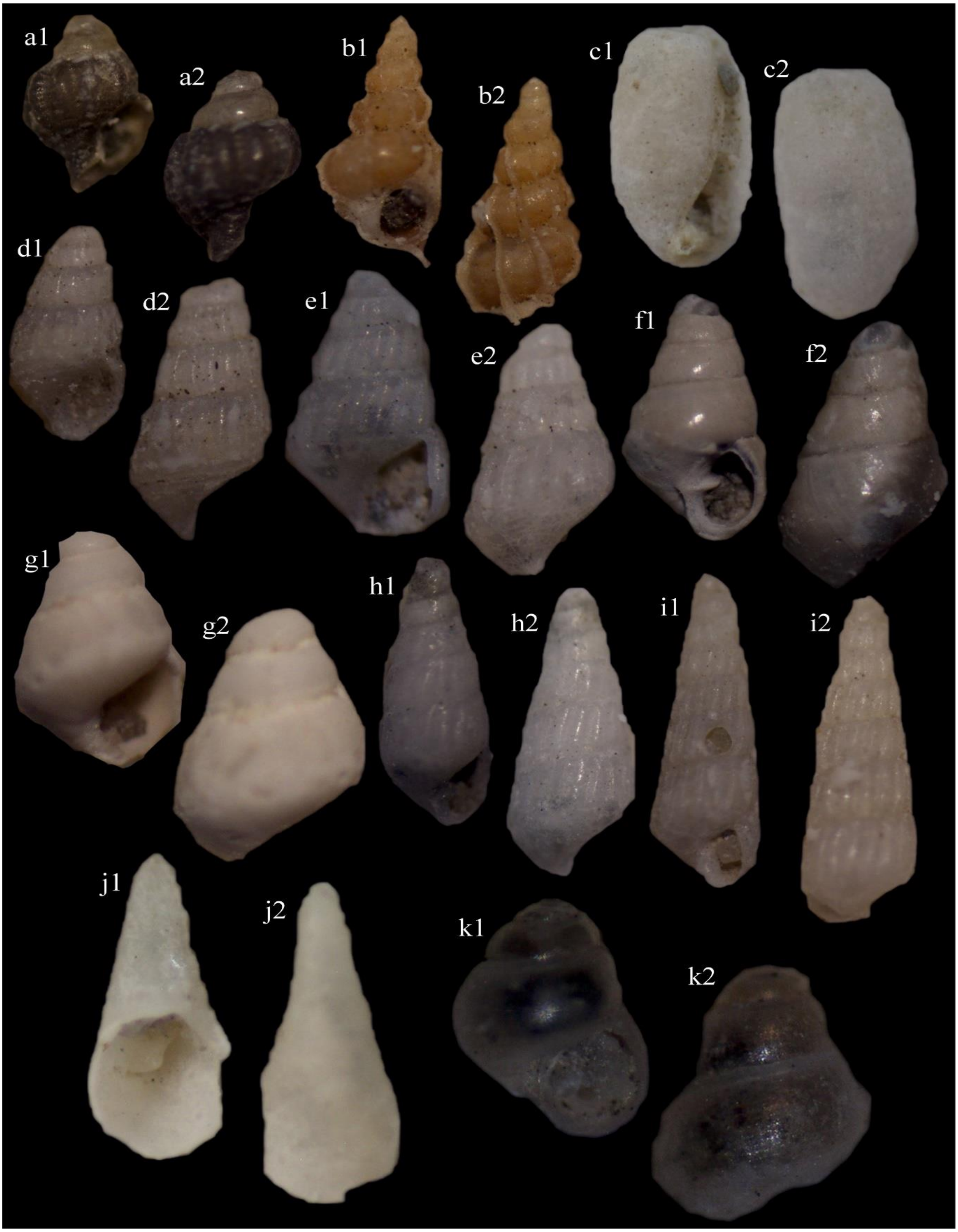

Fig. 19 Photographs of selected gastropod species identified from the İzmit Gulf drillings. **a1, a2.** *Nassarius* sp., height: 1.5 mm, 207/13m. **b1, b2.** *Opalia crenata*, height: 2.5 mm, 207/13 m. **c1, c2.** *Retusa umbilicata*, height: 2.5 mm, 207/9 m. **d1, d2.** *Chrysallida indistincta*, height: 1 mm, 207/9 m. **e1, e2**. *Chrysallida obtusa*, height: 1.5 mm, 207/13 m. **f1, f2.** *Odostomia acuta*, height: 1.5 mm, 206/41m. **g1, g2.** *Odostomia* sp., height: 1mm, 207/26 m. **h1-h2, i1-i2**. *Turbonilla lactea*, height: 2 mm, 207/13 m. and hight: 2.5 mm, 208/5 m. **j1, j2.** *Creseis virgua*, height: 1 mm, 208/5m. **k1, k2.** *Bythinella pannonica*, height: 2 mm, 201/81 m.

