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The effect of submarine thermal springs of Doğanbey Cape (Seferihisar - İzmir) on foraminifer, ostracod and mollusc assemblages

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Research Article

Keywords:
Doğanbey Cape (İzmir), submarine hot water springs, benthic foraminifers, molluscs, ostracods.

ABSTRACT

The aim of this study was to figure out the effects of the submarine hot water springs located on the coast of Doğanbey Cape (north of Kuşadası Bay) on various micro- and macrofaunal assemblages living around these springs. Young sediment samples were collected from different depths at 15 stations. The benthic foraminifer, ostracod and mollusc faunas were investigated. 35 genera and 61 species of benthic foraminifers, 16 genera and 20 species of ostracods and 14 genera and 15 species of molluscs were identified. Typical Aeegan foraminifer fauna was found to be dominant. Besides, individuals with colored tests or abnormal morphology, as well as alien species, which are frequently observed on the Aegean coasts were also observed in the study area. The foraminifer, ostracod and mollusc species also constituted typical Aegean fauna. It is known that the ecological conditions experienced of the Amphistegina lobifera Larsen individuals in typical Aegean benthic foraminifer assemblage have an effect on the abundance distribution. Ideal conditions for Amphistegina lobifera Larsen was found to be 18.00-32.00 m depth range and 19-20^{o}C temperatures. CTD conductivity values gradually increased near to the hot water spring but a decrease in the number of individuals were observed. Chemical analyzes in sediment samples were performed with X-Ray Fluorescence Analysis Spectrometer (WDXRF). Heavy metal ingredients (Cr, Mn, Co, Ni, Cu, Zn and Pb) of the sediments were evaluated, concentrations were recorded as Cr>Ni>Mn in samples DB1-DB6 and also in DB15; Mn>Cr>Ni in DB8-DB11 and DB13-DB14; Cr>Mn>Ni in DB7 and in DB12. The radioactive elements U and Th were found to be high in DB9, DB10 and DB11. The chemical and radioactive properties of the sediments were observed to affect the tests of benthic foraminifers, where as no such effect was found on ostracod and mollusc tests.

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1. Introduction

This study was carried out to investigate the effects of submarine hot springs, which are located on the southern coasts of the Doğanbey Cape (the northern end of Kuşadası Bay), on the benthic foraminifer, ostracod and mollusc fauna living around them (Figures 1, 2 and 3). Both quantitative and qualitative variations of the bottom sediments were evaluated under physical, chemical and radioactive conditions where micro and macro fauna assemblages are present in this area.

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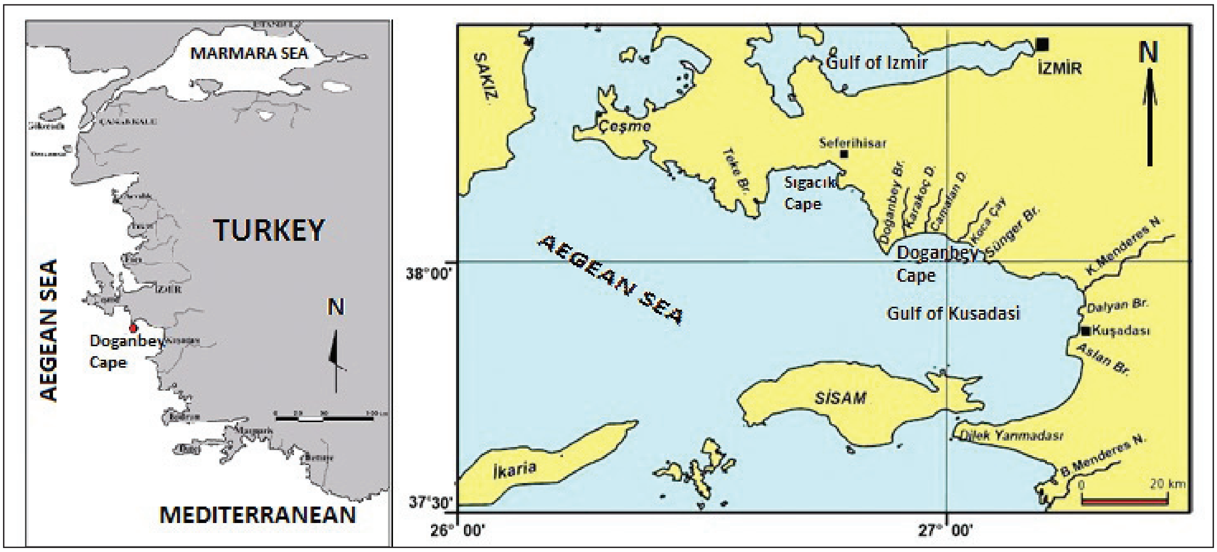

Figure 1- Location map of the investigation area.

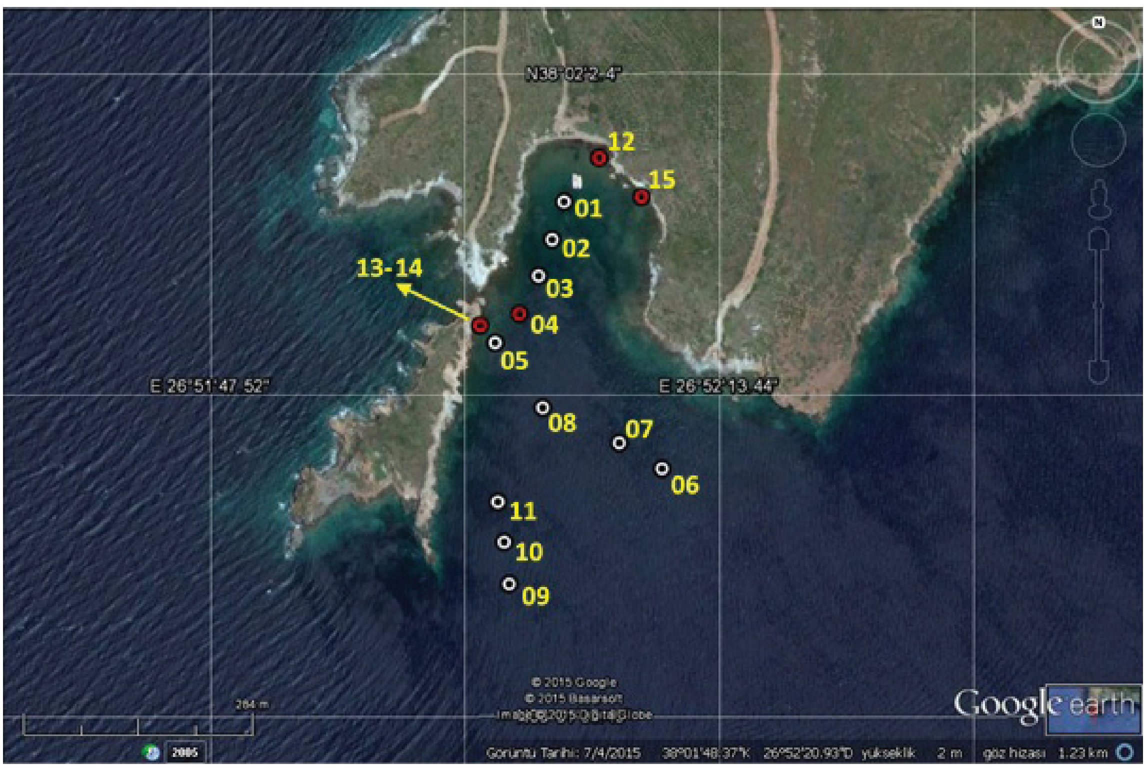

Figure 2- View of sampling points on satellite image. (There are hot water outlets in red colored).

The water depth at which samples were collected, varies between 0.20-31.80 meters, bottom water temperatures vary between 19.95-23.32°C and the bottom salinity values vary between 38.99-39.24‰ (Table 1). The micro and macro fauna biodiversity, which is the topic of research, has the faunal characteristics of the Eastern Aegean Sea. Although the life in the region is quite poor in shallow areas, it is rich in medium to deep regions. The micro and macro faunas observed are similar with the ones observed at the other studies carried out on the Aegean coasts (Avşar and Meriç, 2001; Meriç and Avşar, 2001; Meriç et al., 2002*a, b,* 2003*a, b*, 2004, 2009*a, b, c,* 2010, 2011, 2012*a, b,* 2014; Avşar et al., 2009; Öztürk et al., 2014).

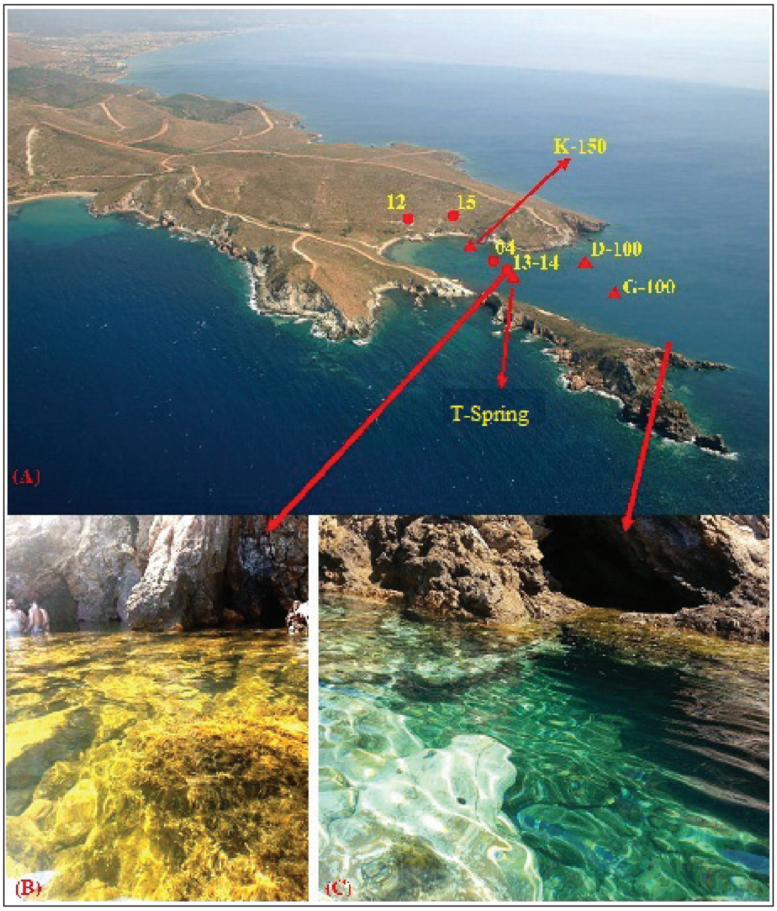

Figure 3- A- Hot water points (circle) and water sample reception stations (triangle) on the aerial photo of Doğanbey Burnu; B- Coastal area with hot water outlet; C- Coastal area without hot water outlet. (Aerial photograph: http://erkmensenan.blogspot.com.tr/2010/07/lebedos-urkmez.html).

