Morphological abnormalities in benthic foraminifers of the Antalya coast

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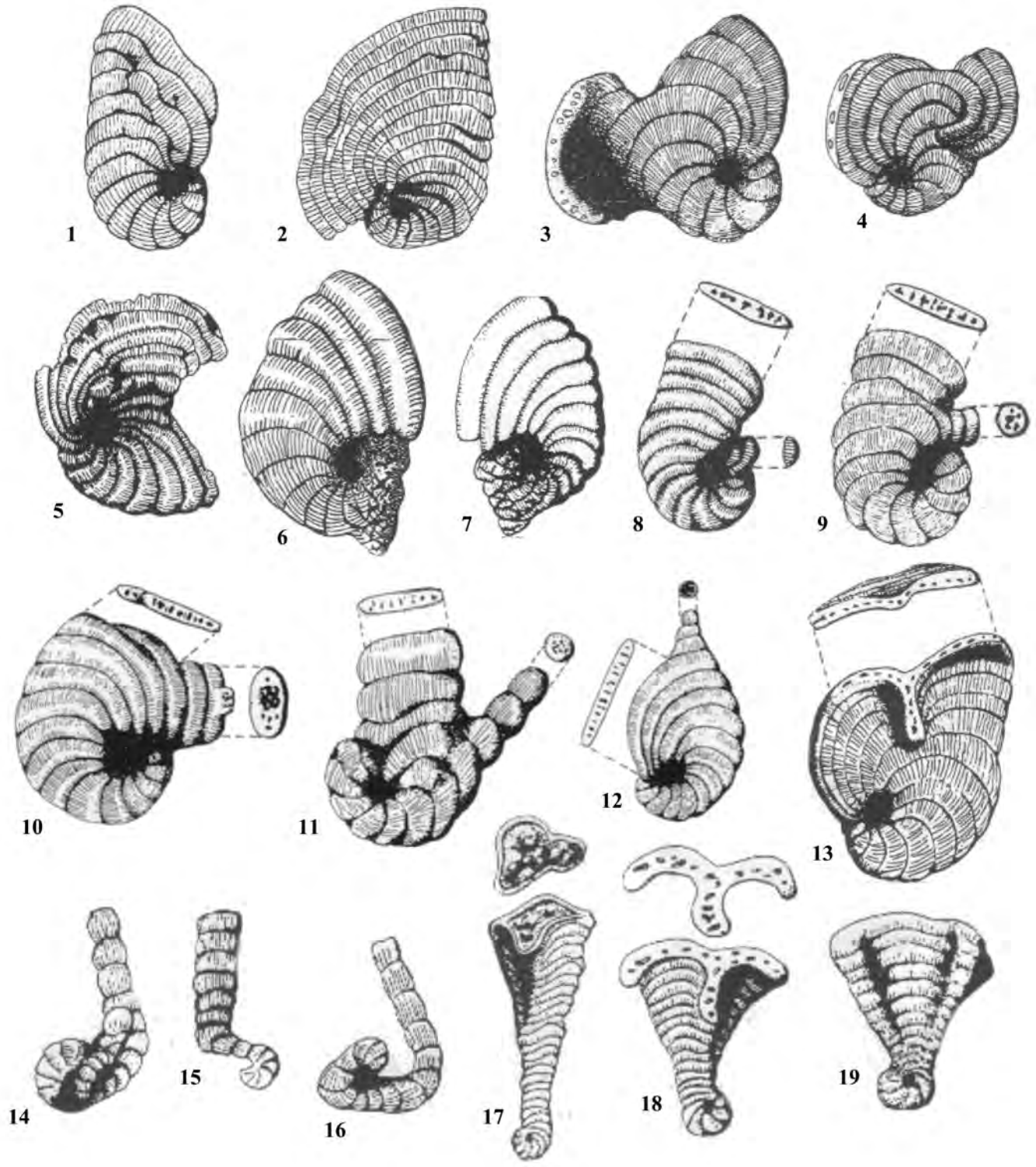
ABSTRACT: Many researchers report abnormal test morphologies in benthic foraminifers and some suggest that anthropogenic pollution may be one of the causes for these anomalies. Some species are even used as bioindicators of anthropogenic pollution. However, environmental stress may be exerted by natural factors also, such as hypersalinity, periodical acidification and strong hydrodynamics. We observed large populations of morphologically abnormal foraminifer individuals in 227 recent sediment samples on the southwestern coast of Antalya (Turkey). In 117 of our samples we found morphologically abnormal *Textularia bocki* Höglund individuals. The proportion of abnormal individuals to normal ones within a population is 3.2%. We also found morphologically abnormal individuals of *Peneroplis arietinus* Batsch, *P. pertusus* (Forskål), *P. planatus* (Fichtel and Moll), *Amphisorus hemprichii* Ehrenberg, *Sorites orbiculus* Ehrenberg, *S. variabilis* Lacroix and *Spiroloculina* cf. *S. angulata* d'Orbigny in 87 of our sediment samples. The abundance and large sizes of these abnormal individuals are significant. There is no industrial plant near the study area and this region is not a popular tourist attraction. Thus, anthropogenic waste cannot be regarded as an important cause for unhealthy foraminifers in this region. There are frequent freshwater springs along the coast around Kalkan, Kaş and eastern Kekova. Seasonal discharge from submarine caves also contributes freshwater to the sea ranging between 12% and 50%. Radioactivity levels and heavy metal concentrations in these submarine discharges are insignificant. However, we see a correlation between the abundance of abnormal individuals and the locations of caves and freshwater springs in the region. Our results suggest that rapid changes in ecological parameters related to submarine groundwater discharge may be responsible for morphological anomalies in foraminiferal genera and species.

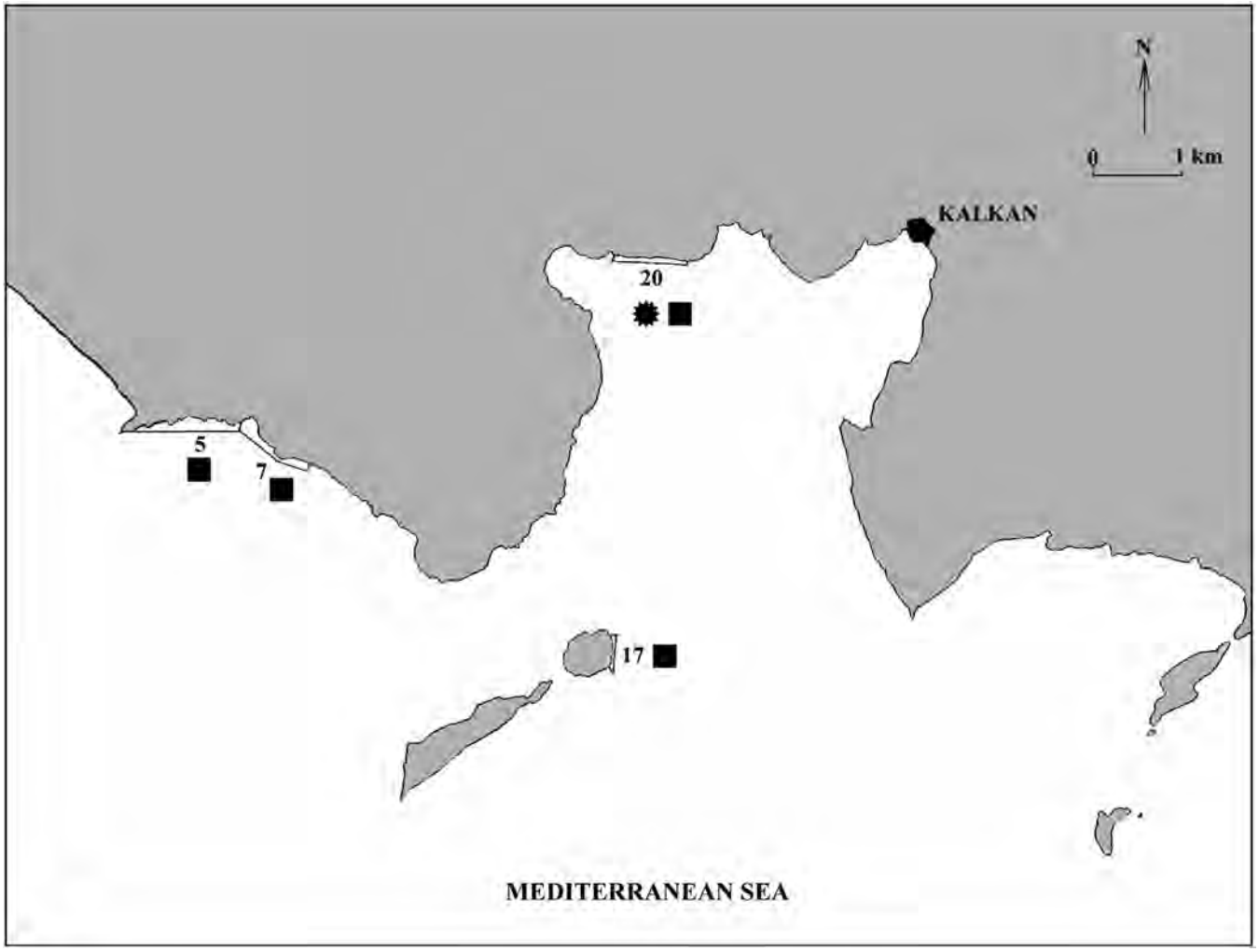
INTRODUCTION

Abnormal test morphology and developmental defects are known to occur in certain foraminifer genera and species (Stouff et al. 1999a and b; Geslin 1998). Such anomalies have been observed in foraminifer individuals collected from many locations in the world, such as shallow waters of the tropical Atlantic, the Caribbean Sea, Brazil (d'Orbigny 1839; Cushman 1929), the Timor Sea, the West Pacific (Loeblich and Tappan 1994) and Vulcano Island in the Tyrrhenian Sea (Cimerman and Langer 1991). The causes behind this phenomenon have been attributed to salinity variations, anthropogenic heavy metal pollution or heavy metals carried by groundwater (Almogi-Labin et al. 1992; Thiermann et al. 1997; Binns ve Deckker 1998; Geslin et al. 1998, 1999, 2000, 2002; Yanko et al. 1998, 1999; Stouff et al. 1999 a and b; Varnavas et al. 1999; Elberling et al. 2003). In one of the most comprehensive reviews about the issue, Boltovskoy et al. (1991) states that temperature, salinity, solubility of calcium carbonate, depth, nutrition, substrate type, dissolved oxygen content, illumination, pollution, water motions, trace elements, and rapid changes in ecological parameters can all be responsible for abnormal test development.

In Turkey, *Peneroplis* and *Sorites* individuals bearing abnormal test morphology were first observed in recent sediments from Ilıca (Çeşme, İzmir) which contain a diverse foraminiferal fauna (Sözeri 1966). Sözeri (1966) did not discuss the causes of these defects, but, pointed out that Ilıca Bay has similar seawater characteristics to the tropical Atlantic where abnormal individuals like the ones they studied were found (d'Orbigny 1839 and Cushman 1929). Following Sözeri's (1966) work, Sellier de Civrieux (1970) published the same study in Spanish as his own work without citing Sözeri (1966), and providing the figures as drawings (Sellier de Civrieux 1970; Pl. 1-3 and text-fig. 1). Un-



TEXT FIGURE 1
Morphological anomalies observed in Peneroplids from Çeşme Ilıca Bay (From Sellier de Civreux 1970).



TEXT FIGURE 2
Sampling stations in Kalkan. ■ *Peneroplis planatus* (Fichtel and Moll), ✹ *Sorites variabilis* Lacroix.