Fig. 20 Photographs of selected bivalvia species identified from the İzmit Gulf drillings. **a1, a2.** *Nucula nucleus*, height: 5 mm, 208/1 m. **b1, b2.** *Anadara diluvi*, height: 2 mm, 207/9 m. **c1, c2.** *Chlamys glabra*, height: 2 mm, 208/9 m. **d1, d2.** *Lucinella divaricata*, height: 1.5 mm, 208/5 m. **e1, e2**. *Dreissena rostriformis distincta*, height: 4 mm, 207/26 m. **f1, f2.** *Dreissena rostriformis tschaudae*, height: 3mm, 204/13 m. **g1, g2.** *Parvicardium exiguum*, height: 2 mm, 201/1 m. **h1, h2**. *Spisula subtruncata*, height: 7 mm, 207/1 m. **i1, i2**. *Lentidium mediterraneum*, height: 3mm, 208/9 m. **j1, j2.** *Timoclea ovata*, height: 6 mm, 205/1.5 m. **k1, k2.** *Clausinella fascita*, height: 3 mm, 208/1 m. **l1, l2.** *Clausinella* sp., height: 2 mm, 207/1 m. **m1, m2**. *Gouldia minima*, height: 2 mm, 208/5 m. **n1, n2.** *Corbula gibba*, height: 4 mm, 207/1 m.