Table 1- Coordinates, depth, temperature, salinity and conductivity values of bottom water at sampling points. (* Temperature, salinity and conductivity measurements were made with RBR XR-620 CTD)

Sample ID	Coordinates (WGS 84)		Depth (m)	Temperature* (°C)	Salinity* (‰)	EC* (mS/cm)
	North	East				
01	38° 1'57.29"	26°52'5.58"	3.70	22.949	39.224	56.359
02	38° 1'55.76"	26°52'4.97"	5.50	22.877	39.233	56.290
03	38° 1'54.30"	26°52'4.28"	7.00	22.647	39.231	56.026
04	38° 1'52.77"	26°52'3.30"	5.50	22.673	39.205	56.022
05	38° 1'51.60"	26°52'2.07"	7.50	22.834	39.199	56.199
06	38° 1'46.52"	26°52'10.57	15.85	19.950	39.235	52.987
07	38° 1'47.56"	26°52'8.39"	18.00	20.260	39.226	53.326
08	38° 1'48.98"	26°52'4.49"	19.00	19.887	39.205	52.881
09	38° 1'41.87"	26°52'2.78"	31.80	18.984	39.208	51.884
10	38° 1'43.56"	26°52'2.53"	27.70	19.830	39.177	52.789
11	38° 1'45.18"	26°52'2.20"	21.20	20.187	39.243	53.265
12	38° 1'59.06"	26°52'7.36"	1.00	---	---	---
13	38° 1'52.30"	26°52'1.30"	0.30	---	---	---
14	38° 1'52.30"	26°52'1.30"	0.30	23.323	38.990	56.486
15	38° 1'57.49"	26°52'9.52"	0.20	---	---	---

2. The Oceanography and Recent Sediment Distribution of the Northern Marine Area of the Kuşadası Bay

In previous studies, which bays the marine area located between the Küçük Menderes River and Sığacık Bay, the depth and recent sediment distribution maps have been prepared (Eryılmaz et al., 1998, Eryılmaz and Aydın, 2001; Eryılmaz and Yücesoy-Eryılmaz, 2001, 2014; Eryılmaz et al., 2014) (Figure 1). According to these studies the maximum depth in Doğanbey Bay is approximately 75 m (Figures 4 and 5). The most significant rivers of the Doğanbey Bay are Karakoç, Çamalan and Koca streams (Figure 1). Küçük Menderes River, which flows into the Kuşadası Bay at a distance of 30 km, is the most important river in the region. Only the Küçük Menderes River continues to flow due to less precipitation during summer.

According to the studies mentioned above, the region is under the effect of the Mediterranean climate. The average annual precipitation amount is 659.5 mm. The prevailing wind directions at the region are north and northwest, and the annual average wind velocity is in 5 knots (9.3 km/h). The study area is a light windy region (Meteoroloji Bülteni, 1984; Eryılmaz et al., 1998; Eryılmaz and Aydın, 2001; Eryılmaz and Yücesoy-Eryılmaz, 2001, 2014; Eryılmaz et al., 2014). According to Erol (1991, 1997), Eryılmaz (1996), Eryılmaz et al. (1998), big and small faults striking perpendicular to the coast were observed along the rocky shoreline with cliffs in the Sığacık Bay between the Teke Cape and Seferihisar. Beaches are well developed in the Doğanbey Bay and a 3 km wide delta is found on the mouth of Koca stream. These marine areas have been filled by terrigenous sediments, which were transported by rivers, and formed recent lowlands.

According to previous studies, the sea bottom topography located between the Sığacık Bay and Doğanbey Cape deepens with a slope of 2-6% towards the open sea. At 600-800 m away from the coast, the sea reaches a depth of 20 m. The bathymetrical depth contours run parallel to the coast as; -10, -20, -50 and -100 m. These contours get much closer to each other in Doğanbey and Sünger Capes and depths suddenly increase in these areas. The average slope in this region is 4% and the sea bottom has a quite flat like appearance (Figures 4 and 5) (Eryılmaz, 1996, 2003; Eryılmaz et al., 1998; Eryılmaz and Yücesoy-Eryılmaz, 2001, 2014).

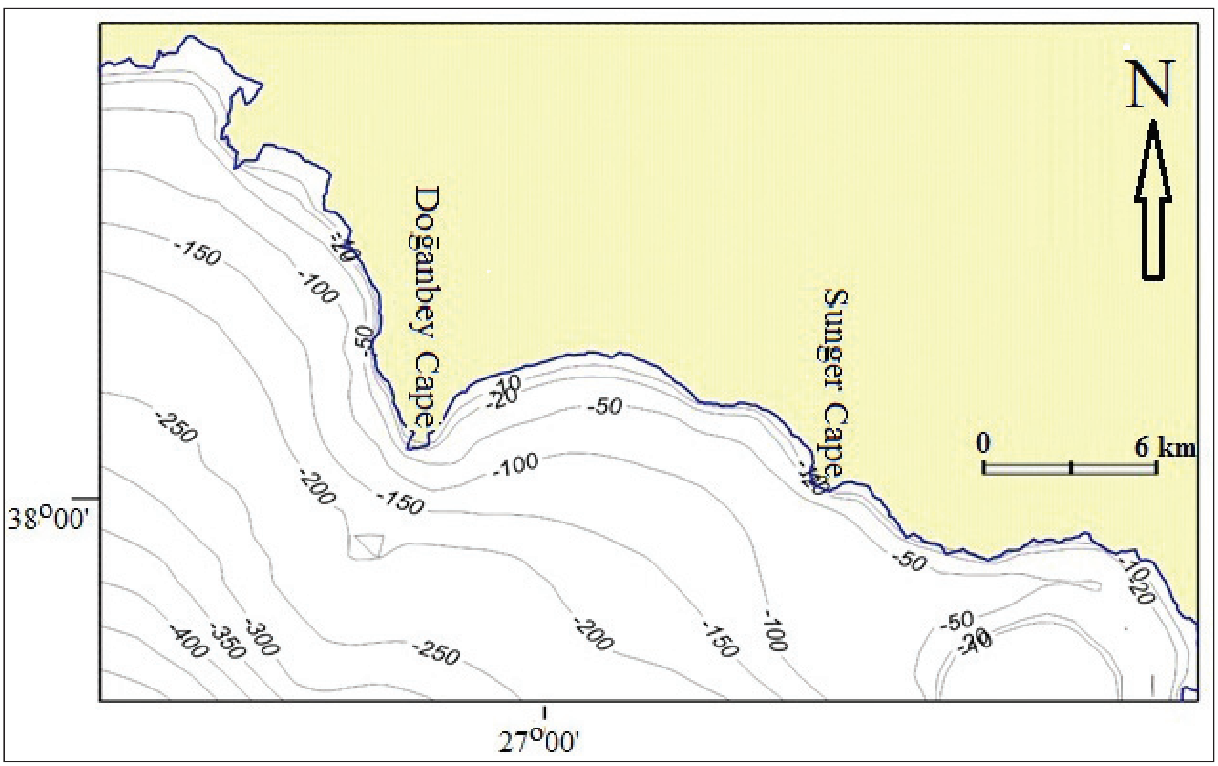

Figure 4- Map of bathymetry of Doğanbey Bay (depths as m).

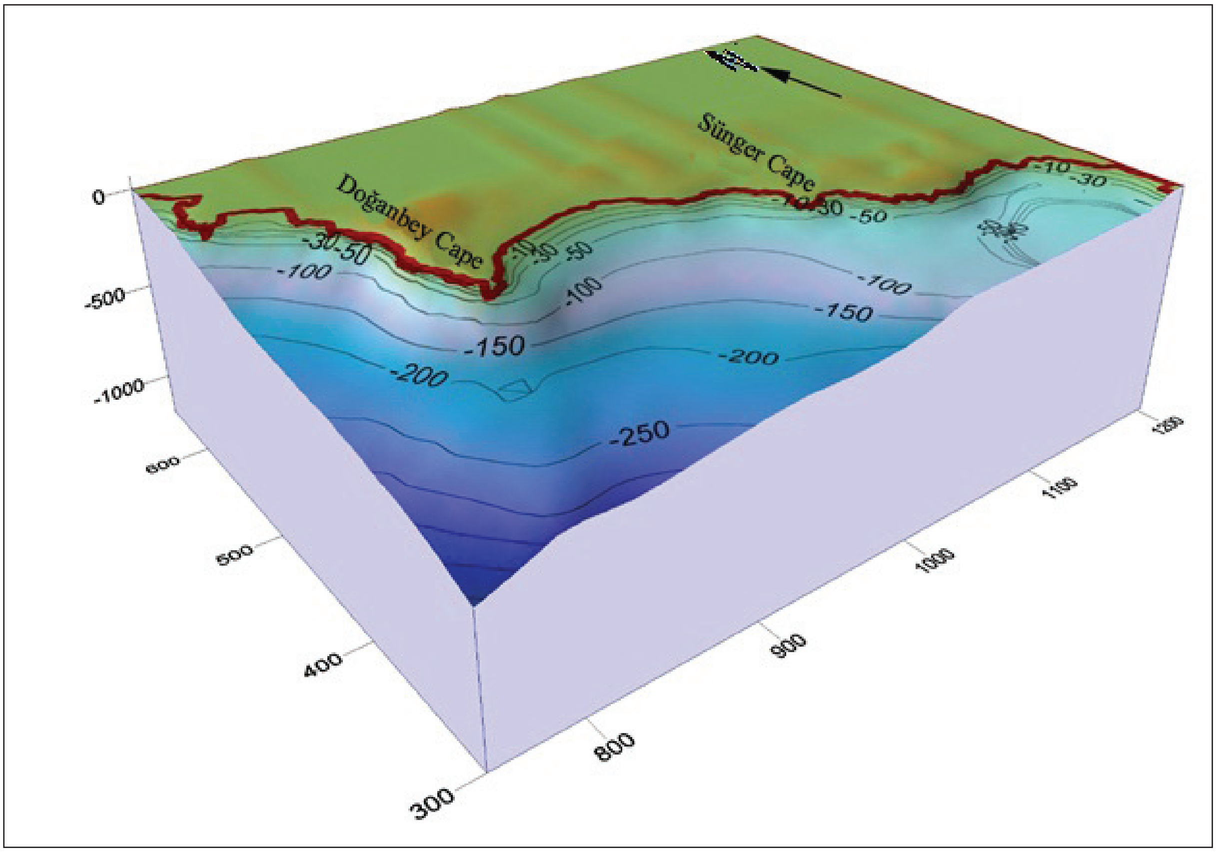

Figure 5- The 3D bathymetry and morphological appearance of Doğanbey Bay (depths as m).

In the study of Eryılmaz and Aydın (2001), the total of 48 recent sediment samples were collected from the sea bottom of the Doğanbey Bay in order to determine the characteristics of bottom sediments. In the study area, the temperature and salinity values were measured seasonally in standard stations using the CTD instrument in the water column ranging from surface to the sea bottom and then these areas were mapped. Besides; the short term seasonal flow measurements were taken at the surface, at 20 m depth and at the sea bottom in one station. Sieve and wet analysis methods were applied to recent sediment samples, which were taken from the surface of the sea bottom, and the results were classified in ternary diagrams (Folk, 1974). Sediments were classified according to the grain size and the results were assessed using bathymetry map. Thus, the sediment distribution map of the region in scale of 1:30.000 was prepared.