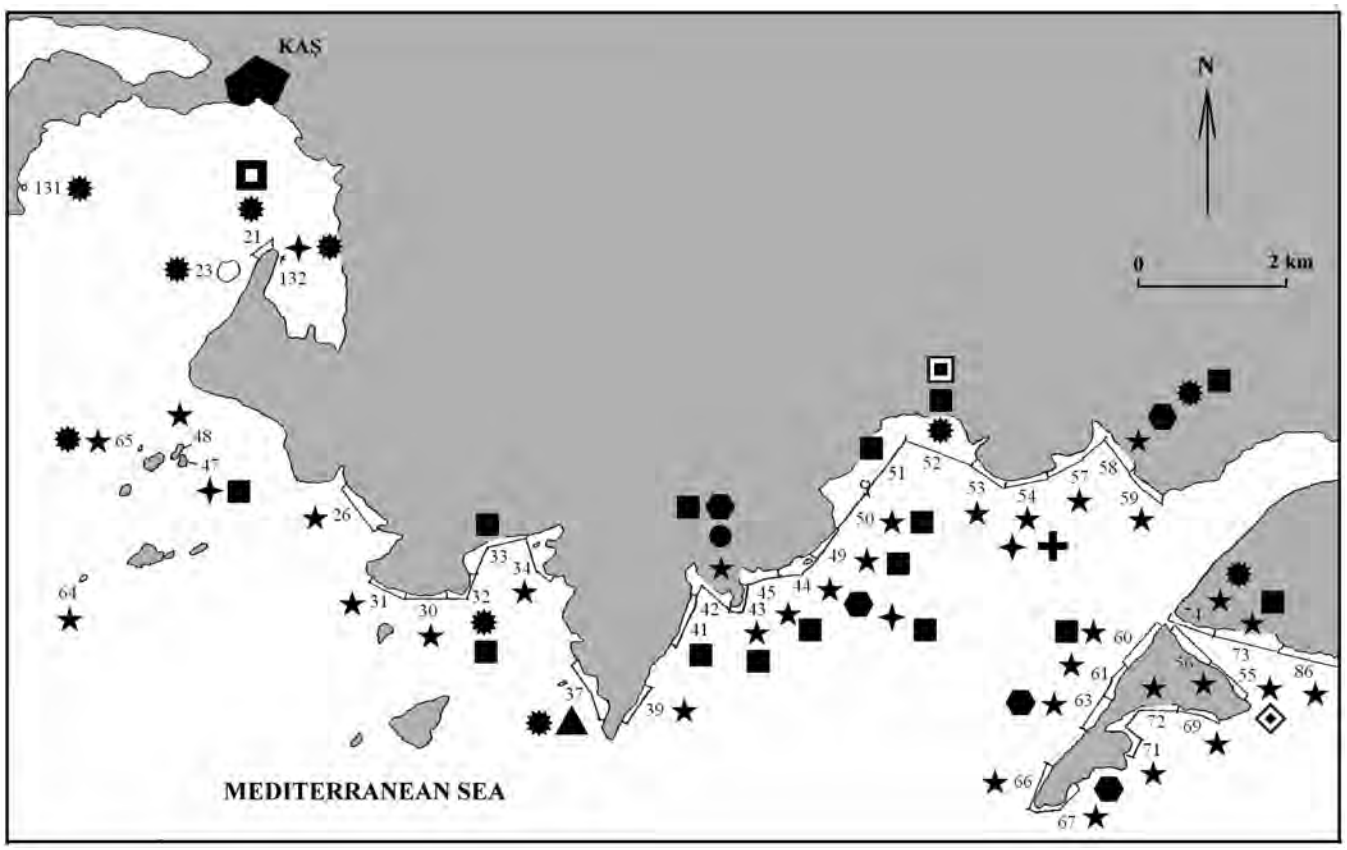
fortunately *Coscinaspira* specimens have been misidentified as *Spirolina* in Sellier de Civrieux's (1970) work. Sellier de Civrieux (1970) indicated that these anomalies observed in Peneroplids should have resulted from genetic mutations leading to the formation of new species, which appears to be unlikely according to current studies in genetics (Ayala 2005). Furthermore, Selleir de Civrieux (1970) was unaware of the presence of hot (58-59°C) submarine springs with high radiation nearing close proximity to their study site at 2.5m depth (Çağlar 1946; Türkiye Madensuları (3), Ege Bölgesi,1974). A recent study carried out on 12 sand samples from Ilıca Beach and Karaburun Peninsula (Meriç 1986; Avşar and Meriç 2001) reveals that Ilıca Beach has a distinct foraminifer fauna when compared to other parts of the peninsula. This suggests that a unique foraminiferal fauna exists around the thermal springs.

Until recently, no *Textularia* specimens showing abnormal test morphology were observed along the Turkish coastline. But in the framework of our study, abnormal *Textularia* specimens, as well as, *Spiroloculina, Coscinospira, Peneroplis, Amphisorus, Sorites* and *Cibicidella* individuals were abundantly observed along the southwestern coast of Antalya, Turkey. The aim of our study is to analyze the morphological anomalies in the above mentioned species and the possible causes leading to the formation of their defective tests.

MATERIALS AND METHODS

227 recent sediment samples have been manually collected by SCUBA divers from Boğaziçi University Diving Club at various depths ranging between 3.5-30m. 5 grams of each wet sample was treated with 5% H_2O_2 for 24 hours. The samples were washed with pressurized water through a 0.063mm sieve, transferred to petri dishes and dried at 50ºC. Dry samples were put through 2, 1, 0.5, 0.25 and 0.125mm sieves, and were analyzed with binocular microscopes.

Water samples were collected with Niskin bottles for heavy metal analysis. The samples were filtered with membrane filters (0.45ìm pore size). The filters kept at -20ºC for the analysis of suspended particles and the filtered water samples were deposited in plastic bottles which have been prewashed with nitric acid. The pH of the samples were adjusted to be <2 by adding



TEXT FIGURE 3
Sampling stations in Kaş. ★ *Textularia bocki* Höglund, ◈ *Spiroloculina* cf. *S. angulata* d'Orbigny, • *Coscinospira hemprichii* Ehrenberg, ▲ *Peneroplis arietinus* (Batsch), ● *Peneroplis pertusus* (Forskål), ■ *Peneroplis planatus* (Fichtel and Moll), ○ *Amphisorus hemprichii* Ehrenberg, ✦. *Sorites orbiculus* Ehrenberg, ✶ *Sorites variabilis* Lacroix, ◘ *Planorbulina mediterranensis* d'Orbigny, ▣ *Cibicidella variabilis* (d'Orbigny), ✚ *Planogypsina acervalis* (Chapman).

concentrated nitric acid. Dissolved metal analysis (Fe, Mn, Pb, Cu, Hg and Cd) were performed with Atomic Absorbance Spectrophotometry (AAS) according to Bruland et al. 1979 and Bruland et al. 1985. Adsorbed heavy metals on suspended particles were also analysed (Al, Fe, Mn, Pb, Cu and Cd). The membrane filters were dried at 150ºC and weighed. The samples dissolved with strong acids (HNO_3, HF and $HClO_4$) in teflon containers and made up to 10ml by adding 1M HCl. The samples were analysed with AAS (Landing and Lewis 1991; Boughriet et al. 1994).

RESULTS

The sediment samples contained a very rich foraminifer fauna. Both the species diversity and the size of the populations were found to be very large, when compared to the other areas on the Turkish coastline.

Morphological Anomalies in *Textularia bocki*

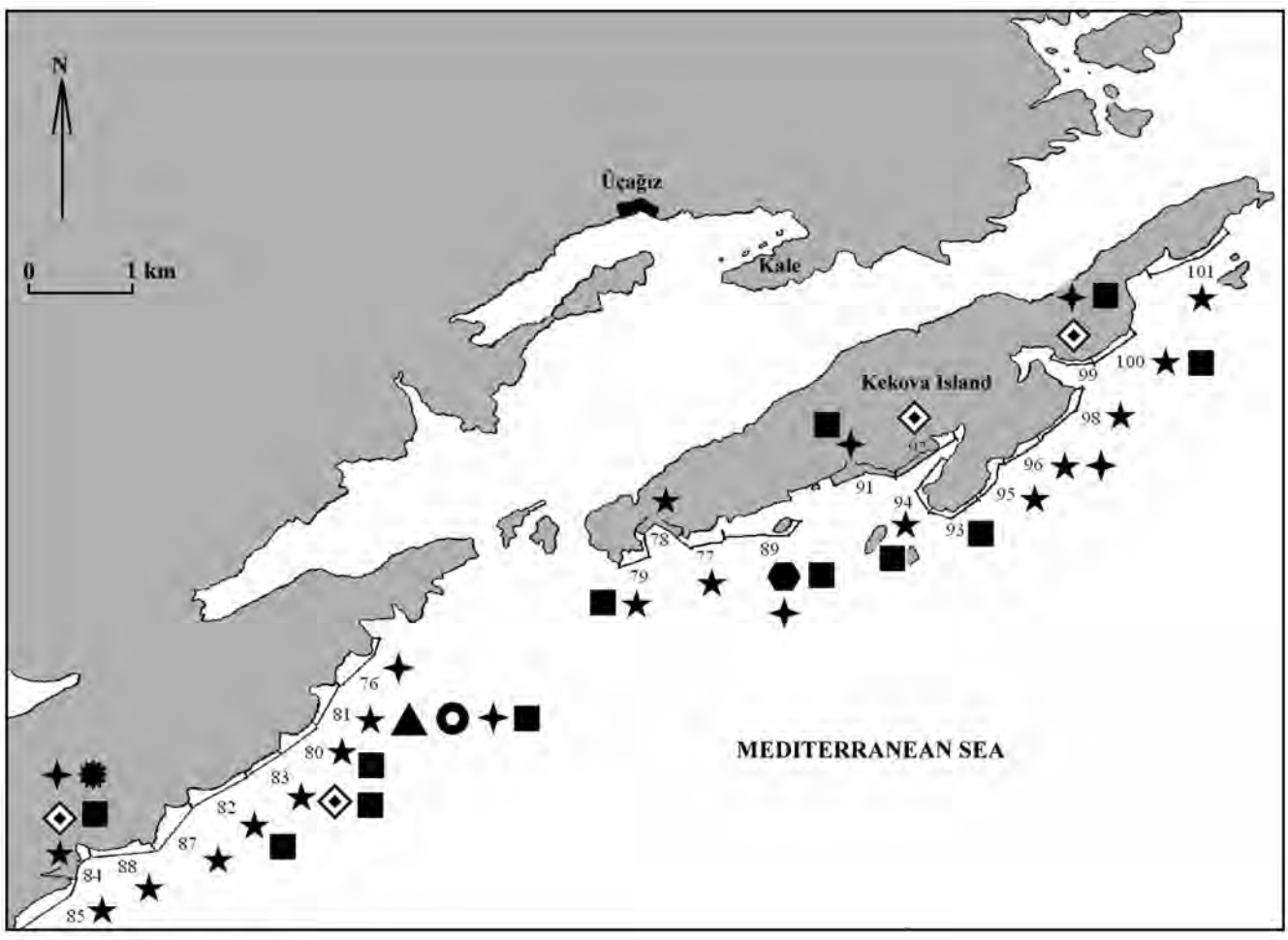
Our sediment samples contain a rich foraminifer fauna. In 117 samples, morphologically abnormal *Textularia bocki* Höglund individuals are observed (text-figs. 2-6 and table 1). The size of these abnormal specimens occasionally exceeds 1mm, but is usually between 0.5-1mm. The number of abnormal individuals in the 0.25-0.5mm size fraction is very small. Generally, 3.2% of *T. bocki* individuals have prominent morphological anomalies, such as the abrupt formation of disfigured chambers after a certain cycle, bending of the tests, distortion of the aperture, and, in some cases, disfigured test forms (plates 1-6).

Morphological Anomalies in *Peneroplis and Spiroloculina, Coscinospira, Amphisorus, Sorites, and Cibicidella*

In 87 of our sediment samples, morphologically abnormal individuals of *Peneroplis arietinus* Batsch, *P. pertusus* (Forskål), *P. planatus* (Fichtel and Moll), *Amphisorus hemprichii* Ehrenberg, *Sorites orbiculus* Ehrenberg, *S. variabilis* Lacroix and *Spiroloculina* cf. *S. angulata* d'Orbigny are observed (text-figs. 2-6 and table 2). Their abundance and large sizes are noteworthy (plates 7-13). Yet, large *Peneroplis* tests were also observed in samples from the Çeşme- Ilıca region (text-fig. 1) (Sellier de Civrieux 1970; Avşar and Meriç 2001, Meriç et al. 2003, 2005, 2006a and b).