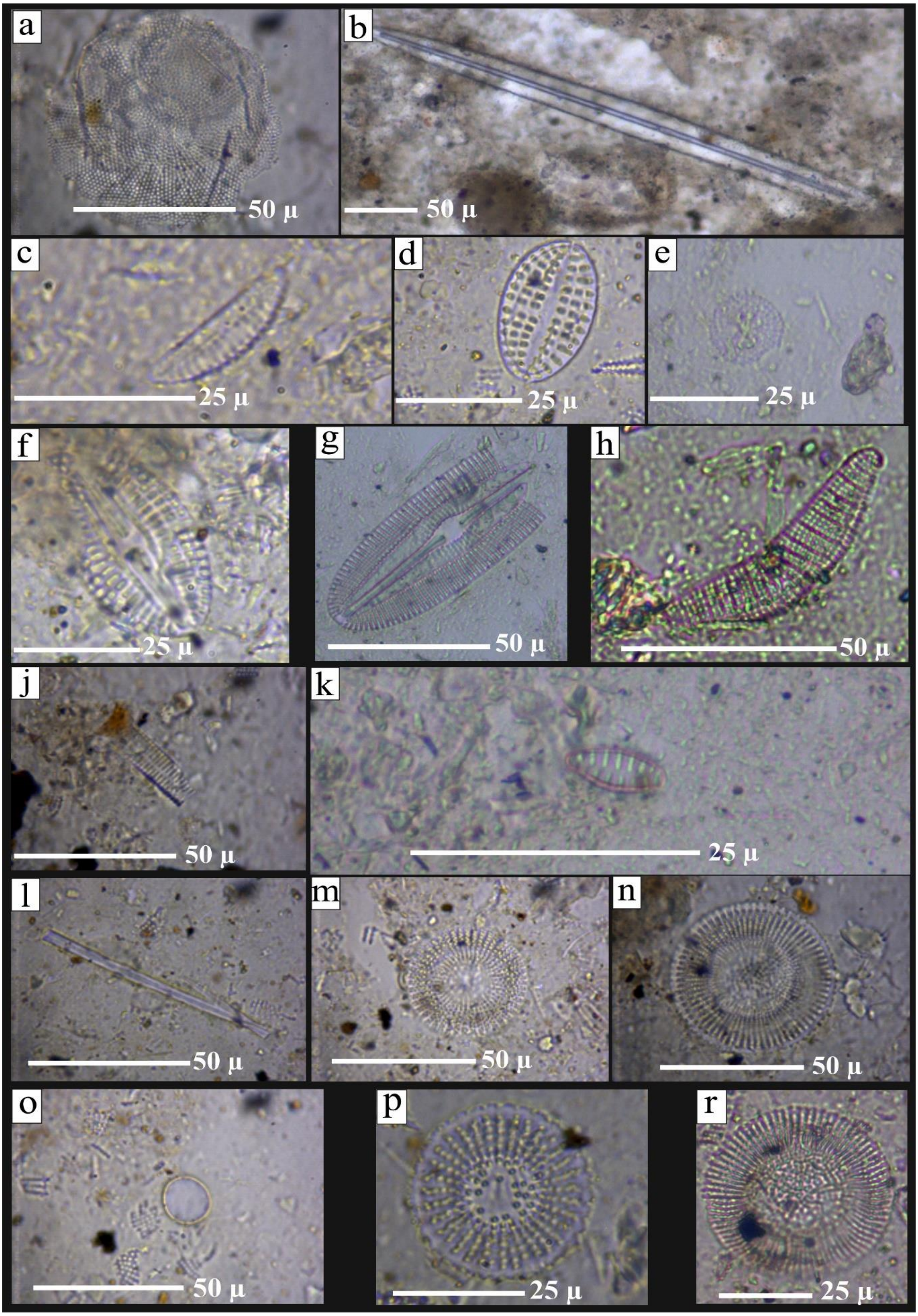

Fig. 21 Microphotographs of diatom taxa identified from drilling 10MB-203. **a.** *Actinocyclus normanii*, 95 m. **b.** *Amphipleura pellucida*, 95 m. **c.** *Amphora libyca*, 143.5 m. **d.** *Cocconeis disculus*, 95 m. **e.** *Cyclotella comensis*, 143.5 m. **f.** *Diploneis elliptica*, 95 m. **g.** *Diploneis parma*, 143.5 m. **h.** *Epithemia turgida* var. *westermannii*, 143.5 m. **j.** *Fragilaria* sp, 95 m. **k.** *Fragilaria lancettula*, 143.5 m. **l.** *Stenopterobia sigmatella*, 95 m. **m.** *Stephanodiscus aegyptiacus*, 95 m. **n.** *Stephanodiscus alpinus*, 95 m. **o.** *Stephanodiscus lucens*, 95 m. **p.** *Stephanodiscus medius*, 95 m. **r.** *Stephanodiscus niagarae*, 95 m.