According to the studies of Eryılmaz and Eryılmaz-Yücesoy (2001, 2014), the variations of seasonal minimum, average and maximum temperatures with respect to depth in the Doğanbey Bay are as follows; 16.99-17.00°C at the surface, 15.70-16.27°C at -50 m in the spring; 17.80-25.55°C at the surface, 16.77-17.26°C at -50 m in the summer; 21.26-22.27°C at the surface, 17.52-19.88°C at -50 m in the fall, and 14.90-15.20°C at the surface, 14.93-15.20°C at -50 m in the winter (Figure 6a).

The variation of the seasonal minimum, average and maximum salinity values with respect to depth in the region were measured as ‰38.98 at the surface; ‰39.03 at the depth of 150 m in the spring, ‰39.26 at the surface, ‰39.16 at the depth of 150 m in the summer, ‰38.66 at the surface; ‰38.30 at the depth of 150 m in the fall and ‰38.42 at the surface; ‰38.43 at the depth of 150 m in the winter (Figure 6b) (Eryılmaz and Yücesoy-Eryılmaz, 2001, 2014; Meriç et al., 2009*b*, 2010; Yokeş et al., 2014).

Within the scope of studies of Eryılmaz and Eryılmaz-Yücesoy (2001, 2014), the short term seasonal flow measurements were taken in two stations of DK-01 (-21 m) and DK02 (-36 m) (Figures 7 and 8). It not possible to mention about a general flow system in the region with the flow data obtained.

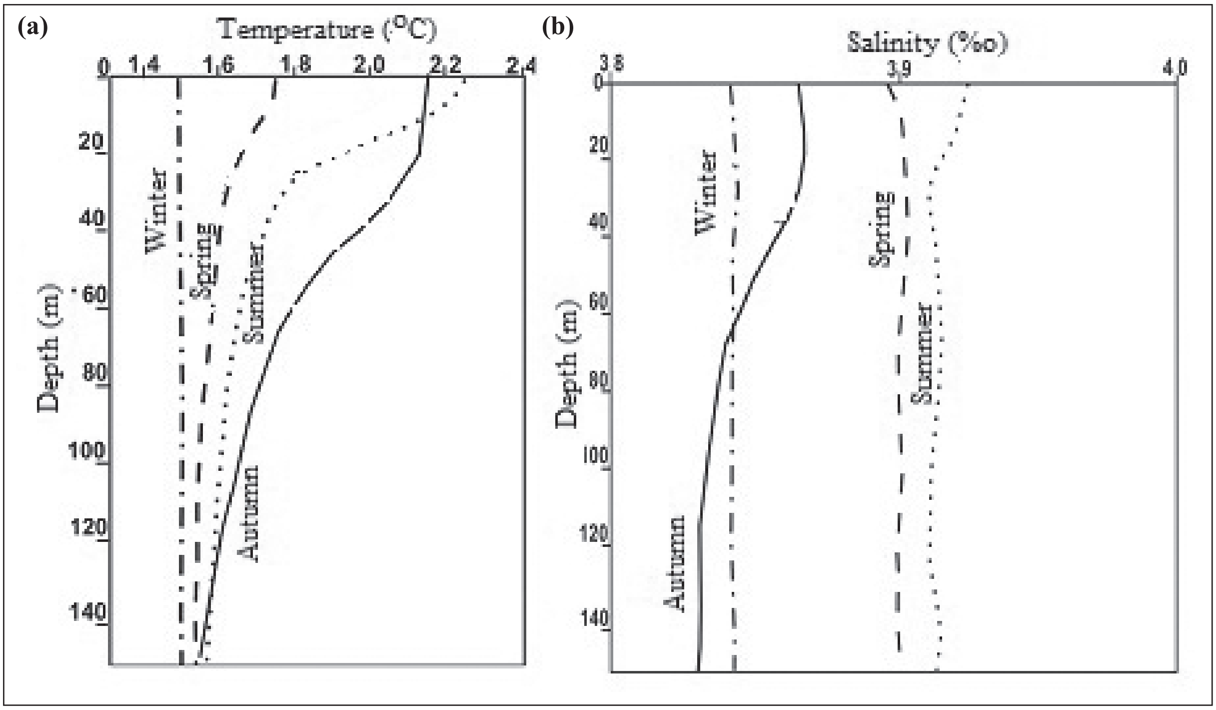

Figure 6- The seasonal average temperature (a) and seasonal average salinity values (b) at Doğanbey Bay.

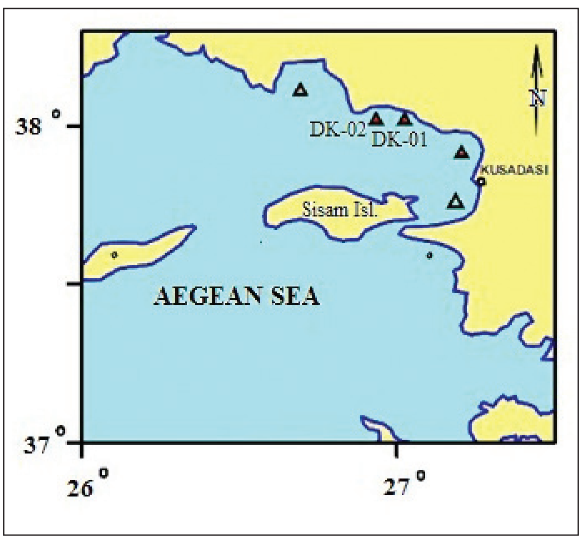

Figure 7- Map of the stations measuring the seasonal discharge at Doğanbey Bay.

In the winter the general flow system returns from west to east and moves very slowly. This mass movement changes direction in northern coasts of the Kuşadası Bay and turns into coastal flows. These flow types are also observed in the Sığacık and Doğanbey bays. Sometimes by the effect of southern winds which blow continuously and strongly, the surface and counter clockwise flows develop. The increase of salinity at the surface layer in the summer and density differences that occur due to the temperature differences between the sea surface and bottom cause local flows in marine areas closer to the coast. Besides; the Etesian winds that blow in the region from west to east in the afternoon cause local flows along the coasts (Figure 8).

Within the scope of studies of Eryılmaz and Aydın (2001) and Eryılmaz and Yücesoy-Eryılmaz (2014), the coastal and bottom sediments were formed from coarse to fine grained sediments which had been carried by the local flows and waves along rivers into the sea. The materials, which were detached by waves from the coast and transported from the land, become smaller by being subjected to re-erosion under the effect of waves and flows in the sea. It is also observed that the sediment grain size becomes smaller from coast to offshore in the region (Figure 9). The sediment distribution in the Doğanbey Bay is mostly lithogenic originally and generally the low cohesive silty material is dominant. While the coarse grained and clastic cohesionless material takes place in the high energy coasts, the cohesive material accumulates in deep regions away from the coast.

According to the studies of Eryılmaz and Aydın (2001), Eryılmaz and Yücesoy-Eryılmaz (2014), the sediments located in the study area are formed from 6

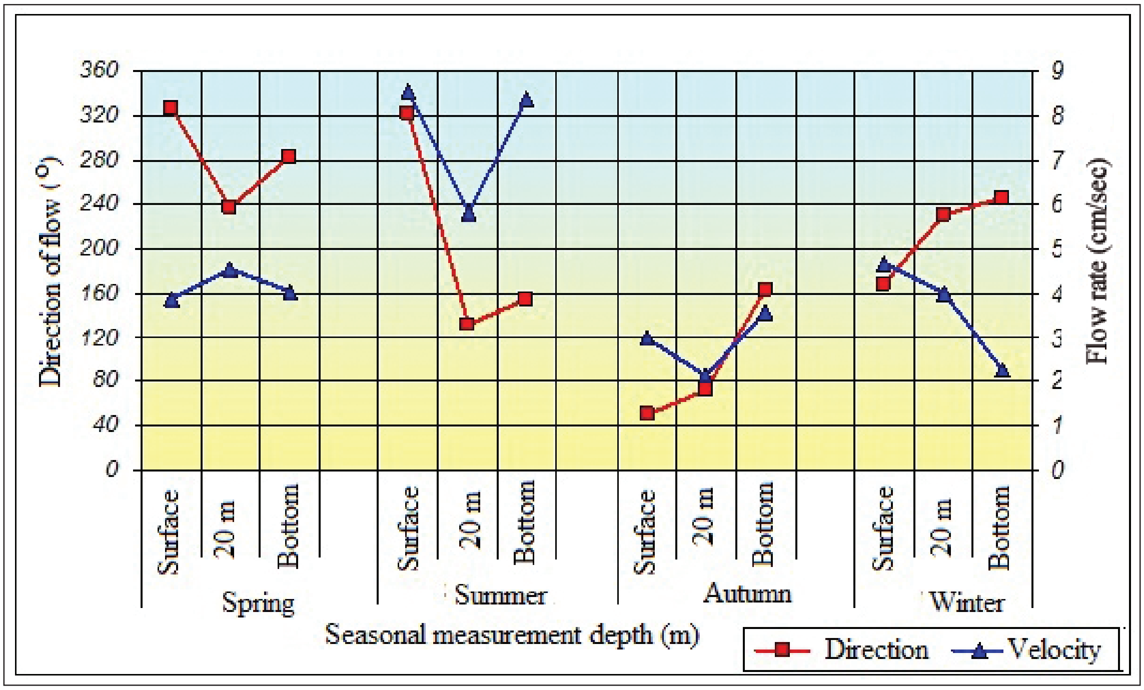

Figure 8- The seasonal flow velocity and direction at Doğanbey Bay.