Heavy Metal Reserves

The most important mines along the coastline between Antalya and Marmaris are the chromite reserves of the Marmaris ophiolite nappe located northwest of the study area. These chromite reserves are frequent around Fethiye, Gürlek and Göcek. There are also manganese reserves, but they are of secondary importance. Most of these small scaled reserves are not economically important. There are some bauxite formations (northeast of Kaş) and minor pyrite and chalcopyrite reserves northeast of



TEXT FIGURE 4
Sampling stations around Kekova Island. ⋆ *Textularia bocki* Höglund, ◈ *Spiroloculina* cf. *S. angulata* d'Orbigny, ▲ *Peneroplis arietinus* (Batsch), ⬢ *Peneroplis pertusus* (Forskål), ■ *Peneroplis planatus* (Fichtel and Moll), ✪ *Amphisorus hemprichii* Ehrenberg, ✦ *Sorites orbiculus* Ehrenberg, ✹ *Sorites variabilis* Lacroix.

Fethiye, both in Katran Mountain, (Şenel 1997b). Chrome reserves also exist in the Tekirova ophiolite. In the Permien carbonates of Çürük Mountain, west of Kemer, hydrothermically formed lead reserves are found (Şenel 1997b). These also do not carry any economical importance. The presence of all these reserves and discharge of underground waters to the sea via karstic cavities, cause natural pollution in the area.

Greenhouses and Agriculture

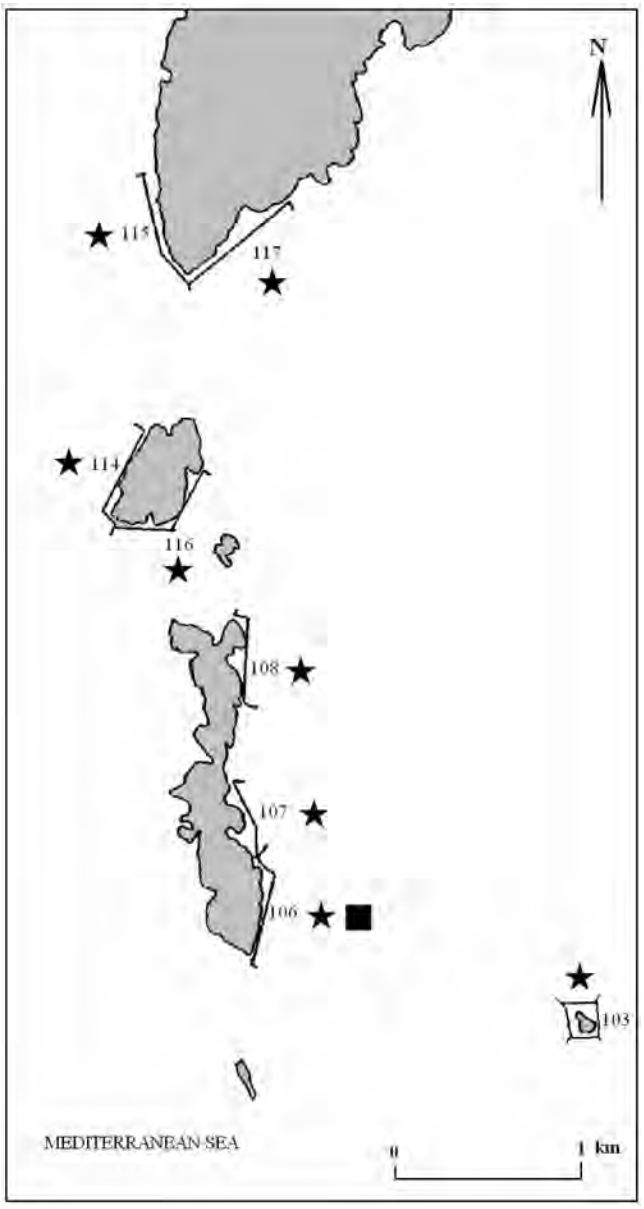
In Korkuteli and Elmalı, to the north of the study area, as well as along the coastline around Kalkan, Kaş, Kale, Finike, Kumluca and Kemer, there is intense cultivation of vegetables, plants and flowers both in greenhouses and open fields. The amount of insecticides, fungicides, herbicides, acaricides, fumingants, nematocides, rodenticides and mollusicides, winter prevention chemicals and summer oils, plant growth regulators, iron composites and attractors used in 2004 alone reaches 3.203.923 kg/lt (table 3). Watering could move these chemicals through karstic cavities and into the sea via the drainage patterns of karst conduits and submarine springs.

We analyzed the usage of agricultural chemicals over multiple years and observed that the year 2000 had the highest usage (text-fig. 7). Chemicals most frequently used in this region are insecticides, fungicides, fumingants, nematocides, winter prevention chemicals and summer oils. Although the usage of these chemicals was reduced by 50% in the years 2000-2002, it increased slightly in subsequent years.

Karstic Characteristics

In the Western Taurus Region, including the research area, Mesozoic and Cenozoic calcareous rocks are predominant. Multi-dimensional fractures, cracks and faults are also prevalent. Thus, groundwater is directed to the south through karstic cavities, towards the coast, and discharged into the sea via springs or caves located along the coast. Much work has been done along the southern coast of Turkey about this issue (text-fig. 8) (Günay 1965, 1968, 1971; Elkhatib 1987, 1992; Hamarat et al. 1998).

The freshwater springs along the coastline around Kalkan, Kaş and eastern Kekova are quite numerous. The morphologic structure of more than 70 submarine groundwater discharge areas varies from narrow cracks to large coastal and submarine caves

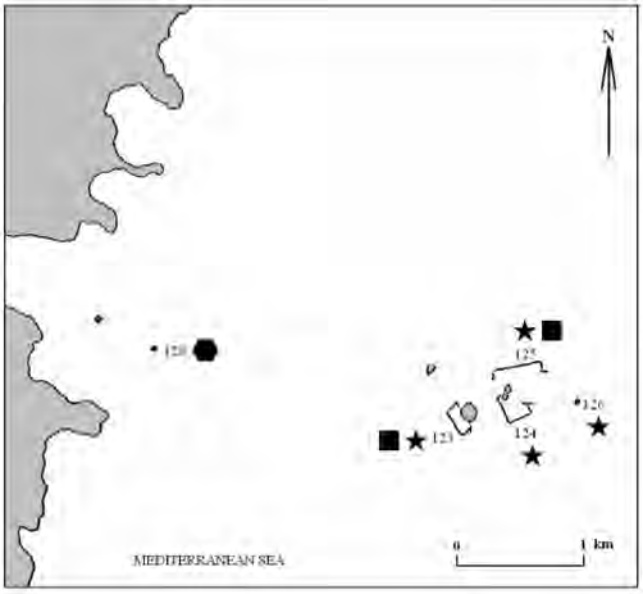


TEXT FIGURE 5
Sampling stations around Beş Adalar ★ *Textularia bocki* Höglund, ■ *Peneroplis planatus* (Fichtel and Moll).

which are penetrable by SCUBA diving (Öztan et al. 2004) (text-fig. 9).

Salinity Variations in Spring Water

Submarine groundwater usually discharges through cracks at sea level whereas, those in the form of submarine caves have outlets located between the sea surface and 40m below sea level (table 4). Salinity observations from different seasons indicate that fresh groundwater contribution to submarine springs ranges between a few percent to about 80%. Freshwater discharge from submarine caves ranges between 12% and 50%, depending on the season. These values suggest a high degree of temporal variability among freshwater contributions in each type of discharge. We placed data loggers in two major submarine caves namely, Altug and Mivini in order to further explore the temporal variability in fresh water discharge rate. Hourly measurements of temperature and specific electrical conductivity (a measure of salinity) reveal that fresh water contributions to groundwater discharge is not only variable but also affected by other processes such as, recharge rate of the aquifer, and earth and sea tides (text-fig. 10). In the case of submarine groundwater discharge at Altug, the rate of fresh water contribution is dominated by precipitation recharge of the aquifer. Consequently, freshwater recharge of the aquifer steadily reduces the specific conductivity and temperature of the water during the wet period between winter and late spring. Then, towards autumn, decreasing groundwater recharge causes an increase in seawater contribution during which time appreciable precipitation does not occur. On the other hand, Mivini submarine groundwater discharge seems to be controlled by a different recharge mechanism. Lower temperatures and specific electrical conductivity values indicate greater freshwater contribution year round. The cyclic variation of observed parameters indicates that sea and earth tides are the dominant external mechanisms that control fresh water discharge rate in Mivini while the effect of recent recharge is negligible.



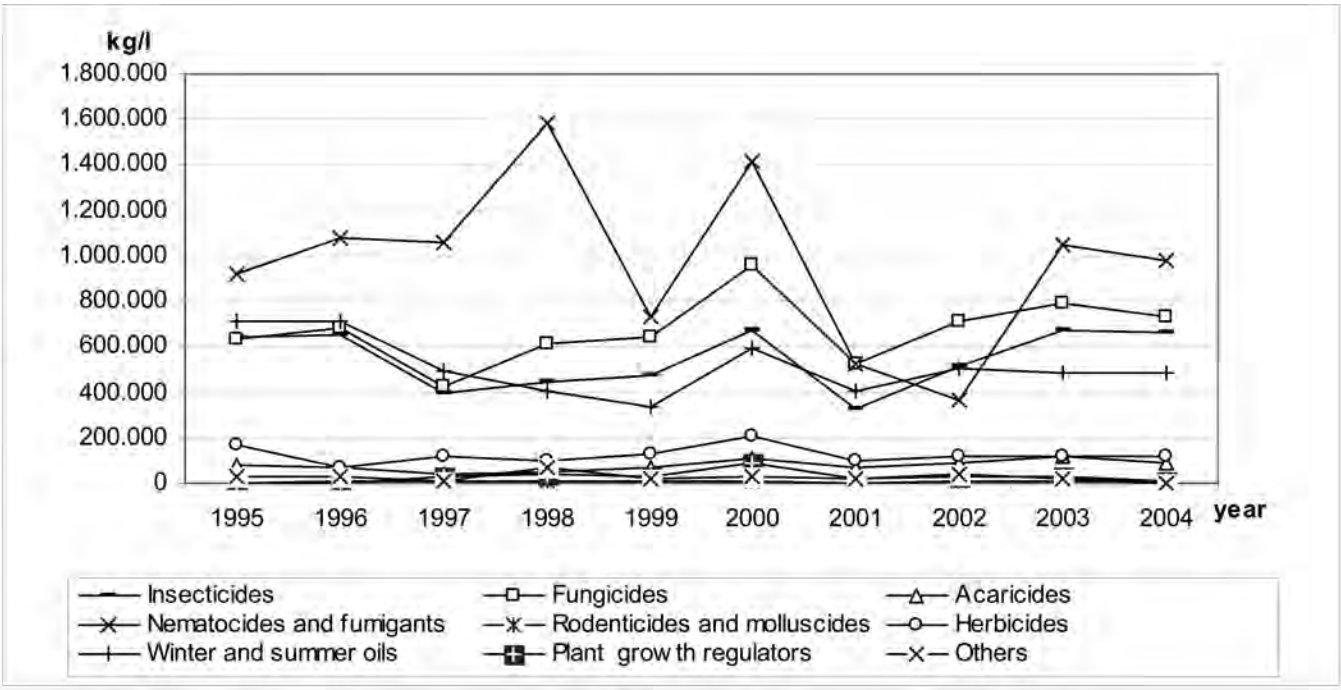
TEXT FIGURE 6
Sampling stations around Üç Adalar ★ *Textularia bocki* Höglund, ● *Peneroplis pertusus* (Forskål), ■ *Peneroplis planatus* (Fichtel and Moll).

