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THE IMPORTANCE OF BENTHIC FORAMINIFERAS IN DETECTING FEATURES OF ECOLOGICAL AND GEOLOGICAL STRUCTURES in EDREMIT BAY AND ON COASTAL AREAS OF DİKİLİ CHANNEL (NE AEGEAN SEA)

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ABSTRACT

Benthic foraminiferal assemblages from the Gulf of Edremit, Lesbos Island, Alibey and Maden islands and Dikili Bay have been investigated and various morphological abnormalities, as well as, colored tests and large sizes have been observed. Besides, abundance of alien species originating from tropical seas attracts attention. Interesting togethernesses were found between different genera and species. Significant differences were observed between the assemblages from the northwest and southeast coasts of the Gulf of Edremit. 57 genera and 97 species were identified in the samples from the northwest coast, where as only 32 genera and 48 species were found on the southeast coast. A diverse foraminifer assemblage were observed around the Ayvalık-Alibey and Maden islands, with large individual sizes, colored tests and morphological abnomalities. Abnormal togethernesses between different genera and species were also observed in this locality. Togethernesses between Peneroplis pertusus (Forskal)-Coscinaspira hemprichii Ehrenberg and Peneroplis planatus (Fichtel and Moll)- Coscinaspira hemprichii Ehrenberg are important findings in the benthic foraminiferal assemblages of Ayvalık Alibey and Maden islands. Orange and brown coloration observed on many Peneroplis pertusus (Forskal) and P. planatus (Fichtel and Moll) individuals is another important finding in this region. Besides, many individuals of Peneroplis pertusus (Forskal), P. planatus (Fichtel and Moll), Lobatula lobatula (Walker and Jacob), Cibicidella variabilis (d'Orbigny), Ammonia compacta Hofker, A. parkinsoniana (d'Orbigny), Challengerella bradyi Billman, Hottinger and Oesterle, Elphidium complanatum (d'Orbigny) and E. crispum (Linné) were found. The presence of Laevipeneroplis karreri (Wiesner), Peneroplis pertusus (Forskal) and P. planatus (Fichtel and Moll) and Sorites orbiculus Ehrenberg on the east coast of Lesbos Island indicates the presence of hotwater springs. An abnormally large Peneroplis planatus (Fichtel and Moll) individual were found. Besides, many Peneroplis pertusus (Forskal) and P. planatus (Fichtel and Moll) individuals with orange-yellow tests, like the ones in Ayvalık, were found, suggesting the presence of submarine springs with Fe content. An abnormal Peneroplis planatus (Fichtel and Moll) individual with three different apertures was found in Dikili samples. One of the apertures was typical of the species, whereas the other two have the aperture characteristics of Coscinospira hemprichii Ehrenberg. The aim of our study is to figure out the factors leading to abnormal test morphologies. It is suggested that the benthic foraminiferal assemblages found in the study area are affected by the physical environmental conditions such as, temperature and salinity, as well as the chemical factors, such as radioactivity.

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1. Introduction

Studies were carried out for benthic foraminiferas on the coasts of Edremit Bay, on the northwestern coasts of the Lesbos Island, in the vicinity of Alibey and Maden Islands of Ayvalık and onthe eastern coasts of Dikili Bay. During these studies the coarsening and coloring in tests, the remarkable morphological abnormality, the abundance of tropical sea types, the presence of individuals showing association between various genera and species and gypsum crystals which had been observed in sediments have revealed that different ecological environments took place in these localities (Figure 1) (Meriç et al., 2002, 2003*a* and *b*, 2008, 2009, 2012*a*).

2. Coastal areas of the Edremit Bay

When 18 young sediment samples which had been collected from the northwestern and southeastern parts of the Edremit Bay were studied, it was seen that there had been a great privilege between the benthic foraminiferal assemblages in which they contain. It was detected that 7 samples which were taken at depths of 15.00 – 334.50 meters in northwest had contained 57 genera and 97 species. However, total of 32 genera and 48 species were found in 11 samples collected on southeastern coasts. The privilege between the two regions makes us consider that there are different ecological conditions between these localities. Again, in 2 samples at northwest, *Peneroplispertusus* (Forskal), *P. planatus* (Fichtel and Moll) and *Cibicidellavariabilis* (d'Orbigny), which prefer tropical conditions, to be observed in 3 samples in this region clearly reveal that different environmental conditions developed in northwest with respect to the southeast. This area, in which the Edremit Bay is located, is the region where there are evident tectonic features the Aegean Sea possesses (Figure 1). There is observed an EW trending fault from the north of the bay (Boztepe-Güney et al., 2001). Apart from these, cold springs beneath the sea around Akçay and Ören and the presence of Küçükçetmi, Bostancı, Güre and Zeytinpınarı hot springs of which their water temperatures vary between 20- 59.5 °C is,on the contrary, one of the reasonshowing the significance of tectonism in the region. Another characteristic of the Biga Peninsula is that it has geothermal springs at south which vary between temperatures of 41-102 °C (Erişen et al., 1996; Şaroğlu et al., 2003). This feature can also be considered as there might be hot springs in the bay.