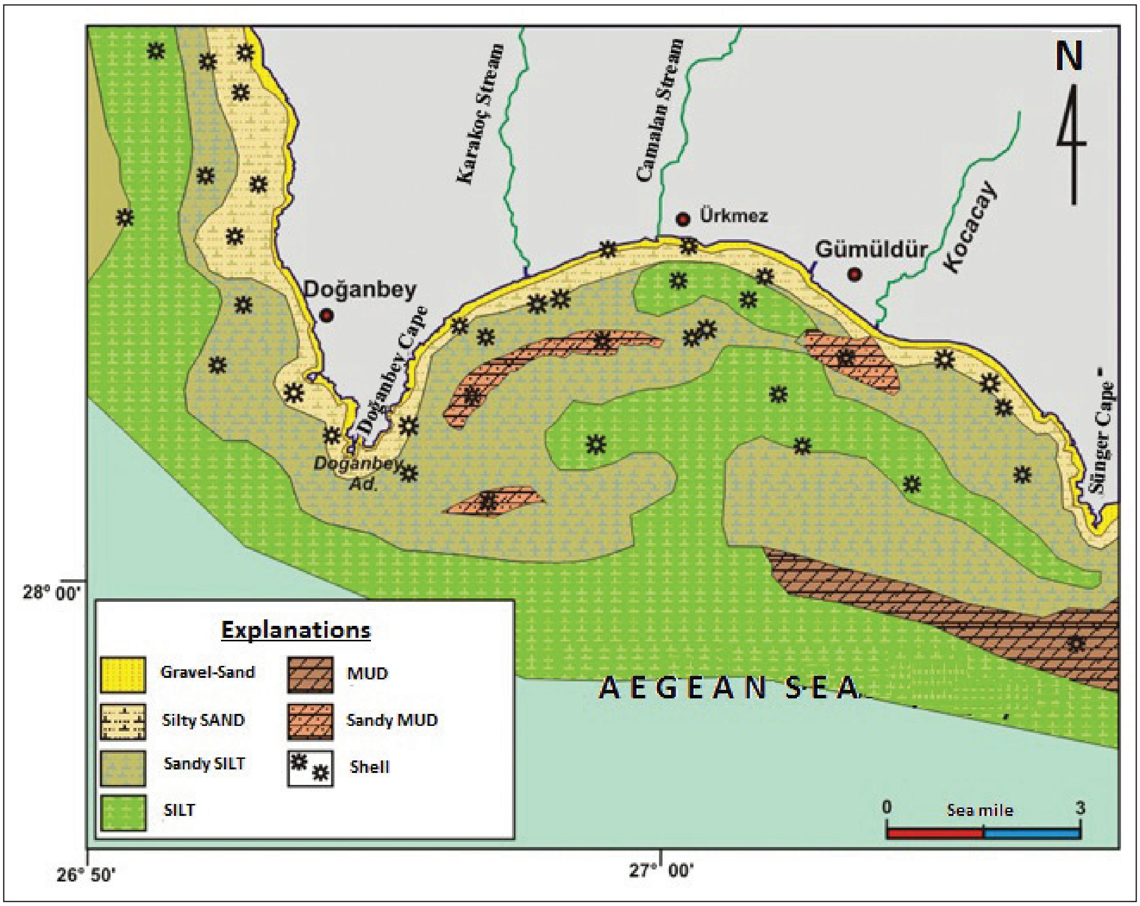

Figure 9- Map of current sediment distribution at Doğanbey Bay.

types of material as rock, pebble, sand, silt and mud. Sandy materials are made up of pebbly sand, sand and silty sand. The sand unit continues to the depth of 7 m. Silty sand is observed until the depth of 20 m respectively. Between the depths of 20-50 meters, the lensoidal sandy mud is located between sandy silt and silt. Sandy silt continues to the depth of 100 meters. However; the silty material reaches down to 200 meters. Moreover; the muddy sediments are observed at a narrow region between the depths of 100-150 meters. All these sediments in the region are observed in the form of parallel bands compatible with the shape of the coastline. The grain size distribution generally changes from coarse to fine from coast to the sea bottom in this region and form bands which make transitions to each other as being parallel to the thin coastal line (Figure 9). A delta was formed in the mouth of Kocaçay River which flows into the Doğanbey Bay and thin sand has been deposited on the shore of delta. The Küçük Menderes River, which flows along the gently inclined riverbed for long distances, only transports silt and clay sized terrigenous material into the sea. It has been determined that these materials had been transported down to the bottom of the open sea in times of river floods.

3. Material and Method

The recent sediment samples were collected by 11 liter ground sampler digger from 15 points at different depths in southeast of the Doğanbey Cape, in 16th of August, 2015 and examined in order to evaluate in terms of foraminiferal, ostracod and mollusc assemblages. Besides; the physical properties of the sea water (temperature and salinity) were synchronously measured by RBR XR-620 CTD instrument at each ground sample station. The foraminifer and ostracod analyses in sediment samples were performed according to Babin (1980) and Bignot (1985). 10% H_2O_2 was added on to the dry samples weighed 10 gr and left for 24 hours. Thereafter; samples were washed on 0.063 mm sized sieve by pressurized water, dried on 50°C oven then sieved on 2, 1, 0.5, 0.25, 0.125 mm sized sieves. These samples were then examined under binocular microscope and foraminifer, ostracod and molluscs were separated from the content.

The measurements of chemical elements (in ppm and ppb) in sediment samples were performed at the Çekmece Nuclear Research and Training Center (ÇNAEM) using a Wavelength Dispersive X-Ray Fluorescence (WDXRF) Spectrometer. The quantitative and qualitative analyses of the elements between Boron (B) and Uranium (U) were carried out by using the X0 ray tube, crystals in different types (LiF220, PX10, GeIII-C, PE 202-C), two sensors, collimators in variable sizes and specifications and relevant software. TDS is the total dissolved solid amount in one liter (mg/L).

During the preparation of sediment samples for counting, the material was first crushed in 200 mesh size and dried. The samples, which are kept in the desiccator, were weighed 12 gr, mixed with 3 gr of wax, placed into 40 mm diameter mold and then compressed into pellet form using 35 tons of pressure. Total Alfa SM 7110 C and Total Beta analyses were carried out by the ASTM D 1890-05 method using Berthold Lb 770 Low Level 10 Channel Proportional Counter instrument. By taking 500 ml water from the sample, the Alfa precipitation (250 ml) and EPA 900.0 (250 ml) methods were studied (MDAα: 0.007 Bq/L, MDAβ: 0.008 Bq/L).

Photographing the abnormal advanced foraminifera and the microprobe analyses of colored foraminifer tests were carried out using Philips XL 305 FEG instrument in Material Science and Engineering Department of the Gebze Technical University. The electron microprobe quantitative analyses were concluded by using the computer controlled Jeol-733 electron microprobe device and online ZAFM quantitative analysis program.

4. Findings

4.1. Micro and Macro Fauna

4.1.1. Distribution of Genera and Species of Benthic Foraminifers

The benthic foraminifer assemblage mirror the typical Aegean Sea fauna (Avşar and Meriç, 2001; Meriç and Avşar, 2001; Meriç et al., 2002*a*, *b*; 2003*a*, *b*; 2004; 2009*a*, *b*, *c*; 2010, 2011, 2012*a*, *b*; 2014). In 13 of 15 samples the foraminifer assemblages is different. This property was also encountered in some genera and species observed in the Mediterranean (Table 2).

The situation which is attractive for the study area is having the characteristics of being the 3rd region in which *Amphistegina lobifera* Larsen individuals are abundantly observed around hot springs that are known or considered to exist in the Kuşadası Bay or

Table 2- The distribution of samples benthic foraminifera genus and species.

Foraminifera	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**14**
Lagenammina fusiformis							+	+					
İridia diaphana								+	+				
Spiroplectinella sagittula								+	+				
Eggerelloides advenus											+		
Eggerelloides scabrus				+			+			+			
Textularia bocki							+	+	+	+	+		
Vertebralina striata							+	+	+	+	+		
Nubecularia lucifuga								+	+	+	+		
Adelosina cliarensis								+	+	+			
Adelosina duthiersi								+					
Adelosina mediterranensis								+	+				
Adelosina partschi								+					
Adelosina pulchella								+	+				
Spiroloculina excavata							+		+				
Spiroloculina ornata								+	+	+	+		
Siphonaperta aspera								+		+	+		
Cycloforina contorta								+					
Cycloforina villafranca						+							
Lachlanella undulata								+					
Lachlanella variolata								+					
Massilina secans								+					
Quinqueloculina bidentata							+						
Quinqueloculina disparilis							+	+	+				
Quinqueloculina jugosa									+				
Quinqueloculina laevigata								+					
Quinqueloculina lamarckiana	+					+	+						
Quinqueloculina seminula	+												
Miliolinella labiosa											+		
Pseudotriloculina laevigata								+					
Pseudotriloculina oblonga								+					
Pseudotriloculina rotunda								+	+	+	+		
Pseudotriloculina sidebottomi							+						
Triloculina marioni							+	+	+	+	+		
Sigmoilinita costata		+						+		+	+		
Sigmoilinita edwardsi			+										
Peneroplis pertusus	+						+	+	+				
Peneroplis planatus							+	+	+		+		+
Cyclorbiculina compressa											+		
Sorites orbiculus								+			+		
Eponides concameratus								+	+	+			
Neoeponides bradyi								+	+		+		
Neoconorbina terquemi								+					
Rosalina bradyi						+		+	+	+			
Rosalina floridensis	+							+	+				
Rosalina globularis	+												
Discorbinella bertheloti												+	+
Cibicides advenum	+												
Lobatula lobatula							+	+	+	+	+		
Cyclocibicides vermiculatus								+			+		

Table 2- continued.

Foraminifera	1	2	3	4	5	6	7	8	9	10	11	13	14
Planorbulina mediterranensis							+	+	+	+	+	+	
Cibicidella variabilis								+	+	+	+		
Asterigerinata mamilla						+							
Amphistegina lessonii								+					
Amphistegina lobifera					+	+	+	+	+	+	+		+
Nonion depressulum	+					+							
Ammonia compacta							+	+		+			
Ammonia parkinsoniana	+						+	+	+	+	+		
Ammonia tepida									+				+
Elphidium advenum								+	+	+	+		
Elphidium complanatum							+	+	+				
Elphidium crispum	+						+	+	+	+	+		

in the NW of the Karaburun Peninsula of the Aegean Sea. The excess abundance of foraminifers (more than 25 individuals) in samples 7, 8, 9, 10 and 11 is a remarkable case for the region (Plates 1 and 2) .

4.1.2. Distribution of Genera and Species of Ostracods

The sediment samples are not rich in ostracod genera, species and individuals. Ostracods were described only in 10 examined samples. They are fewer in samples 1, 4, 6, 13, 14, but quite a few in samples 7, 8, 9, 10, 11 as it was observed in the foraminifer assemblage (Table 3).

Total of 16 genera and 20 species were identified in samples of the Doğanbey bottom sediments. For the description of genus and species, Van Morkhoven (1963), Hartmann and Puri (1974), Bonaduce et al. (1975), Breman (1975), Yassini (1979), Guillaume et al. (1985), Athersuch et al. (1989), Zangger and Malz (1989), Mostafawi and Matzke-Karasz (2006), Joachim and Langer (2008) and "MarBEF Data System" (http://www.marbef.org/data/) were heavily used.

4.1.3. Distribution of Genera and Species of Molluscs

Typically the mollusc fauna of the Aegean Sea is dominant in this area as bivalve and gastropod (Öztürk et al., 2014). In 7 of 15 examined samples (4, 6, 7, 8, 9, 10, 11) gastropods and bivalves were observed. Total of 14 genera and 18 species were found in gastropods.

Some differences were observed among samples based on the number of genus and species content.

Table 3- The distribution of samples ostracoda genus and species.

