BULLETIN OF THE MINERAL RESEARCH AND EXPLORATION

Foreign Edition 2003 Number: 127

CONTENTS

PUBLICATION MANAGER
Nesrin Gülgün HASBAY
e-mail: gulgun@mta.gov.tr

POSTAL ADRESS
Editor Bulletin of Mineral Research and Exploration
Maden Tetkik Arama ve Genel Müdürlüğü
Jeoloji Etütleri Dairesi 06520 ANKARA
editorluk@mta.gov.tr

The English and Turkish issues of the "Bulletin of the Mineral Research and Exploration" can be obtained from "BDT Dairesi" with charge, either directly or with correspondance and paying the mailing fee as well,
e-mail: bdt@mta.gov.tr

Notes to the authors, format and copyright from and PDF files of the papers published in this bulletin can be tound in www.mta.gov.tr

ISSN : 0026 - 4563

Mineral Res. Expl. Bull., 127, 1-14, 2003

A NOTE ON THREE ABNORMAL SAMPLES OF BENTHIC FORAMINIFERS FROM THE DİKİLİ BAY (TURKEY) IN THE NORTHEASTERN AEGEAN SEA: ***Peneroplis planatus*** (Fichtel and Moll), ***Rosalina*** sp., and ***Elphidium crispum*** (Linne)

Engin MERİÇ*; Niyazi AVŞAR**; Fulya BERGİN*** and İpek F. BARUT*

ABSTRACT.- Three of nine foraminifer samples collected from the Dikili Bay in the northwestern Aegean Sea yielded three species demonstrating aberrance in development: *Peneroplis planatus* (Fichtel and Moll), *Rosalina* sp. and *Elphidium crispum* (Linne). We suggest that the cause for such abnormalities may well be thermal springs, which are known to exist in the regions of the Dikili Bay and the Island of Lesbos to the west, and correspondingly high proportion of certain elements in the waters.

INTRODUCTION

The area of the NE Aegean from which the samples are collected is shown in figure 1. Dikili Bay is situated on the western coast of Anatolia between the Gulf of Edremit (to the N) and the Gulf of Çandarlı (to the S), just opposite the Greek Island of Lesbos.

Along the western coast of Turkey, the temperature of the Aegean has been recorded as varying from 9 to 26 °C, with an oxygen content ranging from 4 to10 ml/l (Artüz 1970, Benli and Küçüksezgin 1988, Ergin et al., 1993a). It is thus a relatively warm and well-aerated environment.

In the Middle Miocene, posterior to the collision of the Arabian and Anatolian plates the region began to expand (Şengör and Yılmaz, 1981), shifted westward between two faults: the Northern and Western Anatolian faults. Consequently, an E-W graben system developed (Arpat and Şaroğlu, 1975; McKenzie, 1977; Turgut, 1987; Mascle and Martin, 1990; Yılmaz, 1990) with thermal springs-judging from the existence of those known-likely to appear along the fault lines (Şaroğlu et al., 1992).

The purpose of this paper is to suggest that the quality and quantity of the chemical trace elements supplied by the thermal springs are related to the fault activity in the area that cause aberrant formations in the species of various benthic foraminifer in the Dikili Bay.

FACILITIES AND METHOD OF RESEARCH

In 1996, the research vessel Sismik-1 of the MTA equipped with a Van Veen Grab scoop was able to sample various areas of the seabed in the bay (Fig. 1). Although the coordinates and depth were specified, we had no record of the submarine environment (i.e., temperature, salt content, pH and oxygen content). The depth of the seabed from which the nine samples were recovered ranges from 16 to 49 m.

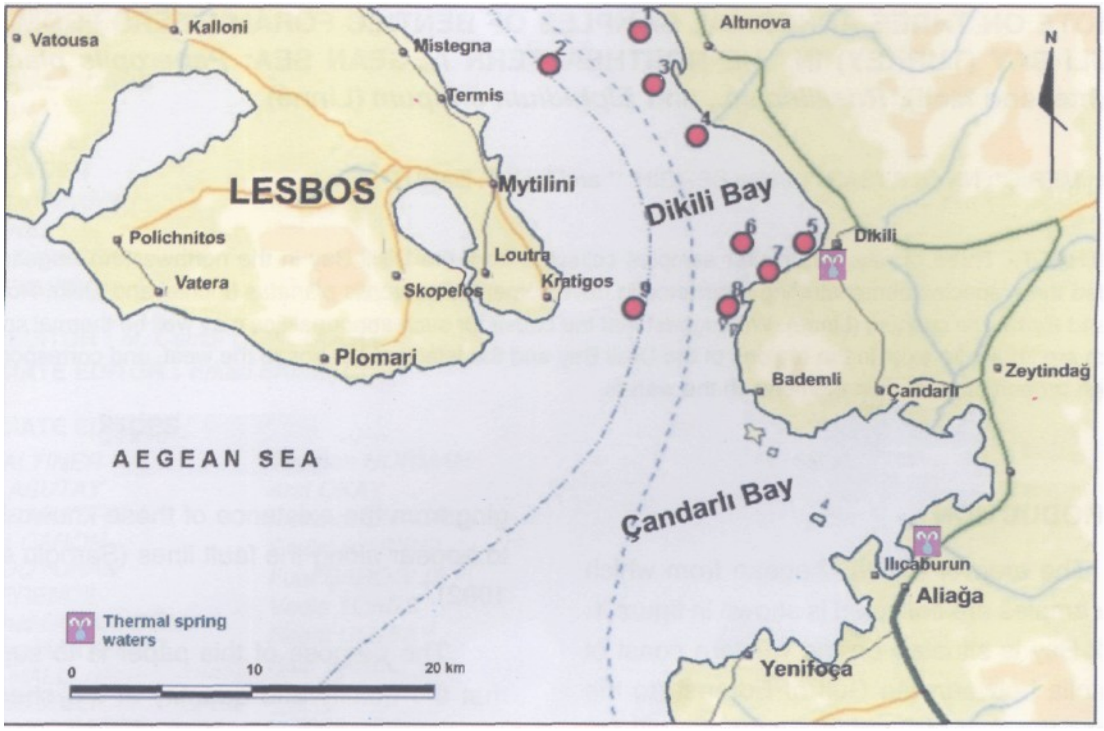

Fig. 1- Location map of the Dikili Bay (Northeastern Aegean Sea) and sampled localities.