Radioactivity Level in Submarine Groundwater Discharge

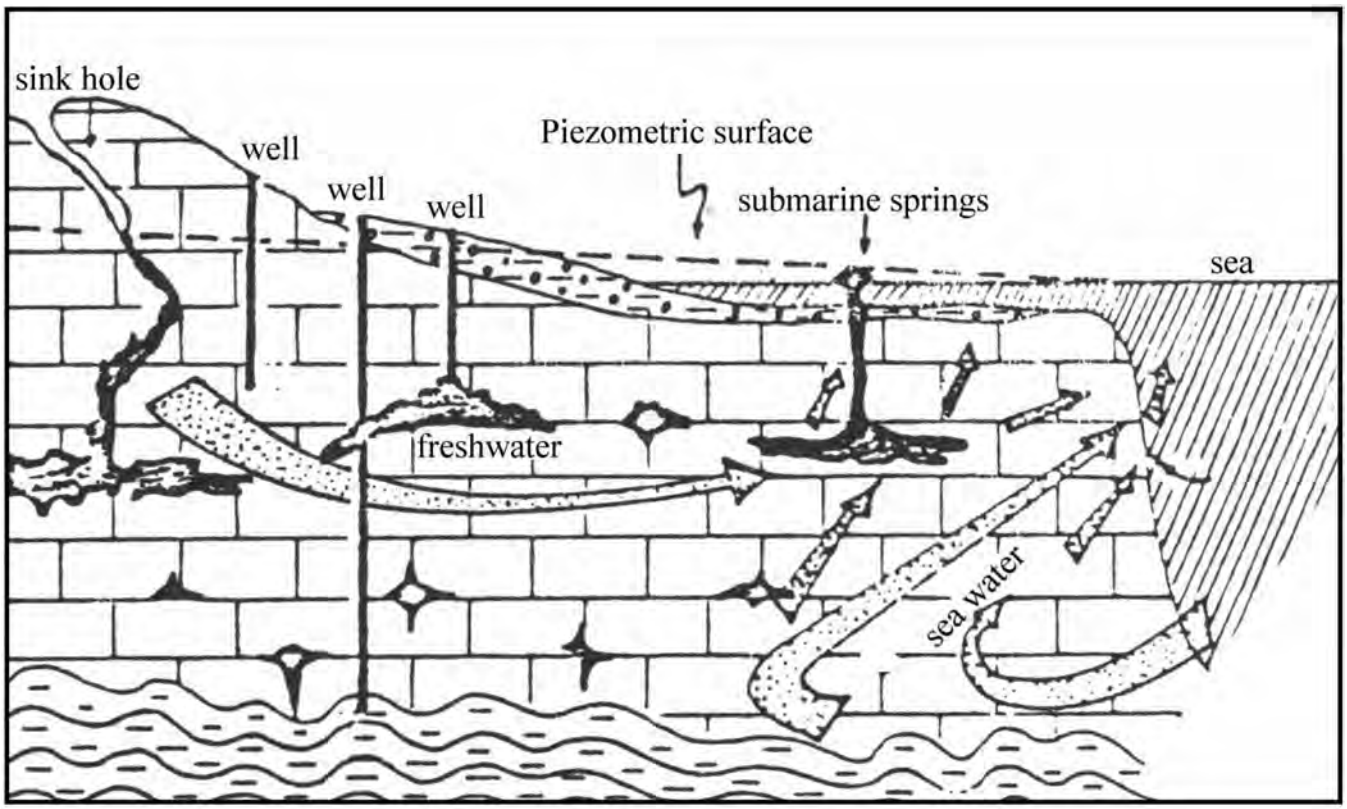
We analyzed radioactivity levels in six water samples collected from submarine caves. Total alpha counts were detected to be at the limit of the value (alpha 0.1bq/litre) given by WHO (WHO 2002), except the sample from Liman Ağzı, which is found to be barely exceeding the WHO limit. Thus, high levels of radioactivity cannot be considered (tables 5 and 6, text-figs. 11-14).

Heavy Metal Analyses in Submarine Groundwater Discharge

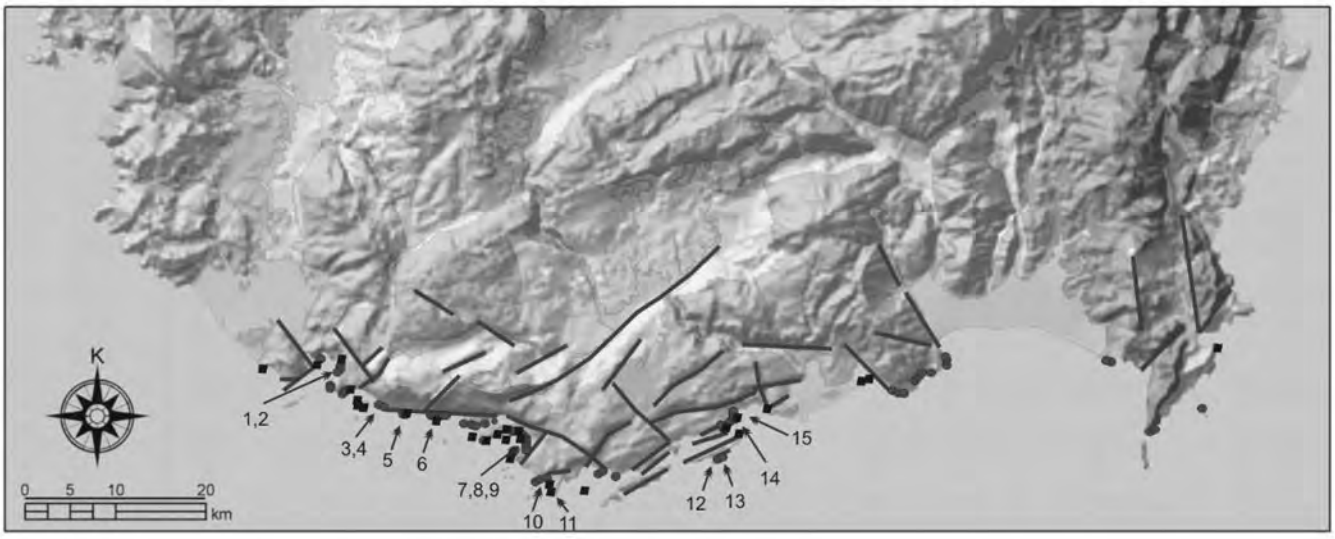
Heavy metal analyses (Pb, Cr, Zn, Cu, Cd, Mn, and Fe) from 8 water samples taken from submarine caves in Kaş (table 7) show high values when compared with seawater values of Krauskopf (1985). We find that Fe concentration is the highest, Pb and Zn are significantly high and Cr and Cd are the lowest



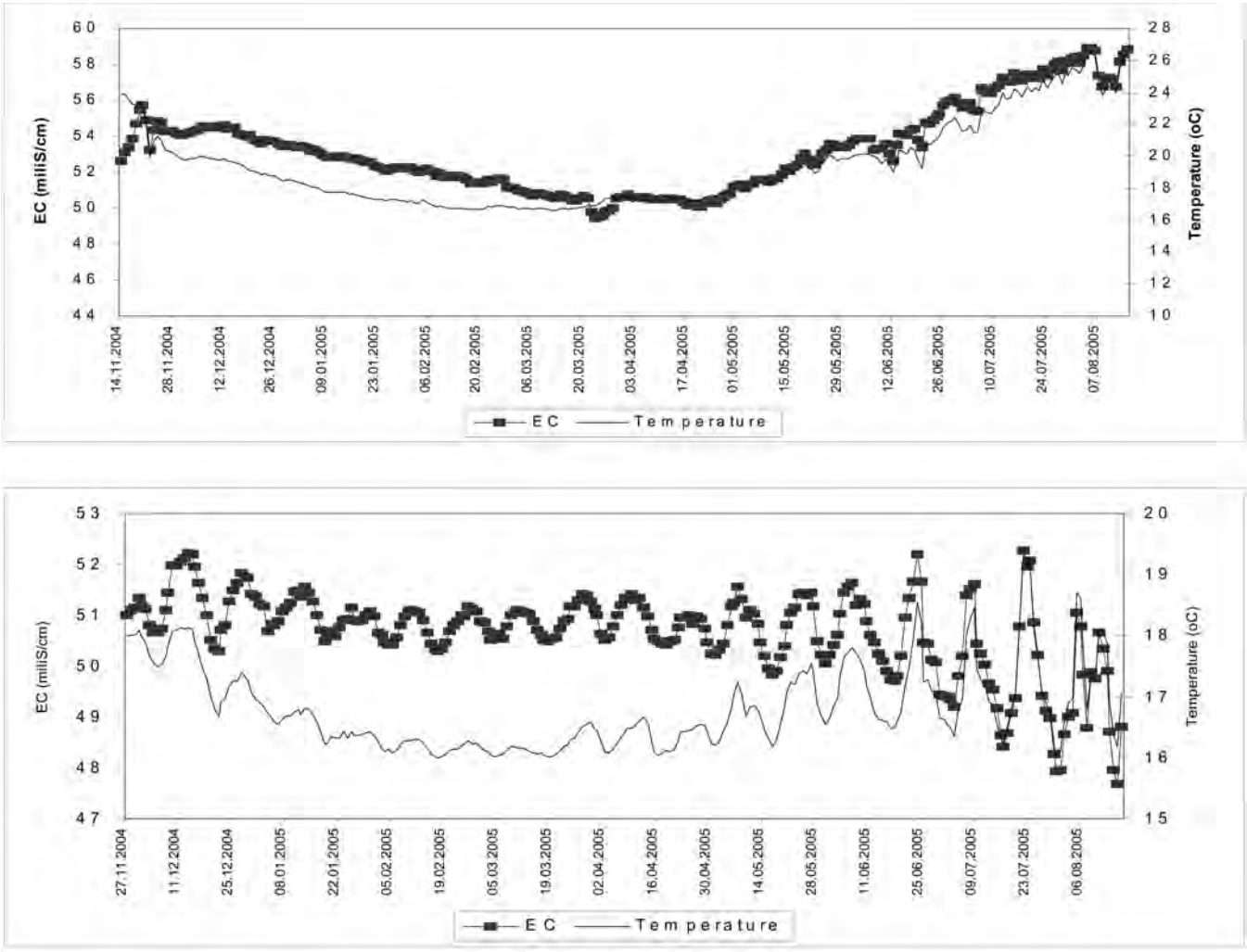
TEXT FIGURE 7
Agricultural chemicals consumed in Antalya.



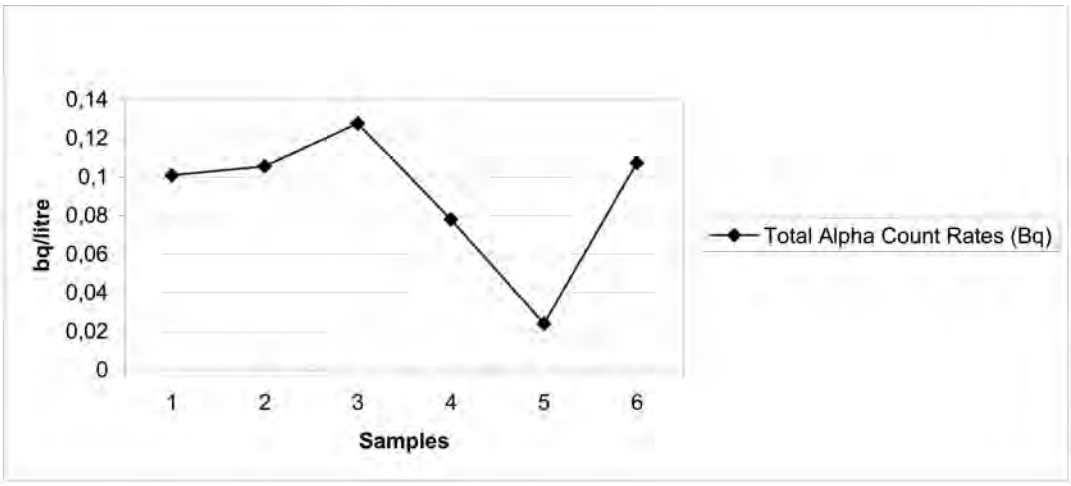
TEXT FIGURE 8
A schematic visualisation of the likely mechanics of the water flow and mixing of the Ovacık submarine springs (after Günay 1973; Yevjevich 1985).