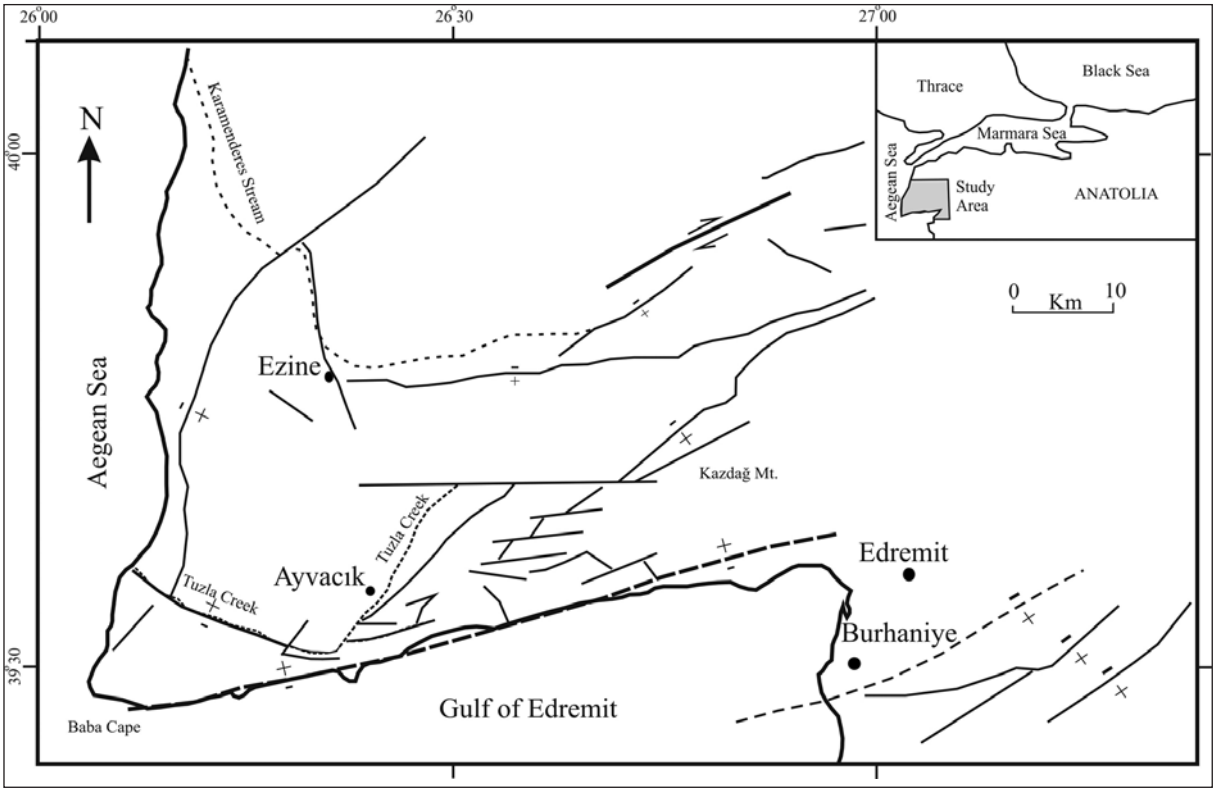

Figure 1- Fault map of the Biga Peninsula (modified from Boztepe-Güney et al., 2001).