THE EVIDENCE

The nine samples inspected for present-day foraminifers in the Dikili Bay (Samples 1-9, Fig.1) proved both plentiful and informative. From depths of 16 to 49 m, we were able to identify 86 benthic foraminifers of at least 50 separate species (Table 1). The literature most helpful in identifying the species includes Cimerman and Langer, 1991; Hatta and Ujiie, 1992; Sgarella and Moncharmont-Zei, 1993; Hottinger et al., 1993; Loeblich and Tappan, 1994; Meriç et al., 1995; Hayward et al., 1999; Meriç and Avşar, 2000 and 2001; Avşar and Meriç 2001 *a-b,* Meriç et al., 2002a, 2003 and 2004; we have attempted to include the most recent sources.

Of note among this benthic life in general are the verification of the foraminifer species *Peneroplis pertusus* (Forskal) at sites 3 and 5, and the presence of progeny of *Cibicidella variabilis* (d'Orbigny) with their unusual shell formations at sites 1, 5, 7 and 8.

Specific to the subject under discussion are single examples of *Peneroplis plantus* (Fichtel and Moll), *Rosalina* sp., and *Elphidium crispum* (Linne) that demonstrate aberrant morphology. The *Peneroplis planatus* (Fichtel and Moll) individual from site 2 displays two abnormal cylindrical protuberances toward the tip (one to the left and one to the right on the second and third units and from the end), both of which most obviously incorporate a mouth. A break at the very tip suggests that there may have been a third protuberance as well (Fig. 2a). While other individuals of *Peneroplis planatus* (Fichtel and Moll) and *P.pertu-*

sus (Forskal) from the neighbouring waters displayed no such abnormalities, aberration was also encountered in the shell formation of sample No. 3 (*Rosalina* sp.), which demonstrates four protuberances-two very prominent-at the sides/along the lateral walls (Fig. 2b). Because of this irregularity in shape, we remain hesitant to assign this individual to any particular species. Sample number 2, an individual of *Elphidium crispum* (Linne), also represents pronouncedly aberrant development as abnormal swellings apparent on the contour (Fig. 2c).

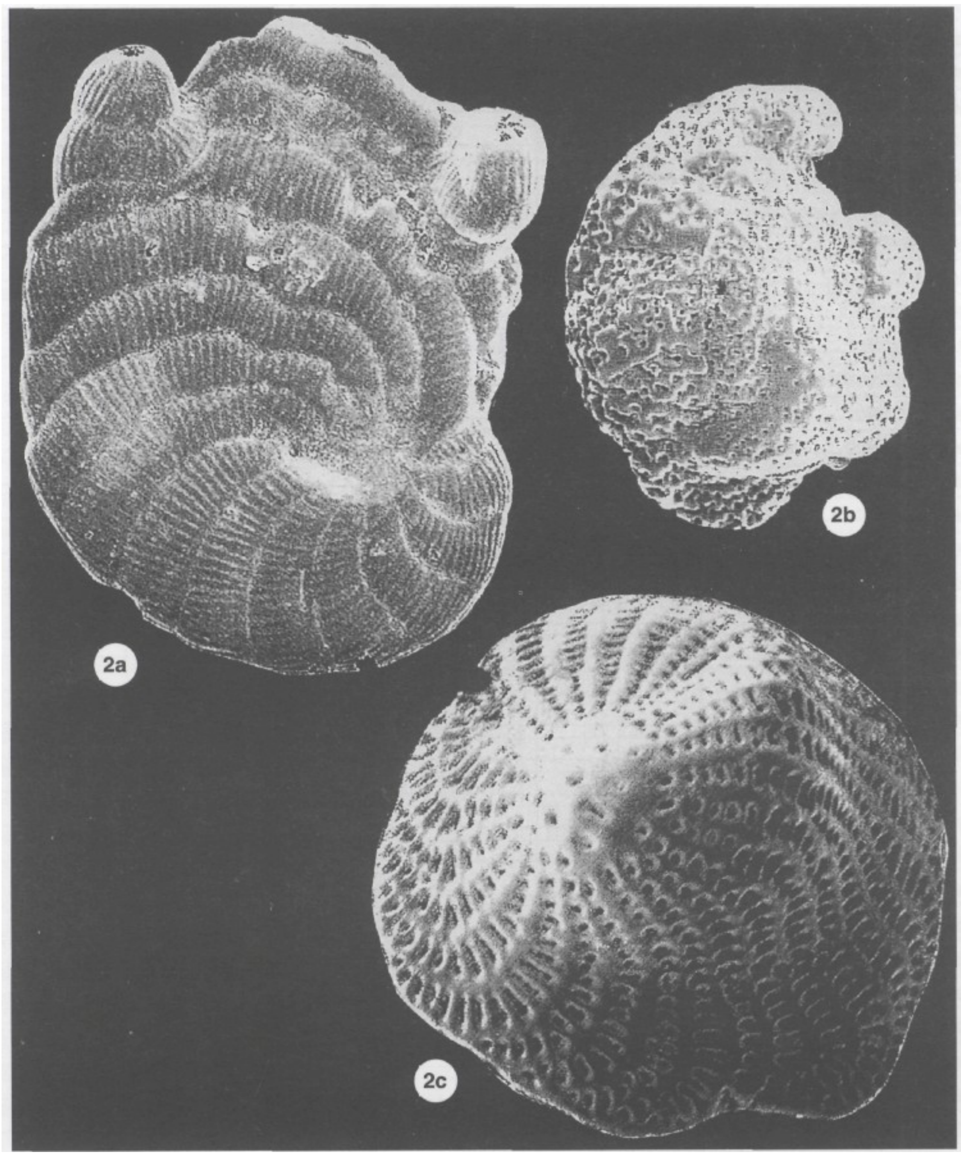

Fig. 2- External views of tests, displaying abnormal morphologies;
2a: *Peneroplis planatus* (Fichtel and Moll), x100;
2b: *Rosalina* sp., x100 ve
2c: *Elphidium crispum* (Linne) x100

Table. 1- Distributions of benthic foraminiferal genera and species from recent samples at the Dikili Bay.