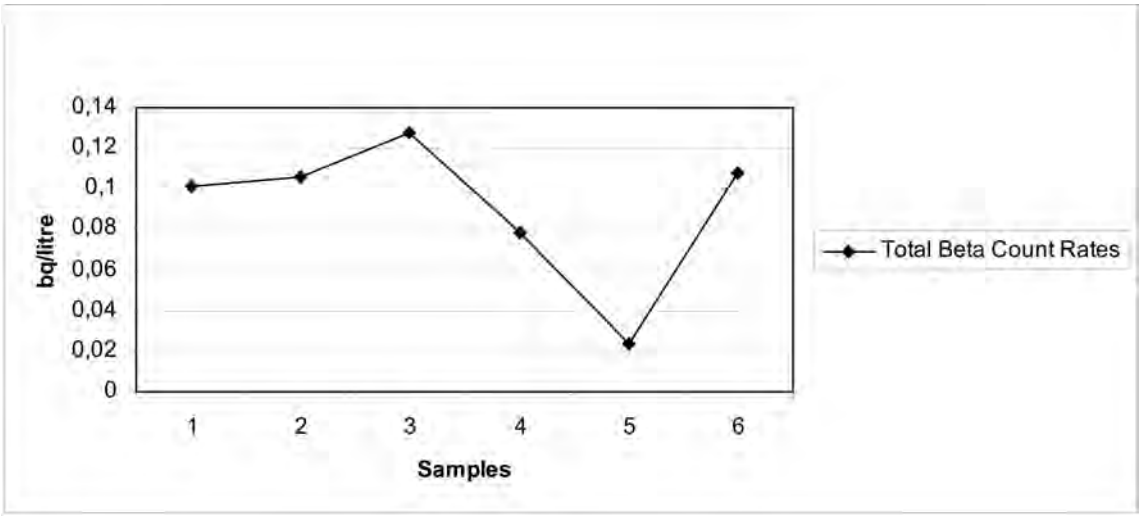
TEXT FIGURE 9
Submarine groundwater discharges and caves located on the coastline between Kalkan and Beş Adalar. 1 Patara Evleri Kovukları; 2 Kömürlük; 3 Doruk; 4 Prenses-Simay; 5 Yılan; 6 Mivini; 7 Havalı; 8 Çakıl; 9 Likya Batığı; 10 Altuğ; 11 Fakdere; 12 Fok; 13 Buza; 14 Gökkaya; 15 İlker Kaptan.



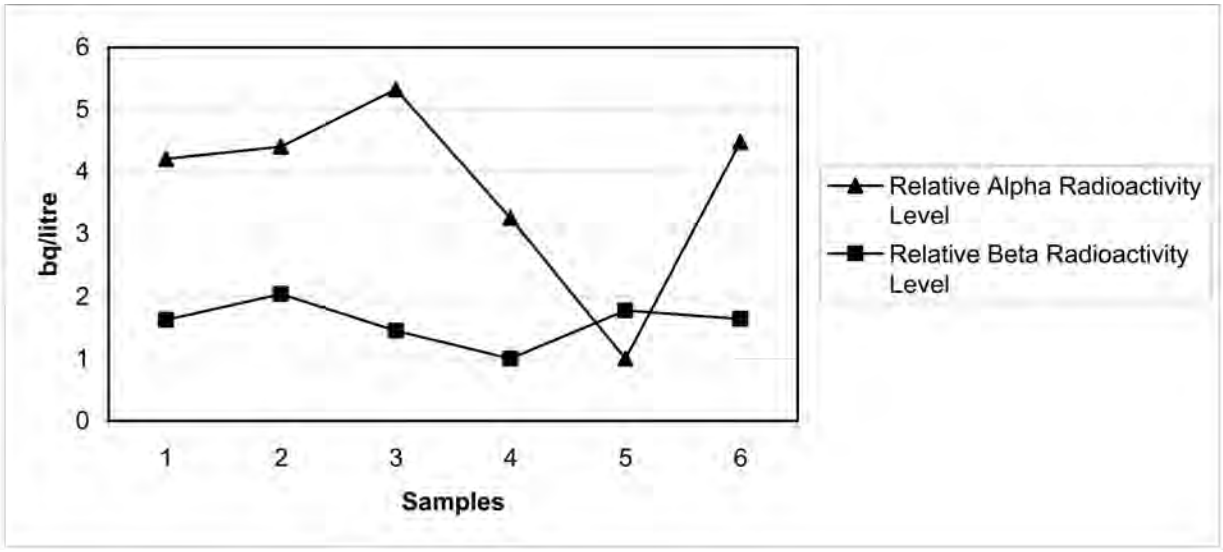
TEXT FIGURE 10
Electrical conductivity and temperature variations according to time (upper: Altuğ Cave, lover: Mivini Cave).



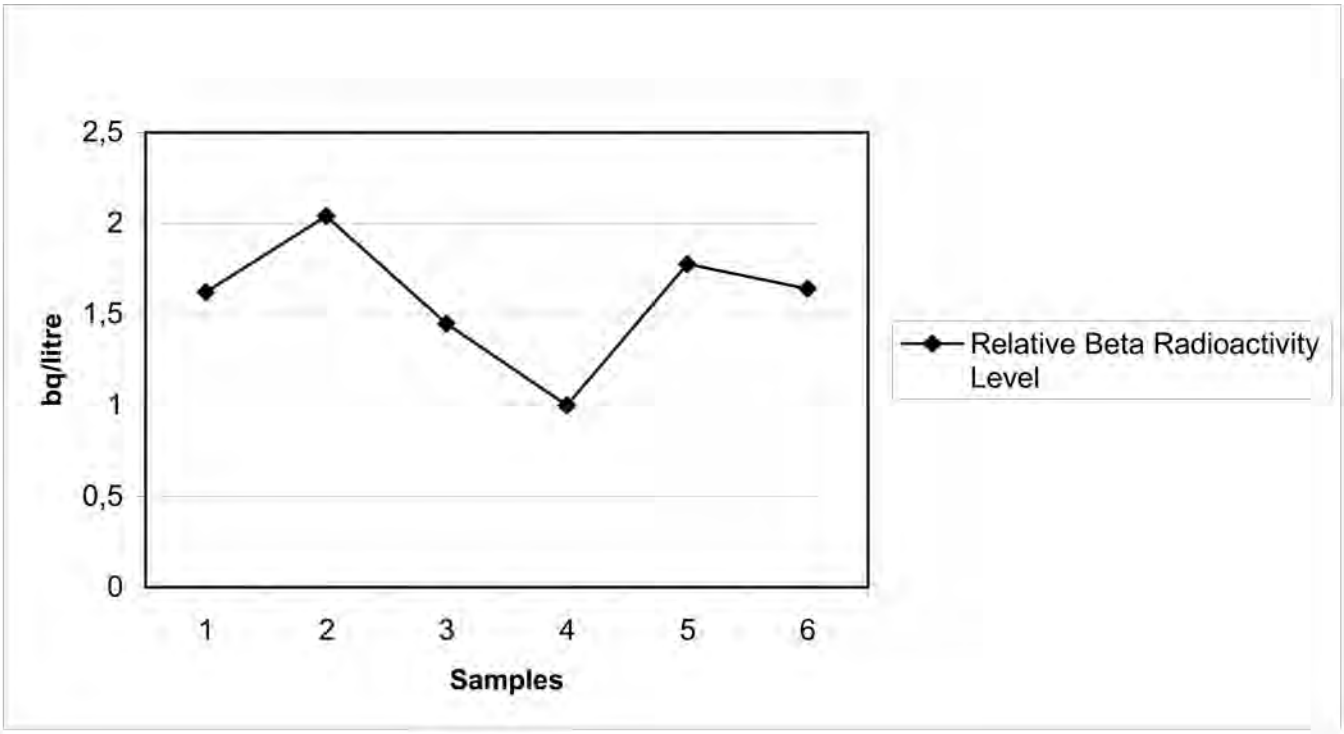
TEXT FIGURE 11
Total alpha count rates of the samples.



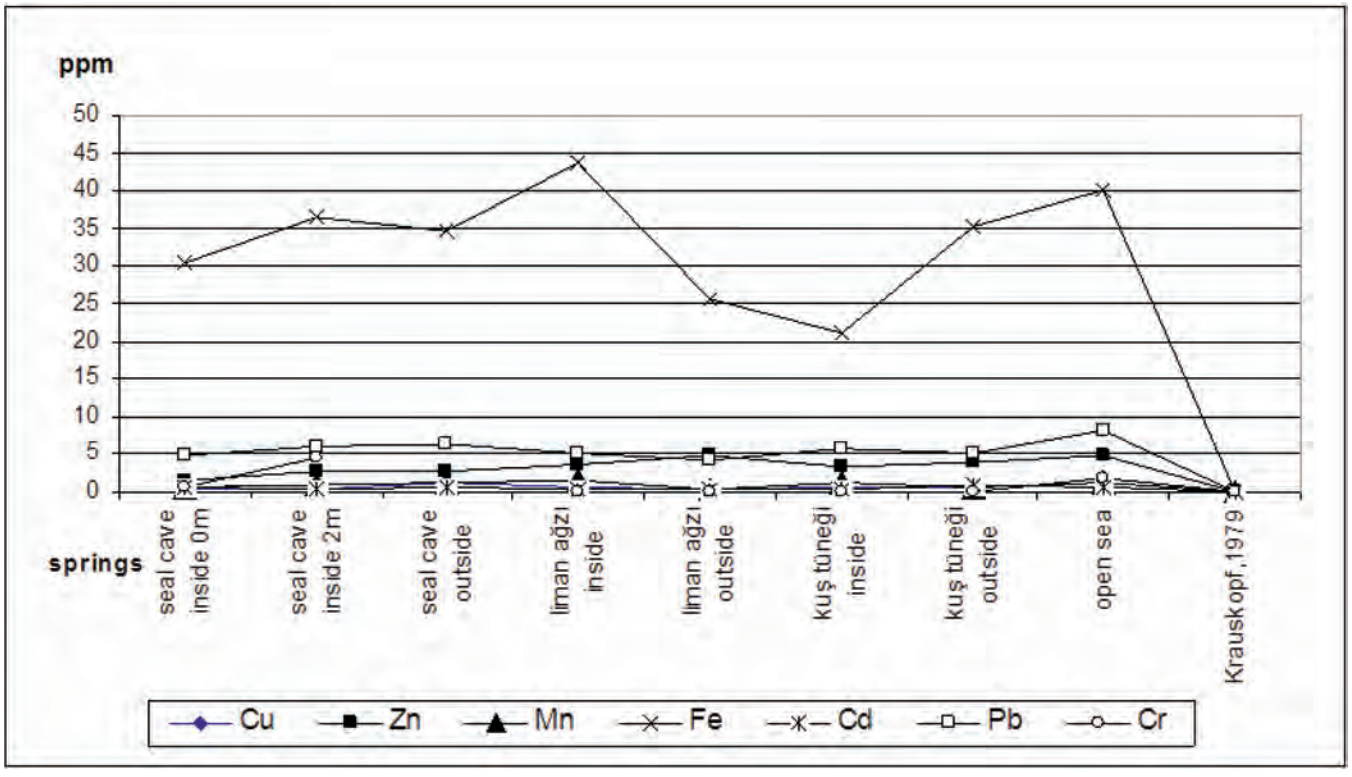
TEXT FIGURE 12
Total beta count rates of the samples.



TEXT FIGURE 13
Relative radioactivity levels of the samples.



TEXT FIGURE 14
Relative beta radioactivity levels of the samples.



TEXT FIGURE 15
Heavy metal analysis of submarine ground waters from Kaş region.



TEXT FIGURE 16
Satellite photographs of the submarine freshwater discharges (http://landsat.usgs.gov/)

(text-fig. 15). Note that the concentration of Cr inside Seal Cave was the highest of all Cr levels in our samples. Pb and Zn showed parallel results inside Seal Cave. Mn concentration is highest in the inner parts of the Limanağzı and the lowest in the inner parts of Kuş Tüneği.

DISCUSSION and CONCLUSIONS

Some researchers argued that the dominant cause for morphological anomalies observed in foraminifer tests are heavy metal and related chemical pollution (Krauschopt 1985; Sharifi et al. 1991; Ergin et al. 1993 a and b; Binns ve Deckker 1998; Geslin 1999; Geslin et al. 1998, 2000, 2002; Yanko et al. 1998, 1999; Debenay et al. 2001a; Elberling et al. 2003; Meriç et al. 2005, Bergin et al. 2006), extremely saline environments (Almogi-Labin et al. 1992; Stouff et al. 1999 a and b; Debenay et al. 2001b; Meriç et al. 2006 a and b) and the existence of various heavy metals in hot and cold water submarine springs (Ivanoff 1972; Tait 1981; Thiermann et al. 1997; Varnavas et al. 1999; Meriç and Avşar 2000; Avşar and Meriç 2001; Meriç et al. 2002a, 2002b, 2002c, 2003; Yalçın et al. 2004). However, there are no industrial plants in the study area. Anthropogenic waste cannot be regarded as an important cause in this region because this region is neither a settlement nor a significant touristic location. Thus, the existence of relatively unimportant mine reserves, the prevalence of Mesozoic limestones with karstic characteristics and the existence of numerous cold water springs within the sea can be considered as equally important causes.