Ostracoda	1	4	6	7	8	9	10	11	13	14
Cytherella alvearium		+				+		+	+	
Neonesidea corpulenta					+	+	+	+		
Neonesidea formosa				+	+	+	+	+		
Triebelina raripila						+				
Aurila convexa						+	+			
Cytheridea neapolitana			+							
Jugosocythereis prava				+	+	+		+		
Urocythereis oblonga					+					
Acantocythereis hystrix				+	+		+	+		
Cytheretta adriatica	+									
Bosquetina carinella					+					
Semicytherura incongruens						+				
Loxoconcha bairdi					+	+	+		+	
Loxoconcha gibberosa				+	+	+	+	+		+
Cytherois sp.				+	+	+	+	+		
Xestoleberis aurantia		+		+	+	+	+			+
Xestoleberis communis				+	+	+	+	+	+	+
Xestoleberis depressa				+	+	+				
Ekpontocypris pirifera							+	+		
Macropyxis adriatica						+	+	+		

In samples 4 and 6; one genus and species, in sample 11; 9 species, in sample 10; 11 species, in sample 9; 13 species, in sample 7; 15 species and as the richest sample point in sample 8; 20 species were identified for bivalves and gastropods (Table 4).

Table 4- The distribution of samples gastropoda with bivalv genus and species.

Gastropoda	**4**	**6**	**7**	**8**	**9**	**10**	**11**
Jujubinus exasperatus				+	+	+	+
Jujubinus striatus				+			
Tricolia pullus			+	+			
Cerithium vulgatum				+			
Bittium latreillii				+	+	+	+
Bittium reticulatum			+	+	+	+	+
Bittium scabrum		+	+	+	+	+	+
Cerithidium submamillatum				+			
Turritella turbona				+	+		
Pusillina inconspicua			+				
Pusillina lineolata				+			+
Pusillina marginata							+
Alvania cimex				+		+	+
Alvania mamillata				+			
Trophonopsis muricatus			+				
Chauvetia mamillata			+				
Raphitoma linearis						+	
Chrysallida sp.				+			
Retusa truncatula				+			
Haminoea sp.			+	+			
Bivalvia							
Nucula hanleyi					+		
Nuculana pella					+		
Striarca lactea				+		+	
Flexopecten glaber glaber					+		
Flexopecten hyalinus			+	+			
Limaria tuberculata			+			+	
Dosinia exoleta				+	+	+	
Myrtea spinifera					+		
Glans trapezia				+	+		
Venericardia antiquata			+				
Parvicardium exiguum			+				
Parvicardium scriptum			+				
Papillocardium papillosum	+		+		+	+	+
Gari sp.							
Gouldia minima			+	+	+	+	+
Hiatella rugosa			+				

4.2. The Evaluation of Geochemical Properties of Sediment Samples

The geochemical properties of the environmental conditions (as like heavy metal, trace element and radioactive element etc.) are effective on the population and numerical values of different species, morphological anomaly or coloring features of meiofauna assemblages observed in the study. Within this scope, it was observed from Cr, Mn, Co, Ni, Cu, Zn and Pb heavy metal distribution of sediment samples that in sediments between D1-D6 and in D15 Cr>Ni>Mn; between D8-D11, in D13 and D14 Mn>Cr>Ni; in D7 and D12 Cr>Mn>Ni (Figure 10) (Table 5). In the distribution of sediments with respect to each other, it was observed that the values of Co, Cu, Zn and Pb are low, whereas the values of Cr, Ni and Mn are high. When the shale values of Krauskopf (1982) were compared with sediment samples, it was observed that Fe was the highest; Cr, Co and Ni were high; and Zn and Cu were observed as the lowest. Also; correlating shale values of Krauskopf (1982), it was detected that Mn value in DB13 and Pb value in DB6, DB8-DB11 intervals were highest.

In the distribution of sediments with respect to each other, the elements Y and U were found as the highest and lowest, respectively (Y>Th>U). So; these values show a parallelism in sediments between the intervals of DB1-DB5 (Figure 11). The values of these elements tend to increase in the interval of DB5-DB11, but tend to decrease in the interval of DB13-DB15. Based on shale values of Krauskopf (1982), the elements of Y and Th are low, but the element U is high in the interval of DB7-DB11 in all samples.

In the trace element distribution of sediment samples (V, Ga, Rb, Sr, Zr, Nb, Ba, La and Ce) relatively to each other, the elements V and Sr were observed as the highest in DB6 and DB8, respectively (Figure 12). Also; the elements of V, Ga, Rb, Zr, Nb, Ba, La and Ce in sediment samples between the intervals of DB7-DB12 show a parallel tendency to increase and decrease. When the shale values of Krauskopf (1982) were compared with sediment samples, it was observed that Sr element was high between the interval of DB8-DB11, and La element was on the threshold value, but V, Ga, Rb, Zr, Nb, Ba and Ce elements were low.

Table 5- Elementary analysis results of sediment samples.

ID / ppm	DB-1	DB-2	DB-3	DB-4	DB-5	DB-6	DB-7	DB-8	DB-9	DB-10	DB-11	DB-12	DB-13	DB-14	DB-15	Şeyl (Krauskopf, 1982)
CaO	22256	5888	10984	3150	36082	7427	98550	236911	177998	144989	156165	20298	183715	70255	42259	
Sc	3.64	3.59	6.97	5.01	8.72	10.93	0	0	4.24	4.51	4.55	5.59	8.4	12.65	3.82	
TiO_2	6407	6331	7205	8915	4332	3346	6567	9045	11438	11697	11572	7234	9226	6115	1110	
V	59.59	65.92	71.59	78.71	67.02	438.18	97.78	97.38	88.64	94.57	100.77	52.24	68.85	109.05	34.88	130
Cr	758	635	1038	1020	1283	991	704	307	253	242	231	676	504	658	1046	100
Mn	462	235	353	310	705	262	486	324	371	310	328	472	1056	702	609	850
Fe_2O_3	38833	32770	46598	43298	88274	255432	58844	49101	52765	53080	56681	32687	94478	93410	57355	0.00047 (Fe)
Co	38.05	44.43	43.8	43.36	57.74	34.93	33.82	27.78	46.46	23.09	21.14	37.1	27.03	41.64	50.55	20
Ni	392	382	524	469	1009	640	418	184	144	153	154	309	378	514	805	80
Cu	3.25	2.49	2.97	1.97	15.24	5.58	11.21	16.92	16.54	20.98	22.24	2.22	16.68	16.02	11.38	50
Zn	25.28	18.15	29.5	26.25	30.91	38.81	45.17	56.02	54.75	61.43	64.59	19.38	16.02	32.72	18.04	90
Ga	3.63	4.06	4.45	4.19	3.14	3.99	5.37	6.39	7.99	8.59	8.82	3.21	1.46	3.76	1.35	25
Rb	20.62	22.19	23.34	22.2	9.63	14.82	34.43	53.46	62.88	69.88	71.96	20.3	12.06	13.85	5.82	140
Sr	84.76	55.26	59.69	53.61	73.39	82.18	343.37	889.88	706.17	493.19	611.84	79	181.29	108.66	73.77	400
Y	5.52	5.15	5.08	5.43	3.1	11.01	10.68	17.35	19.89	19.39	19.34	6.2	9.89	6.5	2.13	35
Zr	26.51	27.89	24.06	26.36	7.3	31.33	59.41	90.26	123.18	142.46	134.09	30.8	25.76	19.51	5.16	180
Nb	4.54	4.2	2.96	3.72	0.06	2.17	5.44	7.54	10.1	11.45	11.07	5.06	0.61	0.49	0.33	15
Ba	45.26	43.9	30.84	41.7	0	40.88	80.69	121.47	154.92	160.9	162.59	48.04	0	0	21.65	600
La	10.61	4.99	8.85	2.17	0.17	8.83	10.71	26.13	39.79	32.01	33.94	8.95	4.01	4.14	0.43	40
Ce	1.39	3.52	0	0	0	19.64	16.71	45.35	56.66	49.85	51.44	-0.03	0.64	0	0	70
Pb	14.54	16.75	13.93	12.61	4.48	26.06	16.48	25.56	22.71	25.01	24.48	17.96	6.6	5.98	4.51	20
Th	1.64	2.11	1.59	1.94	0.27	1.66	5.01	7.02	9.48	8.66	10.02	1.63	1.34	1.1	1.44	12
U	0.25	-0.14	0.24	0.68	0.54	0.13	3.78	6.67	5.81	4.91	6.88	0.47	1.74	0.61	1.35	3.5

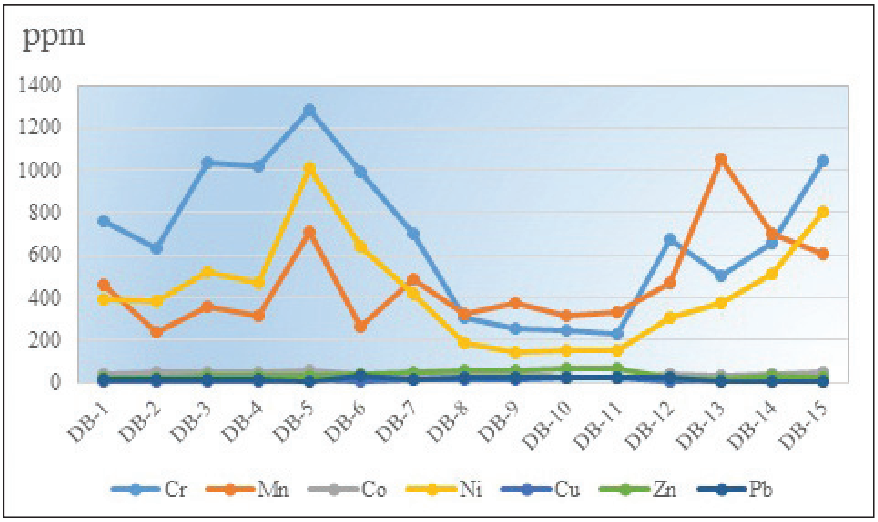

Figure 10- Distribution of heavy metals in sediment samples.

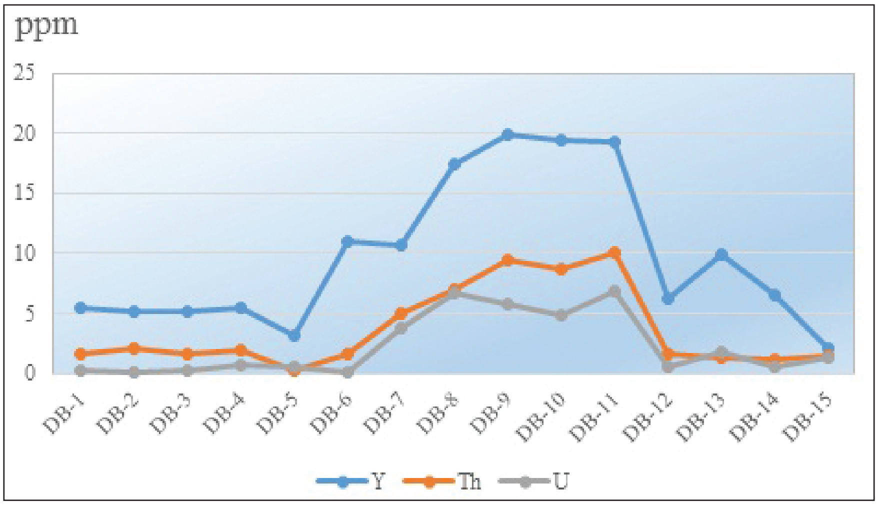

Figure 11- Distribution of Y, Th, and U in sediment samples.