FORAMINIFERA	STATIONS								
	DC1	DC2	DC3	DC4	DC5	DC6	DC7	DC8	DC9
Depths (meter)	16.00	39.50	18.50	18.50	18.00	34.00	35.00	35.80	49.00
Lagenammina fusiformis		★	★					★	
Labrospira subglobosa	★								
Discammina compressa			★					★	
Spiroplectinella sagittula		★						★	★
Ammoglobigerina globigeriniformis								★	
Eggerelloides scabrus	★		★	★	★			★	
Textularia bocki	★	★	★		★	★	★	★	★
Textularia truncata		★						★	
Connemarella rudis									★
Vertebralina striata	★		★		★			★	
Nubecularia lucifuga	★				★			★	
Cornuspira foliacea								★	
Adelosina cliarensis	★	★	★		★	★	★	★	★
Adelosina duthiersi		★	★			★	★	★	
Adelosina mediterranensis	★	★	★		★	★	★	★	★
Adelosina partschi		★	★			★	★	★	★
Adelosina pulchella		★	★		★		★	★	★
Spiroloculina angulosa		★							
Spiroloculina dilatata		★	★		★				
Spiroloculina excavata	★	★	★		★	★	★	★	
Spiroloculina ornata	★	★	★		★	★	★	★	★
Siphonaperta aspera	★	★	★		★	★	★	★	★
Cycloforina contorta	★	★	★		★		★	★	★
Cycloforina rotunda						★			
Cycloforina villafranca		★	★		★	★	★	★	★
Lachlanella bicornis	★		★		★		★	★	★
Lachlanella undulata	★	★						★	
Lachlanella variolata					★			★	
Massilina gualtierina	★		★		★				
Quinqueloculina berthelotiana	★	★	★		★	★		★	
Quinqueloculina bidentata	★	★			★	★	★	★	★
Quinqueloculina disparilis			★		★				
Quinqueloculina jugosa		★			★	★	★		★
Quinqueloculina lamarckiana	★	★	★		★			★	★
Quinqueloculina limbata		★	★						
Quinqueloculina seminula	★	★	★	★				★	★
Miliolinella elongata								★	
Miliolinella semicostata		★			★			★	
Miliolinella subrotunda	★	★	★		★	★	★	★	★
Miliolinella webbiana	★	★	★		★			★	
Pseudotriloculina laevigata	★	★	★		★		★	★	★
Pseudotriloculina oblonga	★	★	★		★		★	★	★
Pseudotriloculina rotunda	★	★	★		★		★	★	★

Continue to Table 1.

FORAMINIFERA	STATIONS								
	DC1	DC2	DC3	DC4	DC5	DC6	DC7	DC8	DC9
Depths (meter)	16.00	39.50	18.50	18.50	18.00	34.00	35.00	35.80	49.00
Pseudotriloculina sidebottomi	★								
Pyrgo inornata		★							
Triloculina marioni	★	★	★	★	★		★	★	★
Triloculina plicata		★			★			★	
Triloculina schreiberiana		★		★	★			★	
Triloculina tricarinata	★				★			★	★
Sigmoilinita costata	★	★	★		★	★	★	★	★
Sigmoilinita edwardsi					★		★		
Articulina carinata								★	
Parrina bradyi		★			★			★	
Peneroplis pertusus			★		★				
Peneroplis planatus			★		★				
Lenticulina cultrata								★	
Valvulineria bradyana								★	
Polymorphina sp 1		★	★					★	
Reussella spinulosa								★	
Eponides concameratus		★						★	★
Neoeponides bradyi		★	★		★	★	★	★	★
Neoconorbina terquemi					★				
Rosalina bradyi	★	★		★	★	★	★	★	★
Rosalina floridensis								★	
Rosalina globularis		★							
Pararosalina dimorphiformis					★		★	★	
Planoglabratella opercularis		★						★	★
Discorbinella bertheloti		★					★		
Lobatula lobatula	★	★	★		★	★	★	★	★
Planorbulina mediterranensis	★	★	★		★			★	
Cibicidella variabilis	★				★		★	★	
Acervulina inhaerens					★			★	
Sphaerogypsina globula									★
Asterigerinata mamilla		★	★		★	★		★	★
Astrononion stelligerum	★	★	★		★	★	★	★	★
Melonis pompilioides								★	
Ammonia compacta	★	★	★	★	★	★	★	★	★
Ammonia parkinsoniana	★	★	★	★	★	★	★	★	★
Ammonia tepida	★	★	★	★	★		★	★	
Chalangerella bradyi		★	★				★		★
Cribroelphidium poeyanum					★		★	★	
Porosonion subgranosum		★	★	★	★	★	★	★	
Elphidium aculeatum	★	★	★		★			★	
Elphidium advenum	★	★	★	★	★		★	★	★
Elphidium complanatum	★		★		★			★	

EVALUATION

Both Associate Professor Gültekin Tarcan (Dokuz Eylül Univercity) and Dr. Levent Çetiner (of the MTA Aegean Directorate) agree that the abnormalities in the specimens presented here (personal communications, June 2002) might well be the result of thermal springs activated by the faults in the region (Fig. 1). Particularly of note here are the hot springs on the mainland and the seabed at Bademli (along the coastal road between Dikili and Çandarlı) and on the promontory of Ilıcaburun (Türkiye Madensuları 3: Ege Bölgesi, 1974; Türkiye Mineralli Su Kaynakları 1: Ege-Bolgesi, 1999). Analyses from these sources are shown in table 2.

Furthermore, along the east coast of Island of Lesbos facing the Gulf to the west we have scattered series of thermal springs introducing water of various temperatures into the environment, most of these reflecting the chemical contents of the seawater. (Meriç et al., 2002b). Considering the existence of such sources on or near the mainland, we would suggest that there might well be hot marine springs affecting the environment in which samples 3 and 5 have been recovered. Such marine sources, with either over- or under-balance of N, I, Va, Li, Fe, Nb, Rb, Zn, Co, P, Mo, Cd or Hg might have easily affected the shell development of these two benthic organisms (Ivanoff, 1972; Tait, 1981; Meriç et al., 2002c). Likewise, the appearance of distinctly

Table 2- Chemical composition of the thermal mineral waters of southern part of Dikili Bay and vicinity of Çandarlı Bay (Türkiye Maden suları (3), Ege Bölgesi, 1974; Türkiye Mineralli Su Kaynaklan (1), Ege Bölgesi, 1999).

Physical and chemical compositions		DİKİLİ-BADEMLİ(1974)	DİKİLİ-BADEMLİ(1995)	ALİAĞA - ILICABURUN(1995)
Temperature (°C)		42	59	51,4
PH		6,24	6,61	6,72
EC (μs/cm)		10500	25000	48400
Rn^{222} (Bekerel)		767,75		
NH_4^+	(mg/l)		6,250	4,34
Na^+	(mg/l)	2634,1	2630,1	6322,25
K^+	(mg/l)	246,5	187,68	262,75
Ca^{2+}	(mg/l)	251,29	128	701,6
Mg^{2+}	(mg/l)	82,76	72,9	643,95
Fe^{2+}	(mg/l)	0,65	2,16	0,79
Al^{3+}	(mg/l)	0,39	0,24	0,1
Cl^-	(mg/l)	4433,2	4115,75	11436,91
I^-	(mg/l)	0,15	0,15	0,8
Br^-	(mg/l)		0,012	14,5
Fl^-	(mg/l)	2,16	2,15	2,45
SO_4^{2-}	(mg/l)	200	262,5	1625
NO_3^-	(mg/l)	0,27	0,33	4,2
CO_3^-	(mg/l)	-	0	0
HCO_3^-	(mg/l)	683,2	694,36	798
$HAsO_4^{2-}$	(mg/l)	0,12	0,11	0,012
H_2SiO_3	(mg/l)	150,8	122,38	1,1
HBO_2	(mg/l)	95,07	93,14	4,8

coloured Peneroplis shells found S and SE of Bozcaada and off the E coast of Lesbos, as well as the remarkably large proportions of the shells of the same species recovered from a depth of 2.5 m in the warm environment (59 ˚C) of the Ilıca Bay near Çeşme, have been accredited to recent-and perhaps still productive-thermal springs in the seabed (Meriç 1986; Meriç and Avşar 2000; Avşar and Meriç 2001b; Meriç et al., 2002a and b; Yalçın et al., 2003).