Numerous greenhouses and frequent fertilizer and hormone usage in these areas should also be taken into account (table 3). Ekmekçi (2005) analyzed nutrient and pesticide content of karstic spring water in Kırkgöz Springs northwest of Antalya (table 8). He found that although nutrient content is not significant, the amount of pesticides is above international standards. This shows that spring waters in the region are subjected to anthropogenic pollution.

Benthic foraminifers with morphological anomalies like *Pyramidulina pauciloculata* (Cushman) (Loeblich and Tappan 1994; pl. 117, figs. 7 and 8), *Amphicoryna separans* (Brady) (Loeblich and Tappan 1994; pl. 127, figs. 5 and 10), *Amphicoryna sublineata* (Brady) (Loeblich and Tappan 1994; pl. 128, fig. 13) were observed in the Timor Sea in West Pacific Ocean (Meriç et al. 2005). Yet, *Amphicoryna scalaris* (Batsch) individuals with the same characteristics were seen around Vulcano Island in the Tyrrhenian Sea (Cimerman and Langer 1991; pl. 54, fig. 6) (Meriç et al. 2002c and 2005). Furthermore,

TABLE 1
Coordinates of stations with abundant abnormal *Textularia* specimens.

STUDY AREA	Section no.	Start		End	
KAŞ	26	36. 09378	29. 39193	36. 09535	29. 38945
	30	36. 08792	29. 39824	36. 08794	29. 39495
	31	36. 08916	29. 39182	36. 08794	29. 39495
	34	36. 09096	29. 40443	36. 08833	29. 40636
	39	36. 08020	29. 41162	36. 08261	29. 41438
	42	36. 08739	29. 41687	36. 08717	29. 41942
	43	36. 08717	29. 41942	36. 08819	29. 42072
	44	36. 08881	29. 42371	36. 08958	29. 42639
	45	36. 08819	29. 42072	36. 08881	29. 42371
	48	36. 09864	29. 37788	36. 09756	29. 37652
	49	36. 08958	29. 42639	36. 09238	29. 42833
	50	36. 09238	29. 42833	36. 09438	29. 43076
	53	36. 09566	29. 43827	36. 09377	29. 44086
	54	36. 09377	29. 44086	36. 08435	29. 44407
	55	36. 08046	29. 45880	36. 08236	29. 45630
	56	36. 08236	29. 45630	36. 08435	29. 45386
	57	36. 08435	29. 44407	36. 09664	29. 44857
	58	36. 09664	29. 44857	36. 09459	29. 45091
	59	36. 09459	29. 45091	36. 09255	29. 45311
KEKOVA	60	36. 08261	29. 45092	36. 08083	29. 44903
	61	36. 08453	29. 45292	36. 08261	29. 45092
	63	36. 08867	29. 44739	36. 07681	29. 44491
	64	36. 09064	29. 37034		
	65	36. 09837	29. 37457		
	66	36. 07681	29. 44491	36. 07340	29. 44271
	67	36. 07340	29. 44271	36. 07489	29. 44644
	69	36. 07845	29. 45747	36. 07941	29. 45440
	71	36. 07950	29. 45159	36. 07689	29. 44998
	72	36. 07941	29. 45440	36. 07950	29. 45159
	73	36. 08378	29. 46068	36. 08429	29. 45712
	74	36. 08429	29. 45712	36. 08517	29. 45400
	77	36. 10136	29. 51431	36. 10081	29. 51017
	78	36. 10081	29. 51017	36. 10202	29. 50805
	79	36. 10202	29. 50805	36. 09992	29. 50677
	80	36. 09303	29. 48773	36. 09109	29. 48493
	81	36. 09489	29. 49026	36. 09303	29. 48773
	82	36. 08846	29. 47896	36. 08957	29. 48227
	83	36. 08957	29. 48227	36. 09109	29. 48493
	84	36. 08478	29. 47030	36. 08574	29. 47302
	85	36. 08207	29. 46597	36. 08360	29. 46974
	86	36. 08367	29. 46152	36. 08207	29. 46597
	87	36. 08846	29. 47896	36. 08577	29. 47600
	88	36. 08577	29. 47600	36. 08574	29. 47302
	94	36. 10486	29. 52732	36. 10243	29. 52625
	95	36. 10241	29. 52937	36. 10447	29. 53219
	96	36. 10447	29. 53219	36. 10626	29. 53505
	98	36. 10626	29. 53505	36. 10834	29. 53643
	100	36. 10968	29. 53823	36. 11158	29. 54166
	101	36. 11429	29. 54216	36. 11629	29. 54720
BEŞADALAR	103	36. 10472	30. 25686	36. 10472	30. 25805
	106	36. 10498	30. 24456	36. 10798	30. 24519
	107	36. 10798	30. 24519	36. 11024	30. 24434
	108	36. 11315	30. 24457	36. 11554	30. 24436
	114	36. 12077	30. 24020	36. 11829	30. 23967
	115	36. 12559	30. 24256	36. 12851	30. 24099
	116	36. 11973	30. 24310	36. 12077	30. 24020
ÜÇADALAR	123	36. 27472	30. 32050	36. 27621	30. 32881
	124	36. 27621	30. 33050	36. 27500	30. 33220
	125	36. 27675	30. 33050	36. 27716	30. 33271
	126	36. 27540	30. 33372		

Peneroplis planatus (Fichtel and Moll), *Rosalina* sp. and *Elphidium crispum* (Linné) individuals found in Dikili Bay in North Agean Sea also show morphological anomalies (Meriç et al. 2003). We argue that morphological anomalies in species mentioned above could be the result of degassing from volcanoes (Vulcano Island) or of discharge from fault-induced hydrothermal springs (Dikili Bay and Timor Sea).

However, neither any industrial plants which would cause heavy metal pollution nor gas or thermal springs were found in the region. The average value of Rn^{222} in natural spring water is 1.175 miliSievert (O'Neill 1993). Thus, the Rn^{222} values of Çeşme and Şifne thermal waters are significant (46.9-314.5 Becquerel) (table 9). However, unlike thermal springs around Ilıca Bay, there are no sources of radiation in the study area (text-figs. 11-14). A more likely cause is the existence of cold water springs formed through karstic cavities and submarine caves in some specific areas (text-fig. 9; Özkan et al. 2004b). The number of abnormal foraminifers is overwhelming in regions southeast of Kaş, south and southwest of Kekova and southeast of Beş Adalar. Comparing text-figures 3 and 4 with text-figures 9, and 16, we see that the abundance of abnormal individuals correlate well with the geographic distribution of caves and spring water discharge areas. Since precipitation of minerals from seawater is controlled to some degree by salinity and temperature, temporal variation of these parameters at a given site would affect crystal formation of minerals, particularly calcite and aragonite. Because these variations do not have the same manner and magnitude in every submarine spring, even in a narrow coastal zone, the resulting crystal formation variations could be different around groundwater discharge areas with different parameter values. We expect that submarine groundwater discharge sites with short term cyclic variations in amplitude would have a more pronounced effect on defective crystal formation.

TABLE 2
Coordinates of stations with abundant abnormal Peneroplids and Soritids specimens.

STUDY AREA	Section no.	Start		End	
PATARA	5	36. 14847	29. 18864	36. 19432	29. 13457
KALKAN	7	36. 14774	29. 19668	36. 14775	29. 20197
	17	36. 13245	29. 22530	36. 13464	29. 22449
	20	36. 15704	29. 22641	36. 15684	29. 23166
KAŞ	21	36. 10958	29. 38428	36. 10784	29. 38298
	23	36. 10783	29. 38133		
	32	36. 08792	29. 39821	36. 08958	29. 39965
	33	36. 08958	29. 39965	36. 09127	29. 40464
	37	36. 08409	29. 40674	36. 08086	29. 40963
	41	36. 08501	29. 41562	36. 08739	29. 41687
	42	36. 08739	29. 41687	36. 08717	29. 41942
	44	36. 08881	29. 42371	36. 08958	29. 42639
	45	36. 08819	29. 42072	36. 08881	29. 42371
	47	36. 09662	29. 37703	36. 09797	29. 37771
	49	36. 08958	29. 42639	36. 09238	29. 42833
	50	36. 09238	29. 42833	36. 09438	29. 43076
	51	36. 09438	29. 43076	36. 09751	29. 43421
	52	36. 09751	29. 43421	36. 09566	29. 43827
	54	36. 09377	29. 44086	36. 08435	29. 44407
	58	36. 09664	29. 44857	36. 09459	29. 45091
	131	36. 11513	29. 36601		
	132	36. 11000	29. 38567		
KEKOVA	60	36. 08261	29. 45092	36. 08083	29. 44903
	65	36. 09837	29. 37457		
	73	36. 08378	29. 46068	36. 08429	29. 45712
	76	36. 09736	29. 49081	36. 09489	29. 49026
	79	36. 10202	29. 50805	36. 09992	29. 50677
	80	36. 09303	29. 48773	36. 09109	29. 48493
	81	36. 09489	29. 49026	36. 09303	29. 48773
	82	36. 08846	29. 47896	36. 08957	29. 48227
	83	36. 08957	29. 48227	36. 09109	29. 48493
	84	36. 08478	29. 47030	36. 08574	29. 47302
	89	36. 10136	29. 51431	36. 10271	29. 51815
	91	36. 10404	29. 52140	36. 10416	29. 52518
	92	36. 10416	29. 52518	36. 10571	29. 52817
	93	36. 10243	29. 52625	36. 10241	29. 52937
	94	36. 10486	29. 52732	36. 10243	29. 52625
	96	36. 10447	29. 53219	36. 10626	29. 53505
	99	36. 10968	29. 53823	36. 10993	29. 53483
	100	36. 10968	29. 53823	36. 11158	29. 54166
ÜÇADALAR	123	36. 27472	30. 32050	36. 27621	30. 32881
	125	36. 27675	30. 33050	36. 27716	30. 33271
	128	36. 27766	30. 31413		

Some recent studies argued that short-term changes in the salinity of seawater could result in morphological anomalies in benthic foraminifer tests (Nigam et al. 2006). Due to numerous cold water springs in the region, there are variations in salinity in certain areas in our study region. However, another study around a submarine spring in Saros Bay, North Aegean Sea (Meriç et al. 2006) illustrated that morphological changes in foraminifer tests were not as prevalent as the ones we present herein. On the other hand, morphological anomalies are extensive in individuals of *Textularia*, *Peneroplis Amphisorus* and *Sorites* along the

TABLE 3
Agricultural chemicals consumed in the city of Antalya.

AGRICULTURAL CHEMICALS CONSUMED IN THE CITY OF ANTALYA (Kg/l)											
Agricultural chemicals	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Insecticides	640.073	651.173	396.496	442.236	475.674	674.184	329.344	511.004	671.895	666.563	752.000
Fungicides	630.781	681.635	423.868	618.080	640.376	958.950	522.201	710.231	790.011	734.139	861.000
Acarícides	82.000	67.100	36.250	50.383	68.270	106.311	73.528	92.196	118.019	91.882	89.000
Nematocides and fumigants	923.475	1.075.450	1.061.589	1.585.400	727.372	1.415.240	523.165	370.648	1.046.804	981.040	1.436.000
Rodenticides and molluscides	4.800	7.250	7.300	11.200	9.000	11.580	4.910	11.500	11.000	7.600	10.000
Herbicides	172.515	67.463	121.666	98.119	130.391	206.098	103.332	117.968	117.109	123.366	151.000
Winter and summer oils	709.500	708.405	492.300	407.110	335.800	592.610	401.900	502.725	486.400	481.673	327.000
Plant growth regulators	-	-	29.262	37.620	31.196	93.059	20.129	31.707	27.000	14.790	16.000
Others	27.240	32.820	13.880	65.993	22.391	28.836	20.000	40.000	19.000	3.200	6.000
TOTAL	**3.190.384**	**3.291.296**	**2.582.611**	**3.316.141**	**2.440.470**	**4.086.824**	**1.998.509**	**2.387.979**	**3.170.219**	**3.104.433**	**3.692.000**

coasts of southwest Antalya. Thus, we argue that the cause of morphological abnormalities in this region is not only related to variations in salinity, but also to the presence of numerous agricultural chemicals which contaminate karstic springs.