In another investigation which was carried out in Edremit Bay, 11 samples were studied in terms of foraminiferas. The sediment sample number 2 which was taken from a depth of 82.00 meters was observed that it had contained 30 genera and 45 species. This situation reveals the presence of the most abundant genera and species of foraminifera in the region in one of 11 samples studied. However, *Eponidesconcameratus* (Williamson) and some other foraminiferal tests observed in the same sample at a size larger than 0.5 mm indicates the abundance $CaCO_3$ intake (58.1 %) in this locality in the study area (Meriç et al., 2012*a*). Also, when the foraminiferal assemblage of 4 samples collected from the eastern part of the Dikili channel (Figure 2) was studied, it was seen that number of species had varied between 32 and 41. Nevertheless, the presence of *Peneroplispertusus* (Forskal), *P. planatus* (Fichtel and Moll) which live in tropical conditions is another data supporting this idea. As a result, data obtained makes us think that there might be some thermal springs also beneath the sea like in coastal areas which developed due to the tectonismextending from north of Edremit Bay to the eastern coasts of the Dikili channels (Figure 1).

3. Alibey and Maden Islands

Total of 4 cores were drilled below the sea around Alibey and Maden Islands in northwest of Ayvalık with thicknesses varying 42 to 52 cm. In these sedimentary deposits, the abundance of *Peneroplispertusus* (Forskal) and *Peneroplisplanatus* (Fichtel and Moll) individuals were observed which are colored within an association of a rich benthic foraminiferal assemblage, several genera and species' such as *Peneroplispertusus* (Forskal), *P. planatus* (Fichtel and Moll), *Lobatulalobatula* (Walker and Jacob), *Cibicidellavariabilis* (d'Orbigny), *Ammonia compacta*Hofker, *A. parkinsoniana* (d'Orbigny), *Challengerellabradyi* Billman, Hottinger and Oesterle, *Elphidiumcomplanatum*(d'Orbigny), *E. crispum* (Linné) which show morphological abnormality and abnormal individuals presenting *Peneroplispertusus* (Forskal)-*Coscinospirahemprichii* Ehrenberg, *Peneroplisplanatus* (Fichtelve Moll)-*Coscinaspirahemprichii* Ehrenberg association. The abundance of individuals with coarse test belonging to genera and species' mentioned above indicates the abundance of $CaCO_3$ intake in this area. Again, there was observed abundant gypsum crystals in core section 3a between 28 – 45 meters starting from sea bottom. The presence of gypsum crystals which formedaround *Challengerellabradyi* Billman, Hottinger and Oesterle, *Elphidiumcrispum* (Linné) individuals and *Posidonia* fragments is an important feature for the region (Meriç et al., 2009). This situation shows that, there have been geothermal springs beneath the sea in recent (Figure 2) (Meriç and Suner, 1995; Meriç et al., 2003 and 2009).

4. Lesbos Island

Young sediment sample taken beneath the sea contains a rich benthic foraminiferal assemblage in east of PirgiThermis, the northeast of Mytilene settlement(southeast of Lesbos Island) (Figure 2). *Laevipeneropliskarreri* (Wiesner), *Peneroplispertusus* (Forskal) and *P. planatus* (Fichtel and Moll), *Soritesorbiculus* Ehrenberg among these assemblages reveal the presence of tropical conditions in this area. Besides; the occurrence of many *Peneroplispertusus* (Forskal) and *P. planatus* (Fichtel and Moll) tests in Ayvalık like orange – yellow color indicates the presence of iron bearing groundwaters in this area as well (Murray, 2006; Yalçın et al., 2008; Meriç et al., 2009, 2012 *b* and *c*). Especially, the assemblage in this region has shown its privilege with respect to the other 4 investigated points. There are many hot springs which have the characteristics of saline water with a temperature varying around 39.7, 43.5, 46.5, 46.9 and 69°C in southern and southeastern parts of the Island (Meriç et al., 2002). Therefore, the development of a different foraminiferal fauna similar to sebhkas in deserts around springs to develop because of thermal influxes is normal around young faults below the sea and in their close vicinities.