Evidence of shell deformation in 30% of the benthic foraminifer (217 species) is noted from the Bay of Haifa in Israel (Yanko et al., 1998). These anomalies have been linked to the presence of heavy metals in the water (see Yanko et al., 1999 for further speculation). The presence of heavy metals has also been suggested as a possible cause of anomalies in the shell structure of foraminifera in the area of the French Isle of You. (Debenay etal., 2001).

The geological characteristics of the region discussed above reflect the gradual movement of the western Anatolian plate, characterized first by the N-S compression of paleotectonic evolution, but later (during neotectontic development) by N-S expansion. The primary faults and graben system in western Anatolia developed during this latter period. Most of the thermal springs appear along these faults and grabens. The marble and limestone schist in the metamorphic rocks of the Menderes massif (marble, quartzite, and limestone schist, and as well as other schist and gneiss) provided convenient passage for the major thermal aquifer, thus providing input for the underground reservoirs in the Bayındır region of Izmir (Barut et al., 2003). Recent hydro-geological research and studies carried out by various scholars suggest that the Kozak region northeast of Dikili is the source of much of the water collected in the Bayındır reservoirs. This model postulates a route transporting surface water deep underground, where it is heated in the graben and other tectonic zones (facilitating its movement through the bedrock) and eventually forms a geothermal reservoir (Barut et al., 2003).

Studies have shown that the source of all thermal springs is surface water that has penetrated the ground and been heated by geothermal/tectonic phenomena, eventually returning to the earth's surface through faults and cracks (Erişen et al., 1996).

Figure 3 tabulates the chemical composition of the mineral waters of the region evaluated on the basis of a Piper diagram (Piper, 1953). In this figure, it is seen that water rich in Mg with a generally very high proportion of Na and K, as well as of carbonates and sulfates; the carbonate component, registers particularly high. Elements characteristic of alkali soils (Ca + Mg) register comparatively low. The best-represented cations are Na, C and K; the best-represented anions Cl, HCO_3, and SO_4. These represent values appropriate for water that has penetrated limestone.

Another factor significant to the region is the many thermal springs scattered throughout the SE peninsula of Lesbos (east of the Bay of Kalloni and just across the channel from Dikili). The salty thermal springs of the small spa are also located on the island of Lesbos at Thermi (46.9 ˚C), slightly northward along the east coast, and at Polychnitos (39.7 ˚C) 45.80 km westward from the administrative center Mytilene, as well as the salt waters of the nearby Lisvario spa (41.50 km from Mytilene), one of the warmest thermal springs in Europe with a temperature of 69 ˚C. The salty hot springs of Methymna (43.5-46.5 ˚C) lie at the north of the island and the spa of Therma is noted for its mixture of fresh and salt waters (39.7 ˚C) only eight kilometers from Mytilene. Considering the above, it would be reasonable to postulate the further existence of thermal sources off the east coast of the Island of Lesbos (Meriç et al., 2002b).

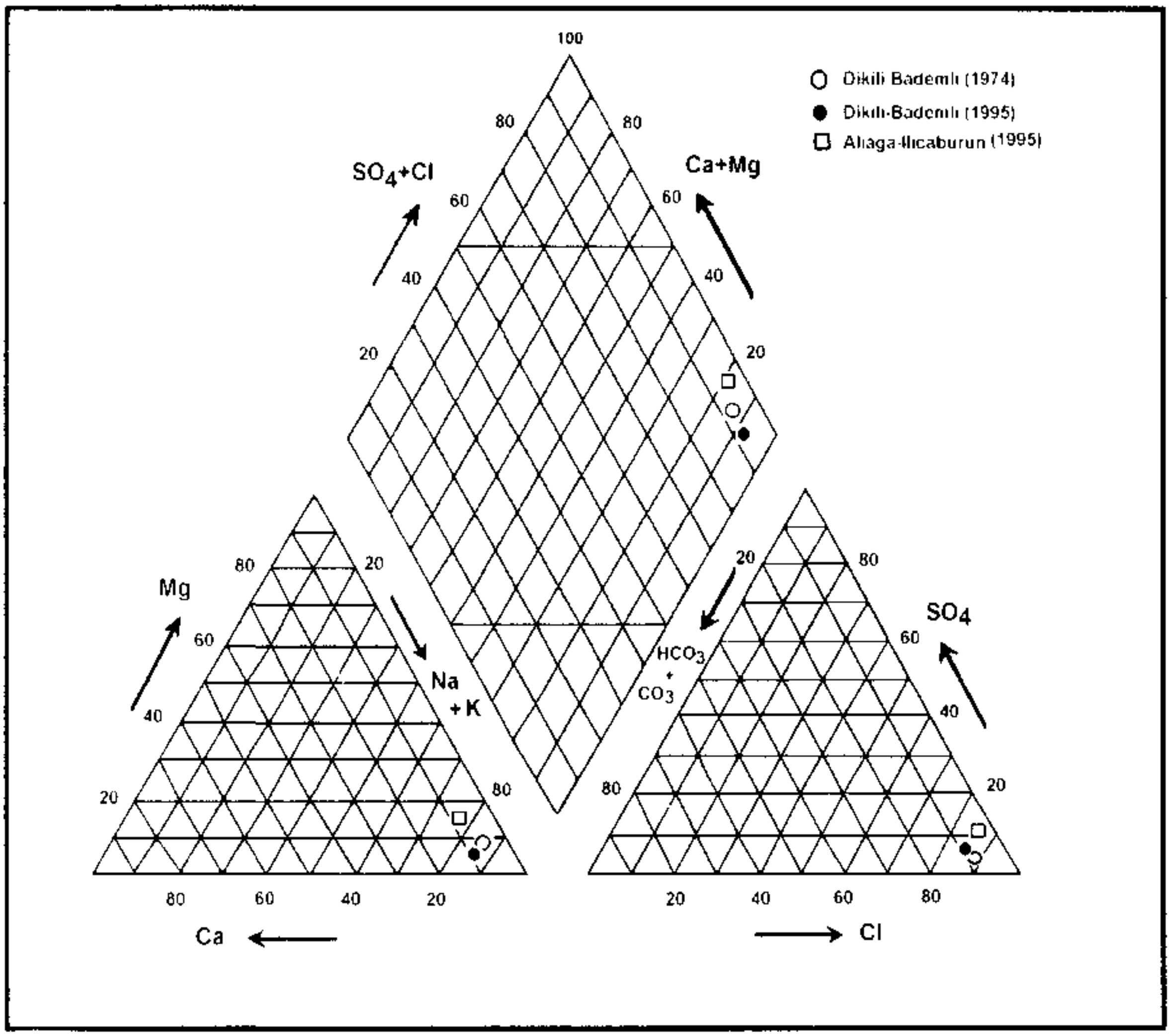

Fig. 3- Geochemical classification, Piper diagram, of the thermal mineralwaters at southern part of Dikili Bay and vicinity of Çandarlı Bay.