Some researchers consider morphological abnormalities of foraminifer tests to be indicators of stressed environments, and some species are used as bioindicators for anthropogenic pollution. However, Geslin et al. (2002) shows that the environmental stress may also be exerted by natural factors such as, hypersalinity, periodical acidification and strong hydrodynamics. Thus, high ratios of abnormal to normal tests can also be observed in environments protected from human impact. We find that along the southwestern coasts of Antalya, Turkey, numerous additive chemicals in karstic spring water may be the cause of morphological anomalies in the foraminiferal genera and species discussed herein. Furthermore, rapid changes in ecological parameters related to submarine groundwater discharge may also be responsible for morphological anomalies in our foraminifers. On the other hand, morphologicaly abnormal individuals are found in most of the sediment samples (33 samples), in which the abnormally colored individuals are observed (43 samples), this coincidence suggests that the heavy metals within the environment can also be a cause (Yalçın et al. 2008, this volume).

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TABLE 4
Characteristics of coastal and submarine caves in the study region.

Sıra No	Cave name	Entrance depth (m)	Depth reached (m)	% freshwater minimum	% freshwater maximum
1	Patara Evleri Kovukları	-1.2	-2.0	17	42
2	Kömürlük	-2.0	-2.0	19	34
3	Doruk	-4.4	-5.1		
4	Prenses-Simay	-40.0	-40.0	12	50
5	Yılan	0.0	-9.0	43	44
6	Mivini	-3.5	-53.0	12	49
7	Havalı	-4.0	-5.1	16	46
8	Çakıl	-1.0	-5.0	16	45
9	Likya Batığı	0.0	-2.5	13	20
10	Altuğ	-12.0	-63.0	42	50
11	Fakdere	-2.0	-2.5	26	50
12	Fok	-9.0	-9.0		
13	Buza	-11.5	-20.0	27	46
14	Gökkaya	0.0	-1.5	14	38
15	İlker Kaptan	-1.6	-7.0	36	41

TABLE 5
Total alpha and beta counts.

Place	Sample	Total Alpha Count (Bq/l)	Total Beta Count (Bq/l)
Kuş Tüneği (inside)	1	0,1010 ± 0,300	1,4213 ± 0,1379
Kuş Tüneği (outside)	2	0,1056 ± 0,0362	1,7871 ± 0,1481
Liman ağzı (inside)	3	0,1278 ± 0,0350	1,2693 ± 0,1366
Liman ağzı (outside)	4	0,0781 ± 0,0326	0,8762 ± 0,1366
Seal Cave (inside)	5	0,0240 ± 0,0294	1,5560 ± 0,1414
BeşAdalar	6	0,1074 ± 0,0347	1,4375 ± 0,1425

TABLE 6
Total relative alpha and relative beta counts.

Place	Sample	Relative Total Alpha Radiaoctivity Level	Relative Total Beta Radiaoctivity Level
Kuş Tüneği (inside)	1	4,208	1,622
Kuş Tüneği (outside)	2	4,400	2,040
Liman ağzı (inside	3	5,325	1,449
Liman ağzı (outside)	4	3,254	1
Seal Cave (inside)	5	1	1,776
BeşAdalar	6	4,475	1,641

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TABLE 7
Heavy metal analyses of water samples from submarine groundwater discharge in Kaş (ppm).

	Cu	Zn	Mn	Fe	Cd	Pb	Cr
Seal cave (inside, 0 m)	0,231	1,449	0,474	30,274	0,57	4,793	0,564
Seal cave (inside, 2.7 m)	0,39	2,595	0,93	36,411	0,408	6,083	4,601
Seal cave (outside)	1,082	2,843	1,082	34,493	0,53	6,308	
Open sea	1,057	4,718	1,184	39,945	0,501	8,172	1,722
liman ağzı (inside)	0,692	3,486	1,55	43,799	0,355	5,1	<0.1
liman ağzı (outside)	0,439	4,674	0,226	25,744	0,375	4,137	<0.1
kuş tüneği (inside)	0,542	3,463	1,175	21,114	0,441	5,694	<0.1
kuş tüneği (outside)	0,545	4,049	0,509	35,379	0,819	5,039	<0.1
Krauskopf,1979	$5x10^{-4}$	0,0049	$2x10^{-4}$	0,002	$1x10^{-6}$	$3x10^{-5}$	$3x10^{-4}$

TABLE 8
Results of pesticide analyses of water samples from Kırkgöz Karst Springs, NW Antalya from Ekmekçi (2005) (all concentrations in µg/l).

ÇEŞME and ŞİFNE	Basic Spring		Kambina spring	Kubakasaları spring	Büyük Hamam	Küçük Hamam	Şifne spring		Şifne Mide suyu	Şifne Büyük İçme		Şifne Küçük İçme	
Date	9/1946	6/1969	9/1946	9/1946	9/1946	9/1946	9/1946	6/1969	10/1946	10/1946	6/1969	10/1946	6/1969
Temperature(°C)	58	55	62	50	50	50	38	42	25,5	24	19	25	25
PH	7.2	6.58					7.2	6.76	7.4	7	6.52	7.2	6.56
EC (mho)													
Rn^{226}(Bekerel)	48.47	259					20.35	314.5	31.08	14.8	278.98	19.61	46.99
Na^{+} (mg/l)	5721.5	6733.77	6295	5902.8	1650	1342	2103.7	8262.15	512.5	3350.3	3012.61	4982.8	5692.78
K^{+} (mg/l)	247.2	387.09	-	-	-	-	96.8	460.21	24.6	119.3	110.65	2992.4	218.57
Ca^{2+} (mg/l)	786	1202.28	786	800	45	28	269.2	1137.97	91.7	576.9	585.3	397.6	941
Mg^{2+} (mg/l)	378	1384.45	378	352	70	63	158	1878.65	24.2	288.7	811.2	534.4	1083.83
Fe^{3+} (mg/l)	0.4	0.22	90	15	52	15	0.56	0.4	0.55	trace	0.66	-	0.6
Al^{3+} (mg/l)	0.7	0.14	-	-	-	-	trace	0.17	trace	trace	0.15	0.12	0.15
Cl^{-} (mg/l)	10 450.7	15 350	11 000	10 437	249	188	3721	18.900	755	755	7050	11 343.9	12 670
Br^{-} (mg/l)	6.2	0.12	-	-	-	-	-	0.13	-	-	0.12		0.13
SO_4^{2-} (mg/l)	1359	1860	1386	1359	158	779	552	2150	145.3	6265	900	1567.1	1490
CO_2^{-} (mg/l)	30.8	41.8	-	-	-	-	13.2	22.1	11	52.8	88	39.6	82.72
HCO_3^{-} (mg/l)	140.3	305.4	183	323.3	2787.7	2763.3	231.8	280.6	311.1	329.4	727.16	274.5	46.36
H_2SiO_3 (mg/l)	39.2	15.08	3.9	trace	57.2	52	21.3	13.91	22,6	54.6	26.26	9.1	14.3

TABLE 9
Chemical composition of thermal mineral waters of Çeşme and Şifne springs (Çağlar 1946; Türkiye Madensuları (3), Ege Bölgesi 1974).

ÇEŞME and ŞİFNE	Basic Spring		Kambina spring	Kubakasaları spring	Büyük Hamam	Küçük Hamam	Şifne spring		Şifne Mide suyu	Şifne Büyük İçme		Şifne Küçük İçme	
Date	9/1946	6/1969	9/1946	9/1946	9/1946	9/1946	9/1946	6/1969	10/1946	10/1946	6/1969	10/1946	6/1969
Temperature(°C)	58	55	62	50	50	50	38	42	25,5	24	19	25	25
PH	7.2	6.58					7.2	6.76	7.4	7	6.52	7.2	6.56
EC (mho)													
Rn^{226}(Bekerel)	48.47	259					20.35	314.5	31.08	14.8	278.98	19.61	46.99
Na^{+} (mg/l)	5721.5	6733.77	6295	5902.8	1650	1342	2103.7	8262.15	512.5	3350.3	3012.61	4982.8	5692.78
K^{+} (mg/l)	247.2	387.09	-	-	-	-	96.8	460.21	24.6	119.3	110.65	2992.4	218.57
Ca^{2+} (mg/l)	786	1202.28	786	800	45	28	269.2	1137.97	91.7	576.9	585.3	397.6	941
Mg^{2+} (mg/l)	378	1384.45	378	352	70	63	158	1878.65	24.2	288.7	811.2	534.4	1083.83
Fe^{3+} (mg/l)	0.4	0.22	90	15	52	15	0.56	0.4	0.55	trace	0.66	-	0.6
Al^{3+} (mg/l)	0.7	0.14	-	-	-	-	trace	0.17	trace	trace	0.15	0.12	0.15
Cl^{-} (mg/l)	10 450.7	15 350	11 000	10 437	249	188	3721	18.900	755	755	7050	11 343.9	12 670
Br^{-} (mg/l)	6.2	0.12	-	-	-	-	-	0.13	-	-	0.12		0.13
SO_4^{2-} (mg/l)	1359	1860	1386	1359	158	779	552	2150	145.3	6265	900	1567.1	1490
CO_2^{-} (mg/l)	30.8	41.8	-	-	-	-	13.2	22.1	11	52.8	88	39.6	82.72
HCO_3^{-} (mg/l)	140.3	305.4	183	323.3	2787.7	2763.3	231.8	280.6	311.1	329.4	727.16	274.5	46.36
H_2SiO_3 (mg/l)	39.2	15.08	3.9	trace	57.2	52	21.3	13.91	22,6	54.6	26.26	9.1	14.3

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PLATE 1

(see page 260)

1 *Textularia bocki* Höglund. Normal form, side view, ×22.5, Kekova-Antalya, Station 89/6m.

2 *Textularia bocki* Höglund. Normal form, side view, ×30, Kekova-Antalya, Station 89/6m.

3 *Textularia bocki* Höglund. Normal form, side view, ×28.5, Kekova-Antalya, Station 89/6m.

4 *Textularia bocki* Höglund. Abnormal form, side view, ×23, Kaş-Antalya, Station 26/25m.

5 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Kaş-Antalya, Station 30/14m.

6 *Textularia bocki* Höglund. Abnormal form, side view, ×21, Kaş-Antalya, Station 34/5m.

7 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Kaş-Antalya, Station 34/5m.

8 *Textularia bocki* Höglund. Abnormal form, side view, ×27.5, Kaş-Antalya, Station 34/6m.

9 *Textularia bocki* Höglund. Abnormal form, side view, ×22.5, Kaş-Antalya, Station 34/6m.

10 *Textularia bocki* Höglund. Abnormal form, side view, ×22.5, Kaş-Antalya, Station 39/14m.

11 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kaş-Antalya, Station 39/14m.

12 *Textularia bocki* Höglund. Abnormal form, side view, ×27.5, Kaş-Antalya, Station 39/14m.

13 *Textularia bocki* Höglund. Abnormal form, side view, ×17, Kaş-Antalya, Station 39/14m.

14 *Textularia bocki* Höglund. Abnormal form, side view, ×32, Kaş-Antalya, Station 42/3m.

15 *Textularia bocki* Höglund. Abnormal form, side view, ×34, Kaş-Antalya, Station 43/6m.

16 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kaş-Antalya, Station 43/21m.

17 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 43/21m.

18 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Kaş-Antalya, Station 44/6m.

PLATE 2

(see page 261)

1 *Textularia bocki* Höglund. Abnormal form, side view, ×21, Kaş-Antalya, Station 44/6 m.

2 *Textularia bocki* Höglund. Abnormal form, side view, ×29, Kaş-Antalya, Station 44/20 m.

3 *Textularia bocki* Höglund. Abnormal form, side view, ×31, Kaş-Antalya, Station 48/12 m.

4 *Textularia bocki* Höglund. Abnormal form, side view, ×38, Kaş-Antalya, Station 49/8 m.