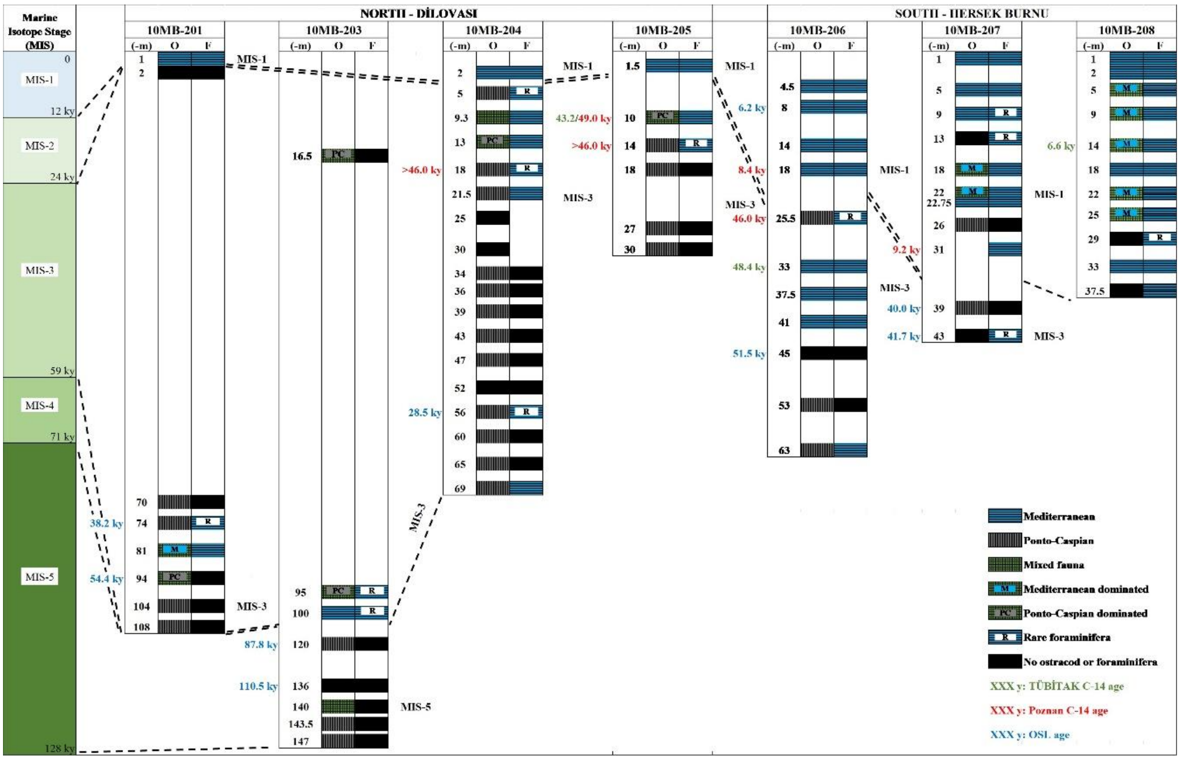

Fig. 22 Chronostratigraphic and faunal correlation of the İzmit Gulf drillings. The radiocarbon dates are expressed as uncalibrated (boundary of marine isotope stages from Imbre et al., 1984). The lower intervals of drillings 10MB-204 (120-80 m), 10MB-205 (117.2-40 m), 10MB-206 (122-80 m), 10MB-207 (120.9-50 m) and 10MB-208 (200-40 m) are not shown due to absence of sample.

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Appendix 1. Benthic foraminiferal assemblage identified in the studied drillings

FORAMINIFERA / LOCATIONS	DİLOVASI				HERSEK B.		
Species / Dillings	201	203	204	205	206	207	208
Adelosina bicornis (Walker & Jacob)					X		
Adelosina carinatastriata (Wiesner)						X	X
Adelosina mediterranensis (Le Calvez J. & Y.)	X						X
Affinetrina planciana (d'Orbigny)					X		
Ammodiscus planorbis Höglund						X	X
Ammonia compacta (Hofker)	X		X	X	X	X	X
Ammonia parkinsoniana (d'Orbigny)	X		X	X	X	X	X
Ammonia tepida (Cushman)	X	X	X	X	X	X	X
Ammoscalaria runiana (Heron-Allen & Earland)							X
Amphicoryna scalaris (Batsch)					X	X	
Astacolus crepidulus (Fichtel & Moll)					X		
Asterigerinata mamilla (Williamson)	X		X	X	X	X	X
Astrononion stelligerum (d'Orbigny)				X		X	X
Aubignyna perlucida (Heron-Allen & Earland)	X		X	X	X	X	X
Biloculinella labiata (Schlumberger)			X				
Bolivina alata (Seguenza)					X	X	
Bolivina dilatata (Reuss)	X		X	X	X	X	X
Bolivina ordinaria Phleger & Parker	X		X	X	X	X	X
Bolivina pseudoplicata Heron-Allen & Earland					X		X
Bolivina spathulata (Williamson)	X		X	X	X	X	X
Bolivina striatula Cushman	X		X	X	X	X	X
Bolivina subreticulata Parr			X				
Bulimina aculeata d'Orbigny	X		X	X	X	X	X
Bulimina elongata d'Orbigny	X		X	X	X	X	X
Bulimina marginata d'Orbigny	X			X	X	X	X
Cassidulina carinata Silvestri	X		X	X	X	X	X
Cibicides advenum (d'Orbigny)				X	X	X	X
Cibicides floridanus (Cushman)							X
Cibicides refulgens Montfort							X
Cibicidoides lobatulus (Walker & Jacob)	X		X	X	X	X	X
Cribroelphidium gerthi (Van Voorthuysen)	X		X	X	X	X	X
Cribroelphidium incertum Williamson					X		
Cribroelphidium poeyanum (d'Orbigny)	X		X	X	X	X	X
Cribrostomoides jeffreysii (Williamson)						X	
Cycloforina contorta (d'Orbigny)	X		X		X	X	X
Cycloforina tenuicollis (Wiesner)	X					X	X
Cycloforina villafranca (Le Calvez J. & Y.)							X
Discorbinella bertheloti (d'Orbigny)	X		X	X	X	X	X
Discorbis vilardeboana (d'Orbigny)				X	X	X	X
Eggerelloides scaber (Williamson)							X
Elphidium aculeatum (d'Orbigny)			X	X	X	X	X
Elphidium advenum (Cushman)					X		X