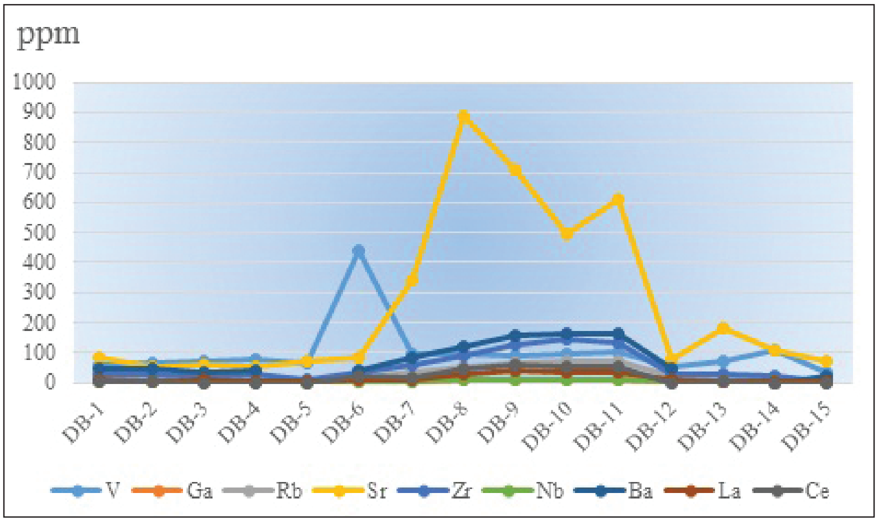

Figure 12- Distribution of trace elements in sediment samples.

4.3. The Evaluation of Total Alfa and Total Beta Characteristics of the Sea Water Samples

In sea water samples, the T-Spring values are high in total alfa and beta counting (Table 6). In samples of D100 and G100, the total alfa values are the same; however, the total beta counting in G100 is high and has a value close to the T-source value. The total beta values of K-150 and D-100 samples are close to each other. However, it is low in T-source in the measurement of total dissolved material, it provides the same value in other samples.

4.4. The Evaluation of Microprobe Analyses of Colored Tests

It was detected that Na, Mg, Al, Si, and K elements in tests did not occur in the sediment content. Whereas Fe and Ca elements are present in tests in addition to the sediments, their contents in tests were determined on a very low value. The distribution of elements in tests of *Peneroplis planatus* as Ca>Si>Al>Mg (Figure 13). When colored (tests ID 16, 17, 18 and 19) and normal individual (test ID 20) were compared according to the tests of *Peneroplis planatus*, which were collected from the sample DB7, it was observed that Fe element was determined as the lowest in normal individual. However, the other elements (Na, Mg, Al, Si, K and Ca) were determined at intermediate values for general distribution.

In colored tests of *Lachlanella variolata* (test ID 20) (Figure 14) collected from the sample DB8 and *Elphidium crispum* (test ID 22), the elements have the characteristics of Ca>Si>Al>Mg (Figure 15). Also; Ca element is high in the colored tests of *Ammonia*

Table 6- Coordinates, total alpha, total beta and TDS values at sampling of sea water.

Sample ID	Coordinates (WGS 84)		Date	Total Alpha		Total Beta		TDS
	North	East		Bq/L	±	Bq/L	±	g/l
K-150	38° 1'54.30"	26°52'4.28"	12.04.2016	0.08	0.014	17.78	3.7	44
T-Spring	38° 1'52.30"	26°52'1.30"	12.04.2016	1.14	0.121	19.87	2.27	38
D-100	38° 1'48.98"	26°52'4.49"	12.04.2016	0.1	0.017	17.93	3.73	44
G-100	38° 1'46.74"	26°52'1.95"	12.04.2016	0.1	0.016	19.76	4.11	44

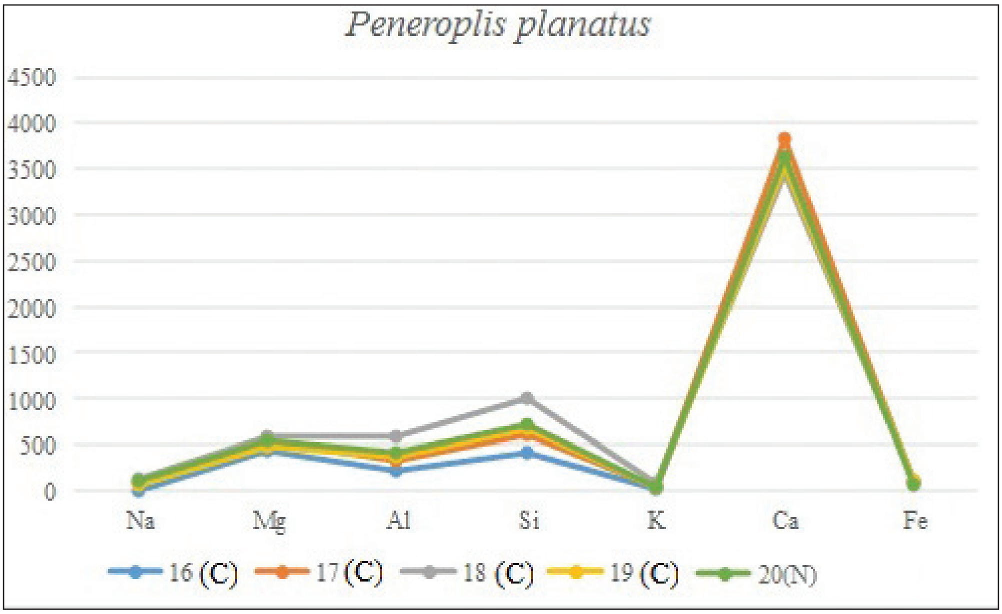

Figure 13- Distribution of elements in tests of *Peneroplis planatus*.

parkinsoniana (test ID 23), which were collected from the same sample (Figure 16). However, the characteristics of Ca>Si>Mg>Al is observed in *Quenqueloculina lamarckiana* (test ID 24) (Figure 17). In colored tests of *Elphidium crispum* (tests ID 26 and 27) collected from the sample DB10 and in the colored test of *Elphidium crispum* (test ID 22) in sample DB8, Ca>Si>Al>Mg was detected (Figure 15). Nonetheless, Al element is the lowest and Fe element is the highest in the colored test 25 in sample DB10. When the tests are compared with the shale values of Krauskopf (1982) it was observed that all elements were low, but only Al, Si, Ca and Fe elements were high with respect to the sea water values.

5. Discussion and Results

The most important finding in the study area is the abundance of *Amphistegina lobifera* Larsen individuals in samples taken at certain points. The presence of

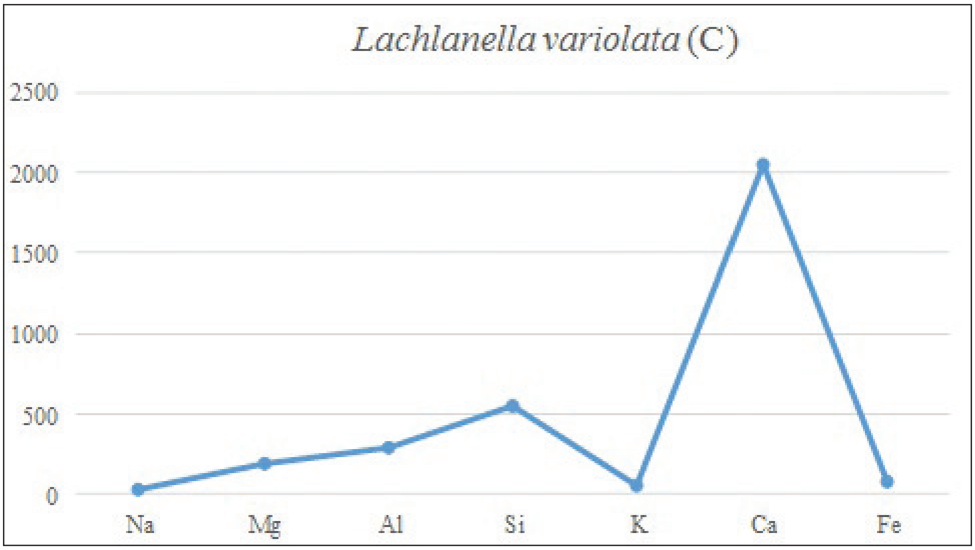

Figure 14- Distribution of elements in coloured test of *Lachlanella variolata*.

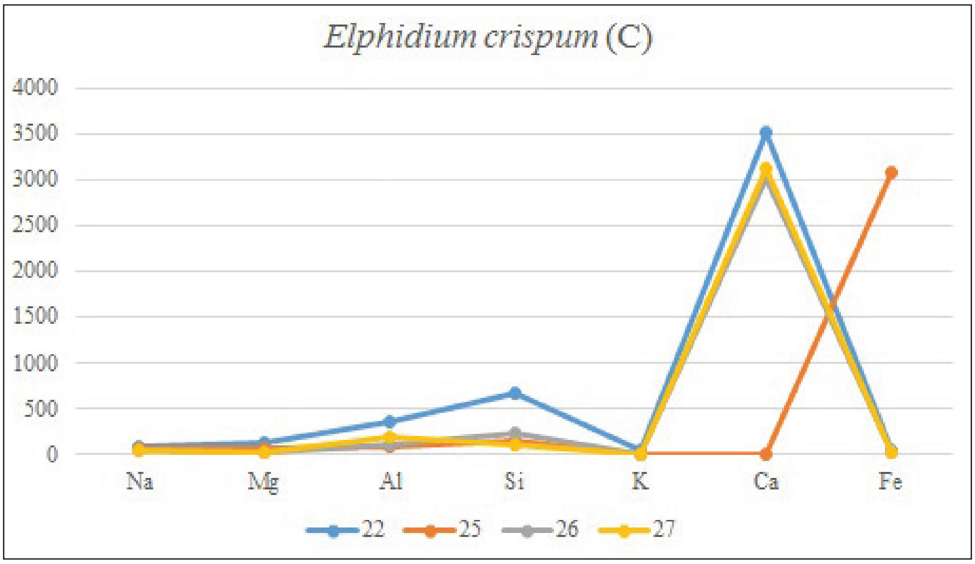

Figure 15- Distribution of elements in coloured tests of *Elphidium crispum*.