Returning to the various samples collected in the Dikili Bay, we should note that five of these contain traces of heavy metals: Pb, Cr, Ni, Cu, Co, Mn and Fe (Table 3). In Samples 3 and 5, although no Fe is reported, Pb is present, and the amounts of Cr, Ni, Cu, Co and Mn recorded-if below the threshold limits (Krauschopf, 1985)-are worthy of note. Samples 2, 4 and 8 contain a notabl proportion of Mn, Cr and Cu, and Sample 5 reveals the highest proportions of Mn, Cr, Cu and Ni. Comparing the values at the stations sites 3 and 5 shown in figure 4a, the values of Mn, Cu and Cr are relatively higher at site 3. The value of Mn is seen to increase at the two sites shown in figure 4b. Although all values aside from that of Co remain under the threshold limit at site 5, the presence of these metals should still be considered significant. A comparison among the values in the Dikili Bay and those from the Çandarlı Bay to the south show us that Co, Cu, and Cr rise above the threshold values in the northern waters, whereas Fe, Mn, and Ni in the southern waters.

Table. 3- Heavy metal concentrations in bottom 5 sediment samples from the Dikili Bay.

Stations	Pb µg/L	Cr µg/L	Ni µg/L	Cu µg/L	Co µg/L	Mn µg/L	Fe µg/L
2	---	6.657	0.060	1.053	0.582	59.003	1401.143
3	0.734	8.992	3.700	5.286	1.797	73.652	---
4	---	6.392	4.750	6.662	7.982	23.748	2971.835
5	0.473	17.641	5.711	29.569	1.776	87.248	---
8	0.030	9.810	2.546	4.284	1.495	56.577	2686.906

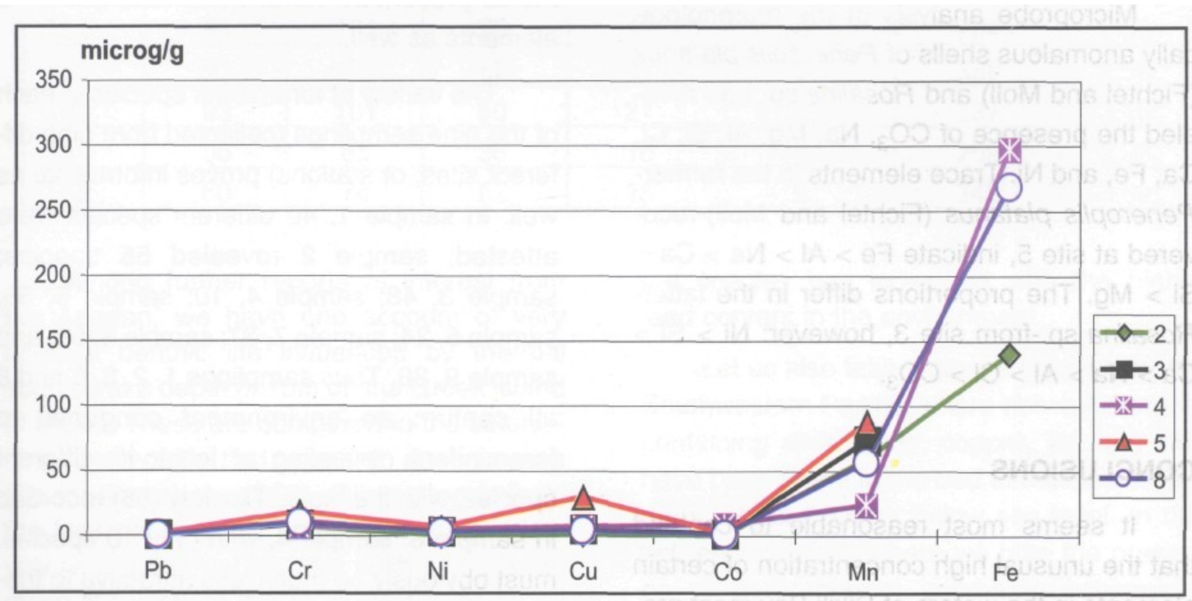

Fig. 4a- Comparison of the heavy metal concentrations with number of stations 2, 3, 4 and 8

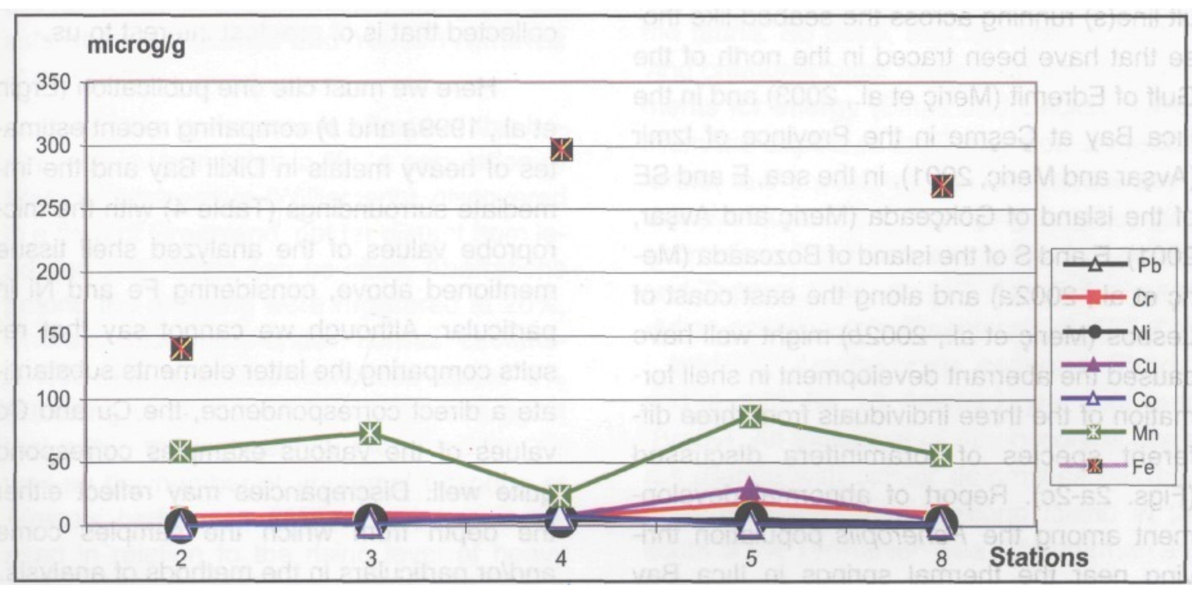

Fig. 4b- Distributions of the abundance of the heavy metal concentrations at the of stations 2, 3, 4 and 8