5. Dikili Bay

In 2 of 9 samples collected from the northern and southern coasts of the Dikili Bay, the presence of *Peneroplispertusus* (Forskal), *P. planatus* (Fichtel and Moll) and *Cibicidellavariabilis* (d'Orbiginy) which have various test shapes were identified. *Peneroplisplanatus* (Fichtel and Moll) individual among these presents a great abnormality in morphology. The aperture of the test developed in three different sections. One of them is single order aperture typical for it. However, the other two have the characteristics of *Coscinospirahemprichii* Ehrenberg. Apart from that, one *Rosalina* sp. and *Elphidiumcrispum* (Linné) individuals observed in the same region show abnormality in morphology. There are hot springs of which their temperatures

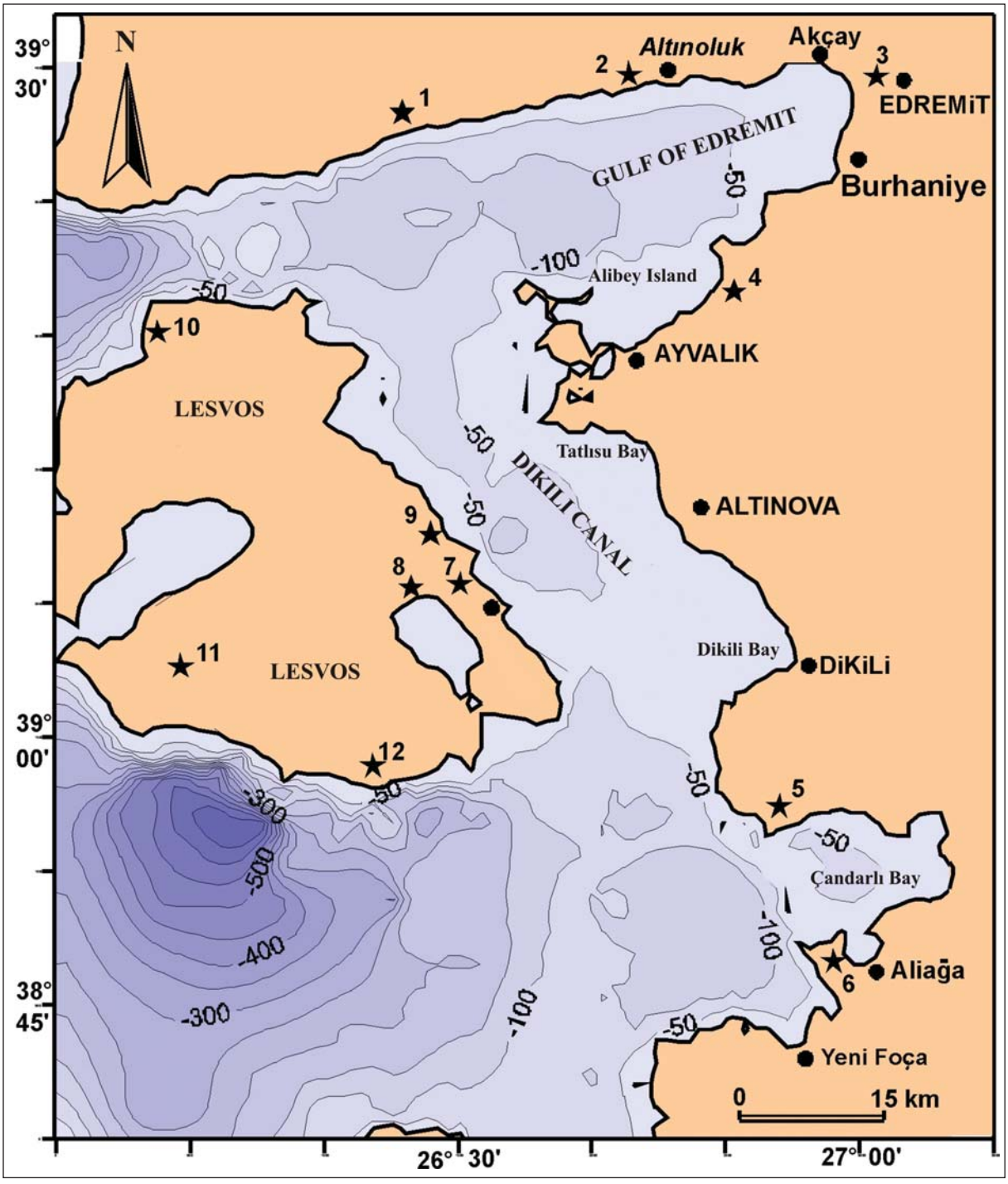

Figure 2- The bathymetry of Edremit Bay and Dikilie channel and hotsprings. (★ 1. Küçükçetmi, 2. Bostancı, 3. Güre, 4. Zeytinpınarı, 5. Bademli, 6. Ilıcaburun, 7. Pirgi Thermis, 8. Larisos, 9. Paralia Thermis, 10. Molivos, 11. Polichnitos and 12. Melinta hot springs)

vary between 40 – 60°C both on land and in the sea in Bademli and Aliağa Ilıcaburun along the road of Dikili – Çandarlı coast (Figure 2) (Meriç et al., 2003*b*). So, it is considered that there might be thermal springs which have heavy and trace elements having abnormal characteristics in or around the localities from where these samples were taken. That is why some benthic foraminiferal individuals have abnormally evolved.