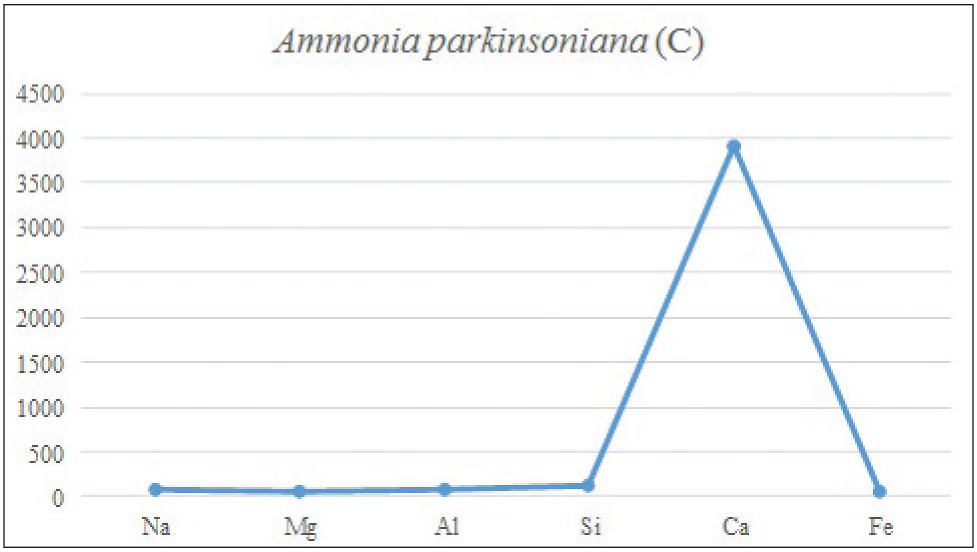

Figure 16- Distribution of elements in coloured test of *Ammonia parkinsoniana*.

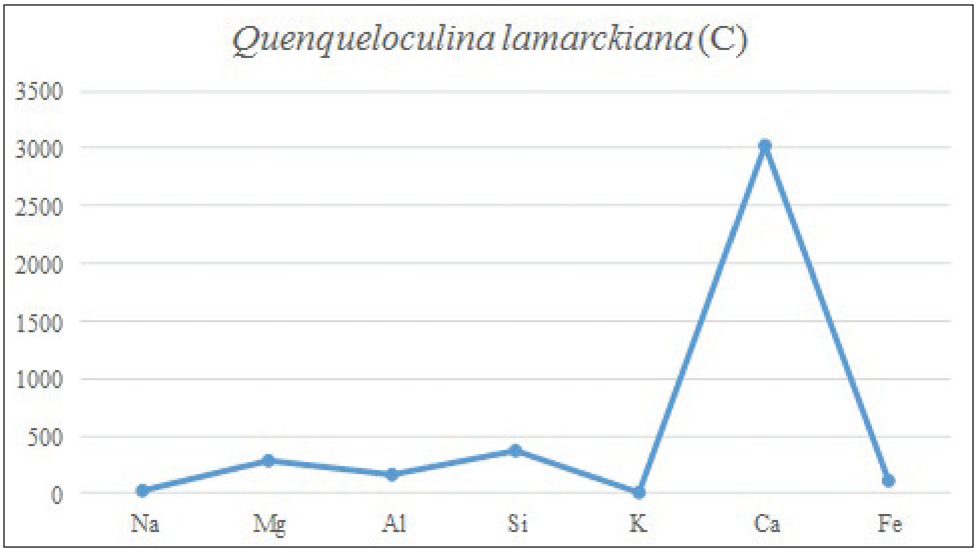

Figure 17- Distribution of elements in coloured test of *Quenqueloculina lamarckiana*.

hot springs, which occur due to the fault line/lines both on the shore areas and in the sea according to the Tuzla Fault, can be considered as the main reason of this abundance (Figure 18). Big similarities are observed between structural geological features of the region and foraminifer assemblage observed in this manner and the benthic foraminifer assemblage of the submarine water spring area located in the Kuşadası Bay (Meriç et al., 2014). It is also interesting in regional scale to encounter *Amphistegina lobifera* Larsen individuals abundantly in the NW section of the Karaburun Peninsula (Meriç et al., 2012*b*). The presence of any hot spring hasn't been detected in this area. Despite that; any *Amphistegina lobifera* Larsen individual/individuals hasn't/haven't been detected in the investigation which has been carried out on 39 samples, although there is also a thermal spring in the Çeşme Ilıca Bay (Meriç et al., 2012*a*). The temperature of the spring here was measured as 28.4°C. This value is 19.6°C in spring in the Kuşadası Bay and is 17.5°C in the surrounding area. However; the bottom water temperature is 23.3°C at sampling points taken from the Doğanbey Bay, and is 19°C in the surrounding area. Although the zoogeographic distribution and bio-ecological conditions formed by thermal activities, in which Indo-Pacific originated

Amphistegina lobifera Larsen individuals were observed, have been interpreted as regional and even point features. The case that they were observed in Marmaris, Datça, Gökova and Kuşadası Bays and in Gökçeada, and that they were heavily populated especially in the Kuşadası Bay and also to have been represented by only one individual only in one of the samples in another study carried out (Meriç et al., 2009*d*). Also, this genus in the southern part of the Dilek Peninsula and to have been quite abundant in the NW shoreline of the Karaburun Peninsula, put forward that these foraminifers mentioned in different localities of the Aegean Sea have been populated in those areas by finding suitable conditions for themselves and maintained their lives (Avşar et al., 2009; Meriç et al., 2010; Yokeş et al., 2014).

When total alfa and beta countings of the springs in the study area are correlated with other hot springs located in Çeşme-Ilıca in northwest and the Kuşadası Bay in south, sea water samples of the Çeşme-Ilıca show resemblance with other hot springs in this area (Yenal et al., 1975; Meriç et al., 2012*a*). However, the total alfa and beta countings of hot springs in the Kuşadası Bay (Güzelçamlı, Kemerli, Kuşadası Kaynağı, Doğanbey, Karakoç, Cumali) are in different values (Yokeş et al., 2014).

Special to the Doğanbey Cape samples, *Amphistegina lobifera* Larsen individuals were not observed between the depths of 3.70-7.00 m at the temperature of 23°C (22.6-22.9°C). Few individuals (3-4 individuals) were observed between the depths of 0-16 m at temperatures of 20-23°C (20-23.3°C). Between depths of 18-32 m at temperatures of 19-20°C (19-20.3°C) they are found abundantly (more than 25 individuals). According to this situation; the ideal live interval of *Amphistegina lobifera* Larsen for the region was determined between the depths of 18-32 m and nearly at the temperatures of 19-20°C. As

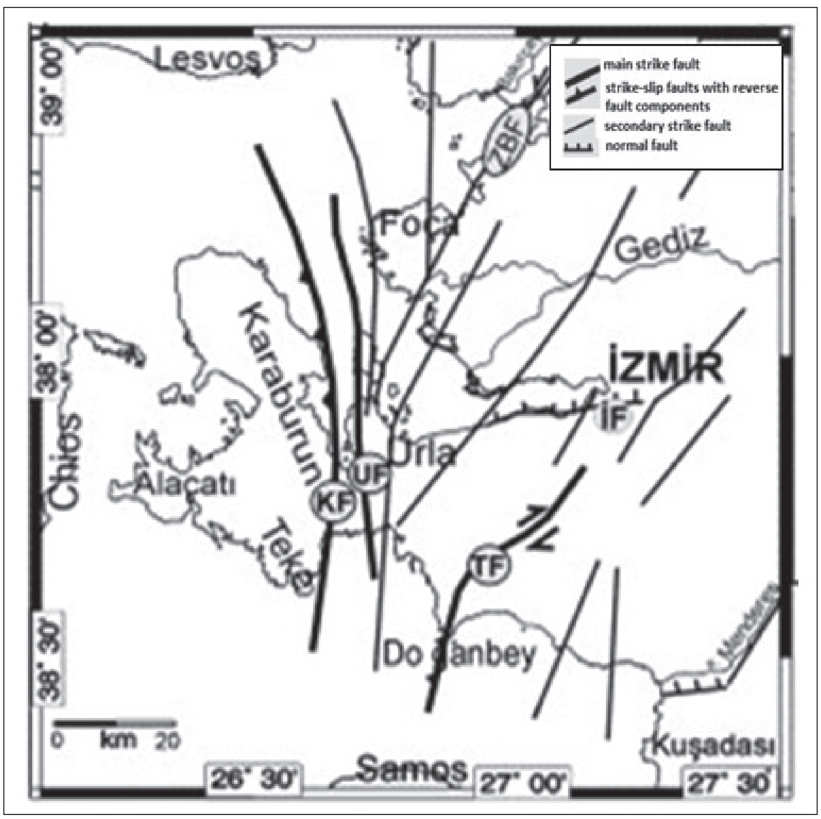

Figure 18- Identifiable and interpretable faults in Izmir and arrounding (Ocakoğlu and Demirbağ 2005).(KF: Karaburun Fault, ZBF: Zeytindağ-Bergama Fault, UF: Urla Fault, TF: Tuzla Fault, İF: İzmir Fault).

another feature, it was detected that the conductivity values have been increasing as being approached to the hot spring; however, the number of individuals have been decreasing in measurements taken by the CTD instrument (Table 7).

When these temperature values were taken into consideration, it was noticed that *Amphistegina lobifera Larsen* did not prefer warm environments. Some researchers (Zmiri et al., 1974; Langer and Hottinger, 2000; Langer et al., 2012) suggest that the change in sea water temperatures is the main cause in the distribution of amphisteginid foraminifers in Eastern Mediterranean. The reason why *Amphistegina lobifera* individuals are not encountered around the Ilıca Bay hot spring is the higher radioactivity in this area in addition to higher water temperature (Meriç et al., 2012*a*). Also, rich foraminifer, ostracod and mollusc assemblages in sediment samples 7, 8, 9, 10 and 11 puts forward the presence of a common feature for the study area (Tables 2, 3 and 4).

Table 7- Coordinate, depth, bottom temperature, salinity and conductivity values of the sampling points and the abundance distribution of *Amphistegina lobifera* Larsen.

Sample ID	Depth (m)	Temperature* (°C)	Salinity* (‰)	EC* (mS/cm)	Individual number of *Amphistegina lobifera*
1	3.7	22.9	39.2	56.4	0
2	5.5	22.9	39.2	56.3	0
3	7.0	22.6	39.2	56	0
4	5.5	22.7	39.2	56	0
12	1.0	---	---	---	0
13	0.3	---	---	---	0
15	0.2	---	---	---	0
5	7.5	22.8	39.2	56.2	1-4
6	15.9	20	39.2	53	1-4
14	0.3	23	39	56.5	1-4
7	18.0	20.3	39.2	53.3	>25
8	19.0	19.9	39.2	52.9	>25
9	31.8	19	39.2	51.9	>25
10	27.7	19.8	39.2	52.8	>25
11	21.2	20.2	39.2	53.3	>25

Another significant feature for the region is to have been encountered quite a few *Peneroplis planatus* (Fichtel and Moll) with colored tests. It was also determined that Na, Mg, Al, Si and K elements had the highest value in the colored test of *Peneroplis planatus* (test ID 18) due to the microprobe analyses carried out on tests of *Peneroplis planatus, Lachlanella variolata, Ammonia parkinsoniana*, *Quenqueloculina lamarckiana* and *Elphidium crispum* in sediment samples DB7, DB8 and DB10 (Plates 1 and 2). The values of Ca and Fe are the highest in *Ammonia parkinsoniana* (test ID 23) and *Elphidium crispum* (test ID 25), respectively. As a result, when tests and geochemical contents of the sediments were compared with each other, any parallelism or resemblance couldn't have been found. As it is in the above-mentioned regions, the activity of heavy metals and trace elements, which are contained by hot waters, can be considered for the acquisition of this property. Also, some foraminifers in which morphological defects are observed can be stated as another evidence of this opinion (figure 4 and 6 at Plate 3). However, any morphological anomaly effect of bio-ecological diversity and of environmental conditions on the distribution of ostracod and mollusc assemblages and on the individuals as pointwise wasn't observed in this study.