Aside from the stream known as the Madra Çay (north of Dikili), there is no surface drainage capable of introducing any appreciable sediment into the bay. The relative abundance of heavy metals in the offshore waters would therefore postulate some aquifers opening directly into the seabed. Many hot springs in the north east of the island of Lesbos likewise support this premise.

Microprobe analysis of the morphologically anomalous shells of *Peneroplis platanus* (Fichtel and Moll) and *Rosalina* sp. has revealed the presence of CO_3, Na, Mg, Al, Si, Cl, Ca, Fe, and Ni. Trace elements in the former-*Peneroplis platanus* (Fichtel and Moll)-recovered at site 5, indicate Fe > Al > Na > Ca > Si > Mg. The proportions differ in the latter-*Rosalina* sp.-from site 3, however: Ni > Si > Ca > Na > Al > Cl > CO_3.

CONCLUSIONS

It seems most reasonable to contend that the unusual high concentration of certain elements in the waters of Dikili Bay most probably a result of thermal springs along the fault line(s) running across the seabed-like those that have been traced in the north of the Gulf of Edremit (Meriç et al., 2003) and in the Ilıca Bay at Çeşme in the Province of Izmir (Avşar and Meriç, 2001), in the sea, E and SE of the island of Gökçeada (Meriç and Avşar, 2001), E and S of the island of Bozcaada (Meriç et al., 2002a) and along the east coast of Lesbos (Meriç et al., 2002b>)-might well have caused the aberrant development in shell formation of the three individuals from three different species of foraminifera discussed (Figs. 2a-2c). Report of abnormal development among the *Peneroplis* population thriving near the thermal springs in Ilıca Bay (Meriç, 1986; Avşar and Meriç, 200I) also supports our contention, as does the morphology of other aberrant instances of this species (Sözeri, 1966; de Civrieux, 1970). Indeed, the number of abnormal shell formations among *Peneroplis planatus* (Fichtel and Moll) from environs fed by thermal springs is quite striking. It seems essential that we consider not only the major and minor chemical elements present in the environment, but trace elements as well.

The variety of foraminifer species in each of the nine samplings (collected from nine different sites, or stations) proves informative as well. In sample 1, 40 different species were attested; sample 2 revealed 55 species; sample 3, 48; sample 4, 10; sample 5, 56; sample 6, 24; sample 7, 37; sample 8, 68; and sample 9, 36. Thus samplings 1, 2, 3, 5 and 8 all confirm an environment congenial to foraminifera, revealing at least 40 different species, with the highest variety (68) recorded in sample 8. sample 4, with only 10 species, must obviously be much less attractive to these benthic species. It is the ecology at the sites from which samplings 2, 3, 5 and 8 were collected that is of greatest interest to us.

Here we must cite one publication (Ergin et al., 1999a and *b)* comparing recent estimates of heavy metals in Dikili Bay and the immediate surroundings (Table 4) with the microprobe values of the analyzed shell tissue mentioned above, considering Fe and Ni in particular. Although we cannot say that results comparing the latter elements substantiate a direct correspondence, the Cu and Co values of the various examples correspond quite well. Discrepancies may reflect either the depth from which the samples come and/or particulars in the methods of analysis.

Table. 4- Heavy metal concentrations in surface sediments from the Dikili and Çandarlı bays (from Ergin et al., 1993)

Stations	Zn µg/L	Cr µg/L	Ni µg/L	Cu µg/L	Co µg/L	Mn µg/L	Fe %
T52	19	9	13	3	2	103	0.59
T53	27	32	30	6	7	172	1.18
T54	37	42	36	11	5	441	2.20
T55	81	73	43	34	9	352	3.07
T56	58	58	35	14	12	377	3.58
T57	98	103	118	27	19	716	4.23
T58	84	161	70	16	12	704	2.98
T59	53	68	62	11	9	388	2.58
T80	93	101	50	21	12	337	3.16
T81	56	65	36	16	9	269	2.99
T82	60	74	52	18	9	343	3.69

Among further reports of interest from the Aegean, we have one account of very unusual benthic life influenced by thermal sources at a depth of 10m off the Greek island of Melos. These are compared to the astonishing forms of life that appear in desert oases (Thiermann et al., 1997). Other reports from the Hellenic volcanic crescent include relatively recent thermal sources such as the spas along the inlets of the Methana peninsula on the west of the Greek Peloponnesus, as well the hot-water springs identified along the coasts of Melos, Samos and Yialos (Varnavas etal., 1999).

Relative to the recent affects of the heavy metals upon benthic life, a population of *Melonis barleeanus* (Williamson) discovered in a fiord of Greenland, not far distant from lead and zinc mines can be cited. Aberrations among the offspring were registered at 20%, whereas elsewhere-under normal circumstances-they have not numbered above 5% (Elberling et al., 2003). The authors suggest that within the last century the proportion-as well as the number-of abnormal offspring of *Melonis barleeanus* (Williamson) has increased in relation to the rising level of heavy metal pollution and shell deformation within the species has increased with the higher lead content in the environment.

Let us also take a glance deep under the Southwestern Pacific, where rich sulfide beds containing silver, gold, copper, tin, and zinc have been found in the bed of the Sea of Bismark, about 2000 m below sea level. In this rich environment, where we note the presence of hydrothermal submarine 'chimneys' emitting dark smoke, benthic life flourishes, with gastropods representing the majority of the fauna. So deep, and deprived of light, living creatures must depend on chemical elements for energy (Binns and Decker, 1998). From the depths of the Timor Sea somewhat further to the west, we can cite various populations of foraminifer displaying morphological anomalies. Examples are given in Loeblich and Tappan 1994, pl. 117, figs. 7-8: *Pyramidulina pauciloculata* (Cushman); pl. 127, figs. 5 and 10, *Amphycoryna separans* (Brady); and pl. 128, fig. 13 *Amphycoryna sublineata* (Brady). An individual of *Amphycoryna scalarus* (Batch) with similar deformities has also been recovered near Volcano Island in the south of the Tyrrhenian Sea (Cimmerman and Langer, 1991: pl. 54, fig. 6).