6. Discussion and Resulsts

Due to the fault and/or faults located in the southern part of the Biga peninsula and in coastal areas of the Aegean Sea (Şaroğlu et al., 1992; Çiftçi et al., 2010), hot or cold springs have developed below the sea, similar to land areas. The abundance of $CaCO_3$ amount in compositions of these hot and cold springs, the springs of which their temperatures vary between 20-59°C along coastal areas, and the presence of geothermal springs which their temperatures reach 41-102°C indicate some geothermal springs under the sea. However, the presence of similar springs at eastern coasts of the Lesbos Island supports this idea (Meriç et al., 2003*a* and *b*).

The observation of a different life around the thermal spring at a depth of 10 meters, in south of Milos Island in Aegean Sea (Thierman et al., 1997) reveals thermal gains in areas where young faults are located in. Again, the presence of hydrothermal springs around many islands on Hellenic Island Arc supports this idea (Varnavas et al., 1999).

As for the study carried out in Haifa Bay, samples presenting a morphological abnormality at 30% among benthic foraminifers belonging to 217 species were encountered and the reason for this abnormality was shown as the presence of heavy metals in the composition of sea water (Yanko et al., 1998). The presence of heavy metals was again shown as a reason for the deformation of tests of foraminiferas (Yanko et al., 1999). In another study, the assumption that there was a relationship between tests of benthic foraminiferas showing abnormality in morphology and heavy metal in sea waters were assessed (Debenay et al., 2001).

There are not many streams or a stream network having the sediment charge capacity around Edremit Bay or the Dikili Channel. The interaction of groundwater with host rocks during its circulation, the intake of heavy and trace elements into its body and to transform it into mineralized spring in many locations in the sea could be considered as a reason for the increase in heavy metal values in marine environment mentioned. Clearly stating, the nature is not only affected by mankind.

In the regional investigation carried out among Edremit Bay, Alibey and Maden Islands, Dikili Bay and Lesbos Island, 143 samples were studied and 45 of them were chemically analyzed (Meriç et al., 2009, 2012*a*). Cu, Pb, Ni, Co, Mn, Cr, Fe and Al analyses were performed in samples taken from Edremit Bay (Meriç et al., 2012*a*). As a result, there was not observed any metal increase related to the expected depth in normal marine conditions as the environment is shallow marine and various marine and terrigenous environments are effective. However, the metal enrichment in Edremit Bay originates from metal ores located in NW Aegean region. As for the samples from Dikili Channel, the reason for metals to be in high content are especially the terrigenous gains flowing from Madra stream (Meriç et al., 2012*a*).

There were found heavy metals such as Cu, Co, Ni, Cr, Zn, Fe and Mn in 32 samples taken from cores 1b, 2a, 3b and 4a around Alibey and Maden islands (Meriç et al., 2009). It is clear that these were formed as a result of heavy metals which reached the sea by means of groundwaters through mine deposits along fault lines. However, according to foraminiferalassemblages in other cores, the biodiversity at this point is quite less. Apart from high Fe and Mn contents, the decrease in mollusk, ostracoda and *Posidonia* amounts observed in cores is another remarkable feature. Hence, it is understood that, groundwaters containing heavy metal and trace element have generated hydrothermal spring/springs and changed ecological conditions by reaching the sea by means of faults in or around this area (Meriç et al., 2009). Core number 4b shows a clear difference compared to other ones. All individuals are red brown, orange, yellow and partly gray colored in the community in which *Peneroplispertusus* (Forskal), *Peneroplisplanatus* (Fichtel and Moll), *Coscinaspirahemprichii* Ehrenberg are dominant. Also, the appearance of the sediment in red brown is a different character.

Hot or cold outflows beneath the sea, which were detected in mny location and are considered to have been still, are significant findings both to monitor fault lines in the sea and to determine its effect on temporal submarine life. Therefore, it is necessary to consider extraordinary characteristics such as; biodiversity in benthic foraminifers, test size/sizes in individuals, coloring on tests and morphological abnormality and common development among different genera and species'.

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