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PLATES

Plate 1

1. *Adelosina mediterranensis* (Le Calvez J. ve Y.). External view, sample no. 8.
2. *Adelosina mediterranensis* (Le Calvez J. ve Y.). External view, sample no. 8.
3. *Adelosina mediterranensis* (Le Calvez J. ve Y.). External view, sample no 8.
4. *Adelosina pulchella* d'Orbigny. External view, sample no. 8.
5. *Spiroloculina antillarum* d'Orbigny. External view, sample no. 8.
6. *Spiroloculina excavata* d'Orbigny. External view, sample no. 8.
7. *Cycloforina contorta* (d'Orbigny). External view, sample no. 8.
8. *Quinqueloculina lamarckiana* d'Orbigny. External view, sample no. 8.
9. *Quinqueloculina lamarckiana* d'Orbigny. External view, sample no. 8.
10. *Triloculina marioni* Schlumberger. External view, sample no. 8.
11. *Peneroplis pertusus* (Forskal). External view, sample no. 8.
12. *Peneroplis planatus* (Fichtel ve Moll). External view, sample no. 7.
13. *Peneroplis planatus* (Fichtel ve Moll). External view, sample no. 7.
14. *Peneroplis planatus* (Fichtel ve Moll). External view, sample no. 7.
15. *Rosalina bradyi* Cushman. External views, a. spiral side and b. umbilical sides, sample no. 8.
16. *Rosalina bradyi* Cushman. External views, a. spiral side and b. umbilical sides, sample no. 10.
17. *Cyclocibicides vermiculatus* (d'Orbigny). External view, sample no. 8.


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Plate 2

1. *Ammonia parkinsoniana* (‘Orbigny). External views, a. spiral side and b. umbilical sides, sample no. 8.
2. *Ammonia parkinsoniana* (‘Orbigny). External views, a. spiral side and b. umbilical sides, sample no. 10.
3. *Elphidium advenum* (Cushman). External view, sample no. 11.
4. *Elphidium crispum* (Linné). External view, sample no. 7.
5. *Elphidium crispum* (Linné). External view, sample no. 8.
6. *Elphidium crispum* (Linné). External view, sample no. 10.
7. *Elphidium crispum* (Linné). External view, sample no. 10.

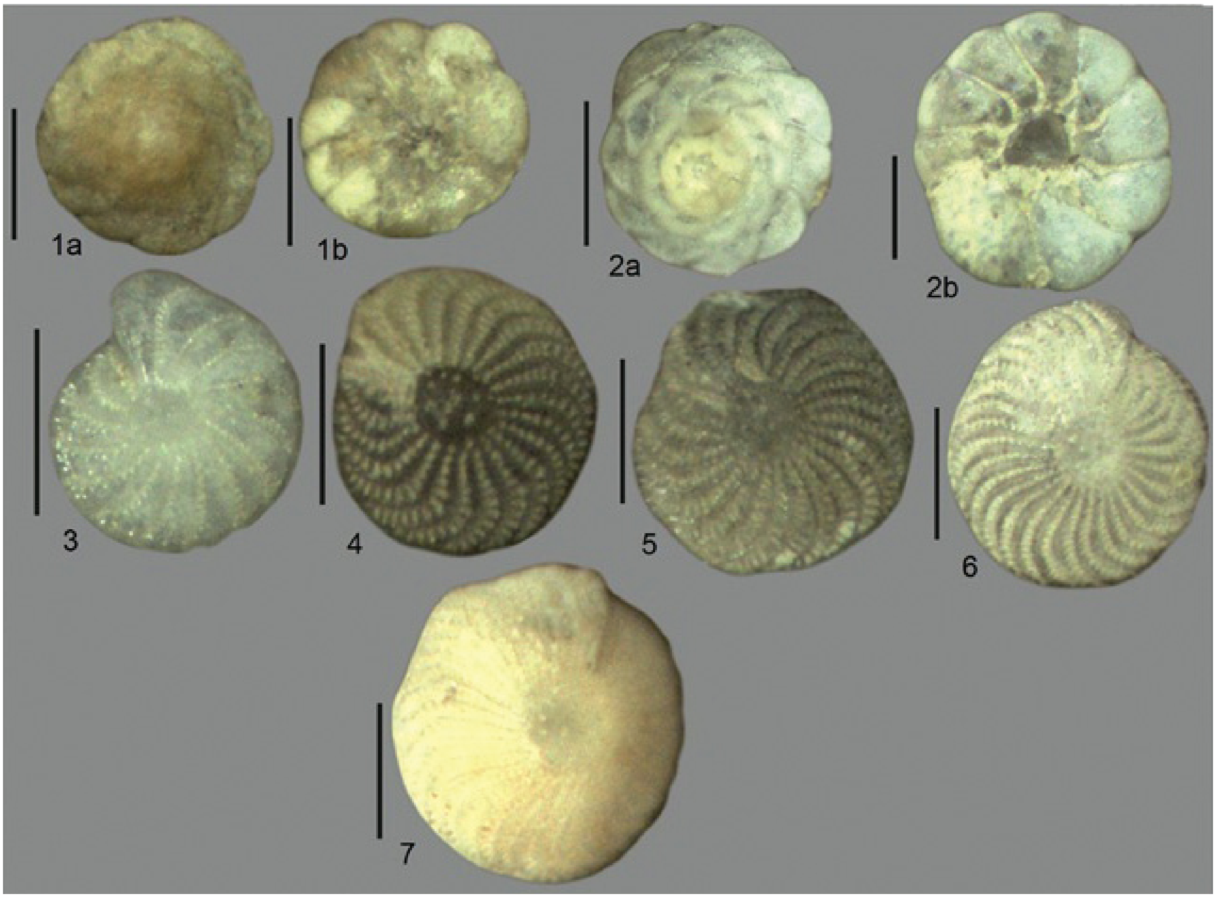
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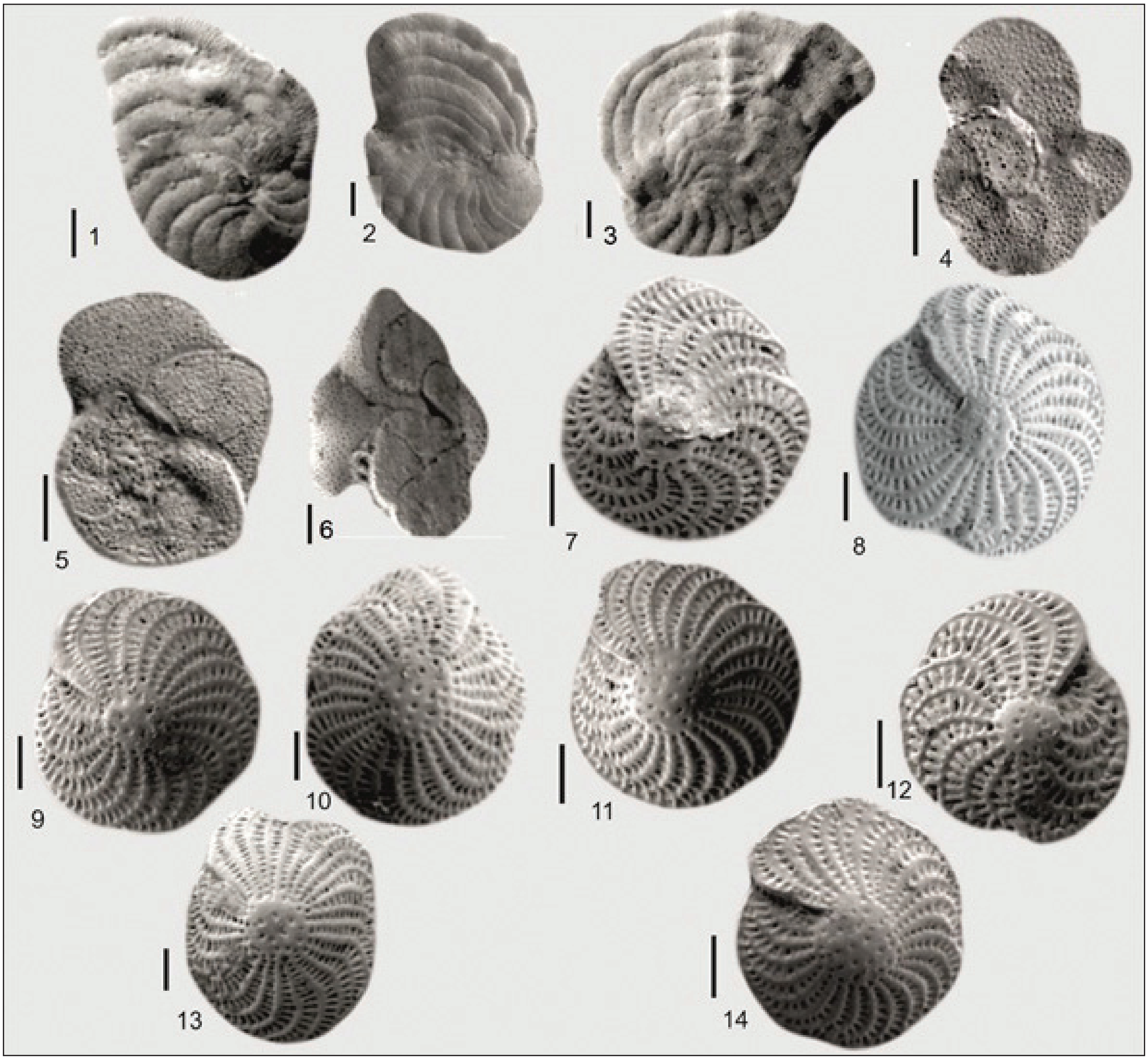
Plate 3

1. *Peneroplis planatus* (Fichtel ve Moll). External view, sample no. 7.
2. *Peneroplis planatus* (Fichtel ve Moll). External view, sample no. 8.
3. *Peneroplis planatus* (Fichtel ve Moll). External view, sample no. 8.
4. *Lobatula lobatula* (Walker ve Jacob). External view, spiral side, sample no. 11.
5. *Lobatula lobatula* (Walker ve Jacob). External view, spiral side, sample no. 11.
6. *Cibicidella variabilis* (d'Orbigny). External view, spiral side, sample no. 11.
7. *Elphidium crispum* (Linné). External view, sample no. 7.
8. *Elphidium crispum* (Linné). External view, sample no. 8.
9. *Elphidium crispum* (Linné). External view, sample no. 8.
10. *Elphidium crispum* (Linné). External view, sample no. 9.
11. *Elphidium crispum* (Linné). External view, sample no. 9.
12. *Elphidium crispum* (Linné). External view, sample no. 10.
13. *Elphidium crispum* (Linné). External view, sample no. 10.
14. *Elphidium crispum* (Linné). External view, sample no. 9.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