In conclusion, these three foraminifer samples representing morphological anomalies (Figs. 2a-2c) most probably owe their deformities to disproportional content of heavy metals in the sea and considered as no anthropogenic phenomenon, but introduced into the ecosystem by natural thermal springs in the seabed. The pollution traces at Çandarlı Bay due to the Aliağa Petroleum Raffinary is important at the north of the gulf (because of the current). Among the five samples collected at this region the morphological abnormalities of foraminifers aren't observed. (Meriç et al., 2004) The evidence in Dikili Bay does not constitute a high proportion of aberrance among the population as is seen in the Bay of Haifa (Yanko et al., 1998). In the explanation of the morphological abnormalities in this area offered in the reports (Yanko et al., 1998, Debenay et al., 2001), there is no mention of either marine thermal springs in the environs or heavy metals in the water. The different researchers talk about of possible cancerogenic affects from the heightened proportion of the gas Rn^{222} along fault lines (Choubey and Ramola, 1997; Shirav (Schwartz) and Vulkan, 1997). The value of Rn^{222} in the hot mineral springs in the environs of Dikili measures Rn^{222} = 8510- 76775 Bekerel (Türkiye Madensulan-3, Ege Bölgesi, 1974). It seems reasonable to assume that natural marine springs would reflect a similar worth; therefore, possible affects of the gas Rn^{222} on the life of one-celled benthic fauna should not be overlooked.

ACKNOWLEDGEMENTS

The authors express their sincere thanks to Professor Cemal Tunoğlu (the Engineering Faculty, Hacettepe University) who provided us with the specimens, as well as to both Associate Professor Melek Türker-Sagan and the specialist Gülhan Özkösemen (Institute of Environmental Studies and Technology, Bogazigi University) who carried out metal analyses on five of the specimens.

Manuscript received June 19, 2003

REFERENCES

Arpat, E. and Şaroğlu, F., 1975, Türkiye'deki bazı önemli genç tektonik olaylar: Türkiye Jeol. Kur.Bült.18, 91-101.

Artüz, M. I., 1970, Some observations on the hydrography of the Turkish Aegean waters during 4-25 September 1963: Publications of the Hydrobiological Research Institute, Faculty of Science, University of Istanbul, Serie B, 1-9.

Avşar, N. and Meriç, E., 2001 *a,* Türkiye'nin güncel bentik foraminiferleri-I (Kuzeydoğu Akdeniz-Kuzey Ege Denizi-Çanakkale Boğazı-Kuzey ve Doğu Marmara Denizi-Haliç-İstanbul Bogazi-Bati Karadeniz): Çukurova Üniv. Yerbilimleri, 38, 109-126,

————and————, 2001 *b, Ç*eşme-Ilıca Koyu (Izmir) bölgesi güncel bentik foraminiferlerinin sistematik dağılımı: Hacettepe Üniv. Yerbilimleri, 24, 13-22,

Barut, I. F.; Erdoğan-Yüzbaşıoğlu, N. and Başak, E., 2003, Hydrogeochemical evalution of Western Anatolian mineralwaters: Environmental Geology (in press).

Benli, H., and Küçüksezgin, F., 1988, Ulusal Deniz Ölçme ve İzleme Programı, Ege Denizi 6lgme ve İzleme Alt Projesi 1988 Dönemi Kesin Raporu: Reports of the Institute of Marine Sciences and Tecnology, Dokuz Eylül Üniv., 281 p.

Binns, R.A. and Deckker, D.L, 1998, The mineral wealth of the Bismark Sea: Scientific American, 9, 3, 92-98.

Cimerman, F. and Langer, M. R., 1991, Mediterranean Foraminifera: Slovenska Akademija Znanosti in Umetnosti, Academia Scientiarum et Artium Slovenica. 118 p.

Choubey V.M., and Ramola R.C., 1997, Correlation between geology and radon levels in groundwater, soil and indoor air in Bhilangana Valley, Garhwal Himalaya, India Environmental Geology, 32 ,4, 258-262.

Civrieux, J.M.S. de, 1970, Mutaciones recientes del genero Peneroplis y relaciones filogenicas con otros Soritidae: Revista Espanola de Micropaleontologia, 11,1, 5-12.

Debenay, J-P.; Tsakiridis, E.; Soulard, R., and Grossel, H., 2001, Factors Determining the Distribution of Foraminiferal Assemblages in Port Joinville Harbor (Ile d'Yeu, France): The Influence of Pollution: Marine Micropaleontology, 43, 75-118.

Elberling, B.; Knudsen, K.L.; Kristansen, P.H. and Asmund, G., 2003, Applying foraminiferal stratigraphy as a biomarker for heavy metal contaminiation and mining impact in a fiord in West Greenland: Marine Environmental Research, 55, 235-256.

Ergin, M.; Bodur, M. N.; Ediger, D.; Ediger, V. and Yılmaz, A., 1993a, Organic carbon distribution in the surface sediments of the Sea of Marmara and its control by the inflows from adjecent water masses: Mar. Chemistry, 41,311-326.

————;————; Ediger V.; Yemenicioğlu, S., Okyar, M. and Kubilay, N., 1993b, Sources and dispersal of heavy metals in surface sediments along the Eastern Aegean Shelf: Bull. Ocean. Teor. Appl., 11,1, 27-44.

————and Yemenicioğlu, S., 1997, Gelogic Assessment of Environmental Impact in Bottom Sediments of the Eastern Aegean Sea: Int. Jour. Environmental Studies, 51, 323-334.

Erişen, B.; Akkuş, İ.; Uygur, N. and Koçak, A., 1996, Türkiye Jeotermal Envanteri, MTA Genel Müdurlugu, 480s.

Hatta, A. and Ujiie, H., 1992, Benthic foraminifera from Coral Sea between Ishigaki and Iriomote Islands: Southern Ryukyu Island arc, northwestern Pasific. Bulletin of Science, University of the Ryukyus, 54, 163-287.

Hayward, B. W.; Grenfell, H. R.; Reid, C. M. and Hayward, K. A., 1999, Recent New Zealand shallow-water benthic foraminifera: Taxonomy, ecologic distribution, biogeography, and use in paleoenvironmental assessment: Institute of Geological and Nuclear Sciences Monograph, New Zealand, 21, 258 p.

Hottinger, L.; Halicz, E. and Reiss, Z., 1993, Recent foraminiferida from the Gulf of Aqaba, Red Sea: Slovenska Akademija Znanosti in Umetnosti, Academia Scientiarum et Artium Slovenica, 179 p.