Elphidium complanatum (d'Orbigny)	X		X	X	X	X	X
Elphidium crispum (Linnaeus)	X		X	X	X	X	X
Elphidium macellum (Fichtel & Moll)	X		X	X	X	X	X
Elphidium margaritaceum Cushman	X						
Elphidium pulvereum Todd				X	X	X	X
Elphidium punctatum (Terquem)	X				X	X	X
Eponides concameratus (Montagu)			X		X		X
Favulina hexagona (Williamson)					X		
Fissurina staphyllearia Schwager					X		
Fursenkoina subacuta (d'Orbigny)	X				X	X	X
Fursenkoina complanata (Egger)	X		X	X	X	X	X
Gavelinopsis praegeri (Heron-Allen & Earland)	X		X	X	X	X	X
Globobulimina affinis (d'Orbigny)	X		X		X		X
Globocassidulina crassa (d'Orbigny)	X			X	X	X	X
Globocassidulina minuta (Cushman)							X
Globocassidulina subglobosa (Brady)	X		X	X	X	X	
Gyroidina umbonata (Silvestri)	X				X		X
Haynesina anglica (Murray)						X	X
Haynesina depressula (Walker & Jacob)	X	X	X	X	X	X	X
Hyalinea balthica (Schröter)					X		
Lachanella undulata (d'Orbigny)						X	X
Lagena semistriata Williamson							X
Lagena striata (d'Orbigny)	X				X	X	X
Massilina gualtieriana (d'Orbigny)							X
Massilina secans (d'Orbigny)						X	X
Miliolinella elongata Kruit					X		X
Miliolinella subrotunda (Montagu)	X			X	X	X	X
Neoconorbina terquemi (Rzehak)	X			X	X	X	X
Neoeponides bradyi (Le Calvez)	X			X	X	X	X
Nonion subturgidum (Cushman)			X	X	X		
Nonionella atlantica Cushman				X			
Nonionoides grateloupii (d'Orbigny)							X
Nonionoides turgidus (Williamson)	X		X	X	X	X	X
Patellina corrugata Williamson			X	X	X	X	X
Planoglabratella opercularis (d'Orbigny)							X
Planorbulina mediterranensis d'Orbigny	X			X			
Planulina ariminensis d'Orbigny					X		
Porosononion subgranosus (Egger)	X		X	X	X	X	X
Pseudotriloculina lecalvezae (Kaasschieter)	X					X	
Pseudotrilocuina limbata (d'Orbigny)						X	X
Pseudotriloculina rotunda (d'Orbigny)					X		X
Pyrgo elongata (d'Orbigny)	X						
Quinqueloculina aglutinans d'Orbigny					X		X
Quinqueloculina berthelotiana d'Orbigny	X					X	X
Quinqueloculina bidentata d'Orbigny				X		X	X

Quinqueloculina bosciana d'Orbigny						X	X
Quinqueloculina irregularis d'Orbigny						X	X
Quinqueloculina laevigata d'Orbigny	X		X	X	X	X	X
Quinqueloculina lamarckiana d'Orbigny	X						
Quinqueloculina parvula Schlumberger				X		X	
Quinqueloculina schlumbergeri (Wiesner)	X			X		X	X
Quinqueloculina seminula (Linnaeus)	X		X	X	X	X	X
Quinqueloculina stalkeri Loeblich & Tappan	X			X	X	X	X
Rectuvigerina phlegeri Le Calvez	X			X	X		
Reussella spinulosa (Reuss)	X						
Rosalina bradyi (Cushman)	X		X	X	X	X	X
Rosalina floridensis (Cushman)	X					X	X
Rosalina globularis d'Orbigny							X
Rosalina macropora (Hofker)	X						X
Sahulia conica (d'Orbigny)	X			X			X
Sigmoilina costata Schlumberger	X				X	X	X
Sigmoilina distorta Phleger & Parker						X	
Sigmoilopsis schlumbergeri (Silvestri)	X						
Siphonaperta aspera (d'Orbigny)						X	X
Siphonaperta dilatata (Le Calvez J. & Y.)						X	X
Sphaerogypsina globulus (Reuss)				X			
Spirillina vivipara Ehrenberg				X		X	X
Spiroloculina depressa d'Orbigny							X
Spiroloculina excavata d'Orbigny	X		X	X	X		X
Spirophthalmidium tenuiseptatum (Brady)	X						
Spiroplectinella wrighti (Silvestri)	X			X	X		X
Spirosigmoilina tenuis (Cžjžek)	X				X	X	X
Stomatorbina concentrica (Parker &Jones)				X		X	
Textularia aglutinans d'Orbigny	X			X		X	X
Textularia bocki Höglund	X						X
Textularia calva Lalicker	X			X	X	X	X
Textularia pala Czjzek	X			X	X	X	X
Textularia sagittula Defrance	X		X	X			X
Trifarina angulosa (Williamson)	X						
Triloculina adriatica Le Calvez J. & Y.							X
Triloculina marioni Schlumberger					X	X	X
Triloculina oblonga (Montagu)	X					X	X
Triloculina plicata Terquem	X			X		X	X
Triloculina schreiberiana d'Orbigny						X	X
Triloculina tricarinata d'Orbigny				X			
Valvulineria bradyana (Fornasini)	X		X	X	X	X	X
TOTAL: 75 genera	**41**	**1**	**27**	**38**	**45**	**43**	**49**
TOTAL: 128 species	**69**	**2**	**39**	**60**	**71**	**77**	**97**