Ivanoff, A., 1972, Introduction a l'Oceanographie: 1, 208 p., Paris.

Krauskopf, K.B., 1985, Introduction to Geochemistry: 2nd Edition, McGraw-Hill Int. Series in the Earth and Planetary Sciences, 550p.

Loeblich, Jr. A. R. and Tappan, H., 1994, Foraminifera of the Sahul Shelf and Timor Sea: Cushman Foundation for Foraminiferal Research. Special Publication 31, 663 p.

Mascle, J. and Martin, L., 1990, Shallow structure and recent evolution of the Aegean Sea: A synthesis based on continuous reflection profiles: Marine Geology, 97, 271-299.

McKenzie, D.P., 1977, Can plate tectonic describe continental deformation?, In: Structural history of the Mediterranean Basins: Biju-Dual, B., and Montadert, L., (eds), Editions Technip, Paris, 189p.

Meriç, E., 1986, Deniz dibi termal kaynakların canlı yaşamına etkisi hakkında güncel bir örnek (Ilıca-Çeşme-İzmir). Türkiye Jeol. Kur. Bült., 29,2, 17-21.

————; Yanko, V. and Avşar, N., 1995, İzmit Körfezi (Hersek Burnu-Kaba Burun) Kuvaterner istifinin foraminifer faunası: Meriç, E., (ed.), İzmit Körfezi Kuvaterner İstifi, 105-151

————and Avşar, N., 2000, Deniz diplerindeki aktif fayların belirlenmesinde bentik foraminiferlerin önemi: Batı Anadolu'nun Depremselliği Sempozyumu (BADSEM-2000), 198-205, Izmir.

————and————, 2001, Benthic foraminiferal fauna of Gökçeada Island (Northern Aegean Sea) and its local variations: Acta Adriat., 42, 1, 125-150.

————,————and Nazik, A., 2002 *a,* Bozcaada (Kuzey Ege Denizi) bentik foraminifer ve ostrakod faunası ile bu toplulukta gözlenen yerel değişimler: Çukurova Üniv. Yerbilimleri, 40-41, 97-119.

————,————and Bergin, F., 2002 *b,* Midilli Adası (Kuzey Ege Denizi) bentik foraminifer topluluğu ve bu toplulukta gözlenen yerel değişimler: Çukurova Üniv Yerbilimleri, 40-41, 177-193.

————, Görmüş, M.; Avşar, N. and Ünsal I., 2002 *c,* Güncel nodosariid bentonik foraminiferlerde üreme sırasındaki anormal oluşumların önemi ve rastlantı faktörü: TPJD Bülteni, 14, 1, 67-82.

Meriç, E.; Görmüş, M.; Nazik, A.; Eryılmaz, M. and Eryılmaz-Yücesoy, F., 2003, Saros Körfe zi'nin (Kuzey Ege Denizi) bentik ve planktik foraminifer toplulukları ile çökel dağılımı: Hacettepe Üniv. Yerbilimleri, 28 (In press).

————; Avşar, N. and Bergin, F., 2004, Benthic foraminifera of Eastern Aegean Sea (Turkey), systematics and autoecology: Istanbul (In press), 310 p

Piper, A.M., 1953, A graphic procedure in the geochemical interpretation of water analyses. US Geol. Survey, Groundwater Note 12.

Sgarella, F. and Moncharmont-Zei, M., 1993, Benthic foraminifera of the Gulf of Naples (Italy), systematic and autoecology: Bulletino della Societa Paleontologica Italiana, 32, 2, 145-264.

Shirav (Schwartz), M., and Vulkan, U., 1997, Mapping radon-prone areas- a geophysical approach: Environmental Geology, 31,3/4, 167-173.

Sözeri, B., 1966, İzmir, Çeşme Ilıcası plaj kumundaki aktüel foraminiferler ve variasyonları: Türkiye Jeol. Kur. Bült.,10, 1-2, 143-154.

Şaroğlu, F.; Emre, Ö. and Kuşçu, I., 1992, Türkiye dirifay haritası (1/1.000.000 ölçekli orijinal haritadan küçültülmüş baskı): MTA Genel Müdürlüğü, Ankara.

Şengör, A.M.C., and Yılmaz, Y. 1981, Thethyan evolution of Turkey: a plate tectonic Approach: Tectonophysics, 75, 181-241.

Tait, R.V., 1981, Elements of marine ecology: London, 356 p.

Thiermann, F.; Akoumianaki, I.; Hughes, J. A. and Giere, O., 1997, Benthic fauna of a shallow-water gaseohydrothermal vent area in the Aegean Sea (Milos, Greece): Marine Biology, 128, 1, 149-159.

Turgut, S., 1987, Ege denizi'nin paleocografik gelişimine ait rapor: TPAO Raporu.

Türkiye Mineralli Su Kaynakları (Ege Bölgesi), 1999, Istanbul Universitesi, Tip Fakültesi Tıbbi Ekoloji ve Hidro-Klimatoloji Anabilim Dalı, I.Ü. Araştırma Fonu Projesi Sonuç Raporu: 874/090896 (unpublished report), 119s.

Türkiye Madensuları (3), Ege Bölgesi, 1974, I.Ü. Tip Fakültesi, Hidroklimatoloji Kürsüsü, 335 s.

Varnavas, S.P.; Halbach, P.; Halbach, M., Panagiotaras, D.; Rahders, E. and Hubner, A., 1999, Characterization of hydrothermal fields and hydrothermal evolution in the Hellenic Volcanic Arc: International conference Oceanography of the eastern Mediterranean and Black Sea, 23 to 26 February 1999, Athens, Greece, 343.

Yalçın, H.; Meriç E.; Avşar N.; Bozkaya Ö. and Barut I.F., 2003, İskenderun Körfezi Güncel Çökel ve Foraminiferlerinde Gözlenen Jeokimyasal Anomaliler: Türkiye Jeol. Kur. Bült., 46, 2, (In press).

Yanko, V.; Ahmad, M. and Kaminsky, M., 1998, Morphological Deformities of Benthic Foraminiferal Tests in Response to Pollution by Heavy Metals: Implications for Pollution Monitoring: Journal of Foraminiferal Research, 28, 3, 177-200.

————; Arnold, A., and Parker W., 1999, The effect of marine pollution on benthic foraminifera: Sen Gupta, B., ed., Modern Foraminifera, Kluwer Academic Publishers, 384 p.

Yılmaz, Y., 1990, An approach to the origin of young volcanic rocks of Western Turkey: Şengör, A.M.C., ed..Tectonic evolution of the Thethyan region, Kluwer Academic, 159-189.