5 *Textularia bocki* Höglund. Abnormal form, side view, ×42, Kaş-Antalya, Station 49/8 m.

6 *Textularia bocki* Höglund. Abnormal form, side view, ×39, Kaş-Antalya, Station 49/8 m.

7 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kaş-Antalya, Station 49/14 m.

8 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 50/3.5m.

9 *Textularia bocki* Höglund. Abnormal form, side view, ×47, Kaş-Antalya, Station 50/14 m.

10 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 54/15 m.

11 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Kaş-Antalya, Station 54/16 m.

12 *Textularia bocki* Höglund. Abnormal form, side view, ×24, Kaş-Antalya, Station 54/16 m

13 *Textularia bocki* Höglund. Abnormal form, side view, ×44, Kaş-Antalya, Station 54/23 m.

14 *Textularia bocki* Höglund. Abnormal form, side view, ×33, Kaş-Antalya, Station 55/14 m.

15 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 56/13 m

16 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 56/13 m.

17 *Textularia bocki* Höglund. Abnormal form, side view, ×22, Kaş-Antalya, Station 57/15 m.

18 *Textularia bocki* Höglund. Abnormal form, side view, ×24.5, Kaş-Antalya, Station 58/14m.

PLATE 3

(see page 262)

1 *Textularia bocki* Höglund. Abnormal form, side view, ×15, Kaş-Antalya, Station 58/24m.

2 *Textularia bocki* Höglund. Abnormal form, side view, ×47.5, Kaş-Antalya, Station 60/14m.

3 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 60/14m.

4 *Textularia bocki* Höglund. Abnormal form, side view, ×45, Kaş-Antalya, Station 61/5m.

5 *Textularia bocki* Höglund. Abnormal form, side view, ×29, Kaş-Antalya, Station 61/5m.

6 *Textularia bocki* Höglund. Abnormal form, side view, ×28, Kaş-Antalya, Station 61/12m.

7 *Textularia bocki* Höglund. Abnormal form, side view, ×31, Kaş-Antalya, Station 63/12m.

8 *Textularia bocki* Höglund. Abnormal form, side view, ×32, Kaş-Antalya, Station 63/12m.

9 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 63/24m.

10 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 65/6m.

11 *Textularia bocki* Höglund. Abnormal form, side view, ×38.5, Kaş-Antalya, Station 66/20m.

12 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Kaş-Antalya, Station 69/12 m

13 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Kaş-Antalya, Station 71/8m.

14 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kaş-Antalya, Station 73/8m.

15 *Textularia bocki* Höglund. Abnormal form, side view, ×35, Kaş-Antalya, Station 73/12 m

16 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kaş-Antalya, Station 74/6m.

17 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Kekova-Antalya, Station 78/24m.

18 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Kekova-Antalya, Station 80/6m

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PLATE 4

(see page 263)

1 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Kekova-Antalya, Station 80/6m.

2 *Textularia bocki* Höglund. Abnormal form, side view, ×47, Kekova-Antalya, Station 80/6m.

3 *Textularia bocki* Höglund. Abnormal form, side view, ×33, Kekova-Antalya, Station 81/5m.

4 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Kekova-Antalya, Station 81/5m.

5 *Textularia bocki* Höglund. Abnormal form, side view, ×21, Kekova-Antalya, Station 81/5m.

6 *Textularia bocki* Höglund. Abnormal form, side view, ×22, Kekova-Antalya, Station 81/8m.

7 *Textularia bocki* Höglund. Abnormal form, side view, ×21, Kekova-Antalya, Station 81/8m.

8 *Textularia bocki* Höglund. Abnormal form, side view, ×19.5, Kekova-Antalya, Station 81/8m.

9 *Textularia bocki* Höglund. Abnormal form, side view, ×19.5, Kekova-Antalya, Station 81/8m.

10 *Textularia bocki* Höglund. Abnormal form, side view, ×34, Kekova-Antalya, Station 81/12m.

11 *Textularia bocki* Höglund. Abnormal form, side view, ×37, Kekova-Antalya, Station 81/12m.

12 *Textularia bocki* Höglund. Abnormal form, side view, ×21.5, Kekova-Antalya, Station 82/5m.

13 *Textularia bocki* Höglund. Abnormal form, side view, ×24, Kekova-Antalya, Station 83/6m.

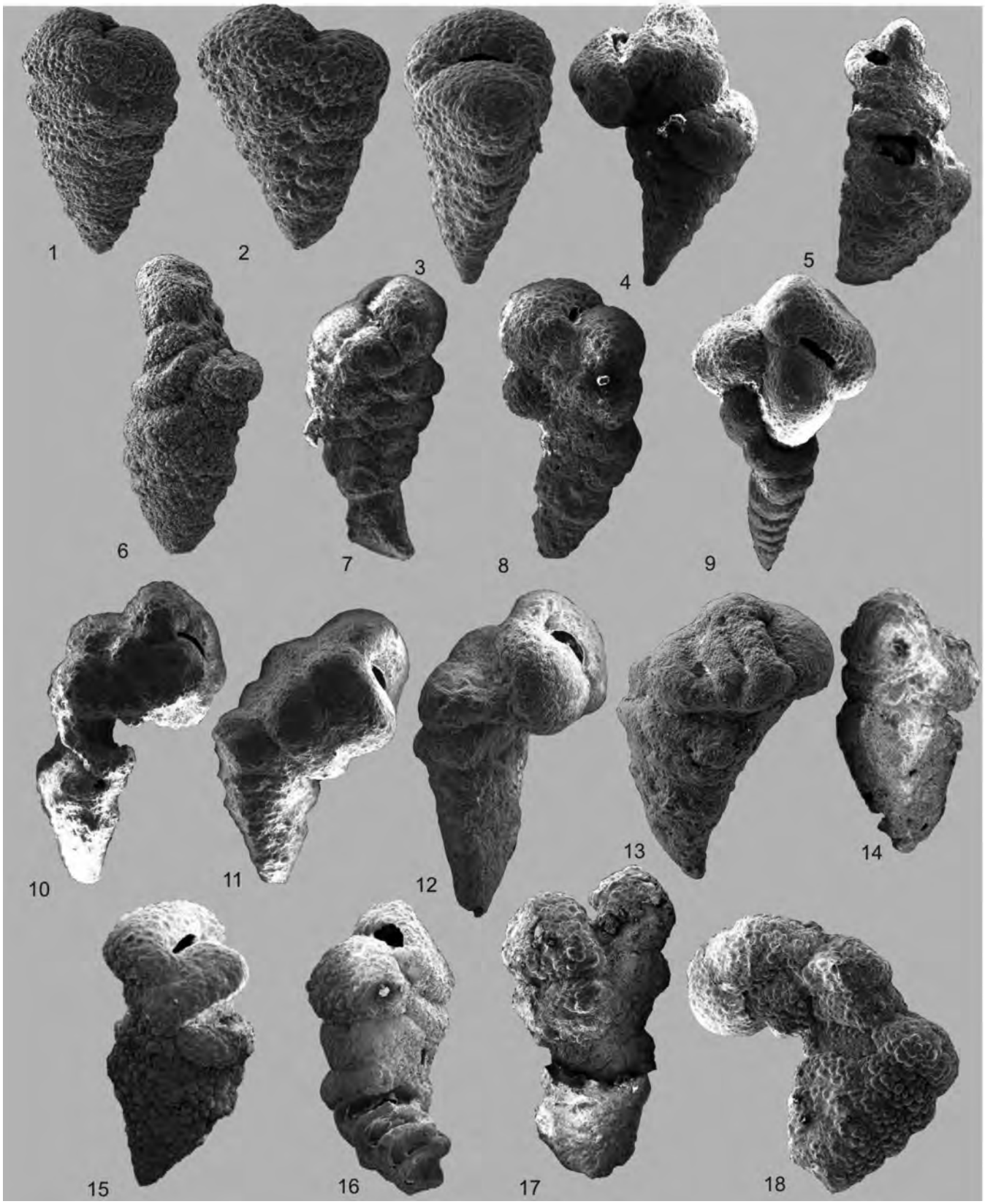
14 *Textularia bocki* Höglund. Abnormal form, side view, ×32, Kekova-Antalya, Station 83/13m.

15 *Textularia bocki* Höglund. Abnormal form, side view, ×31, Kekova-Antalya, Station 84/3 m

16 *Textularia bocki* Höglund. Abnormal form, side view, ×25, Kekova-Antalya, Station 84/10m.

17 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Kekova-Antalya, Station 85/23m.

18 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Kekova-Antalya, Station 86/15m.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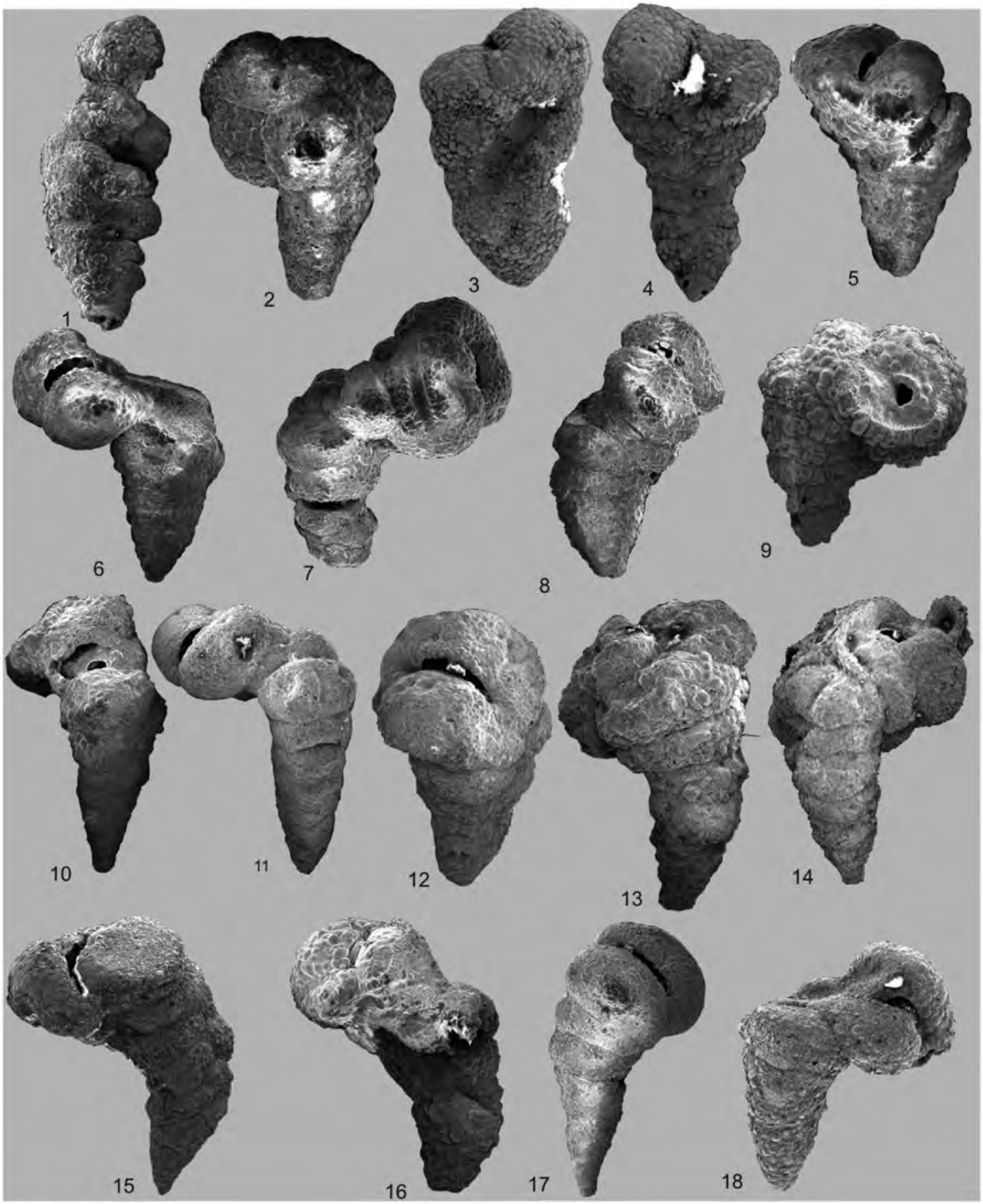
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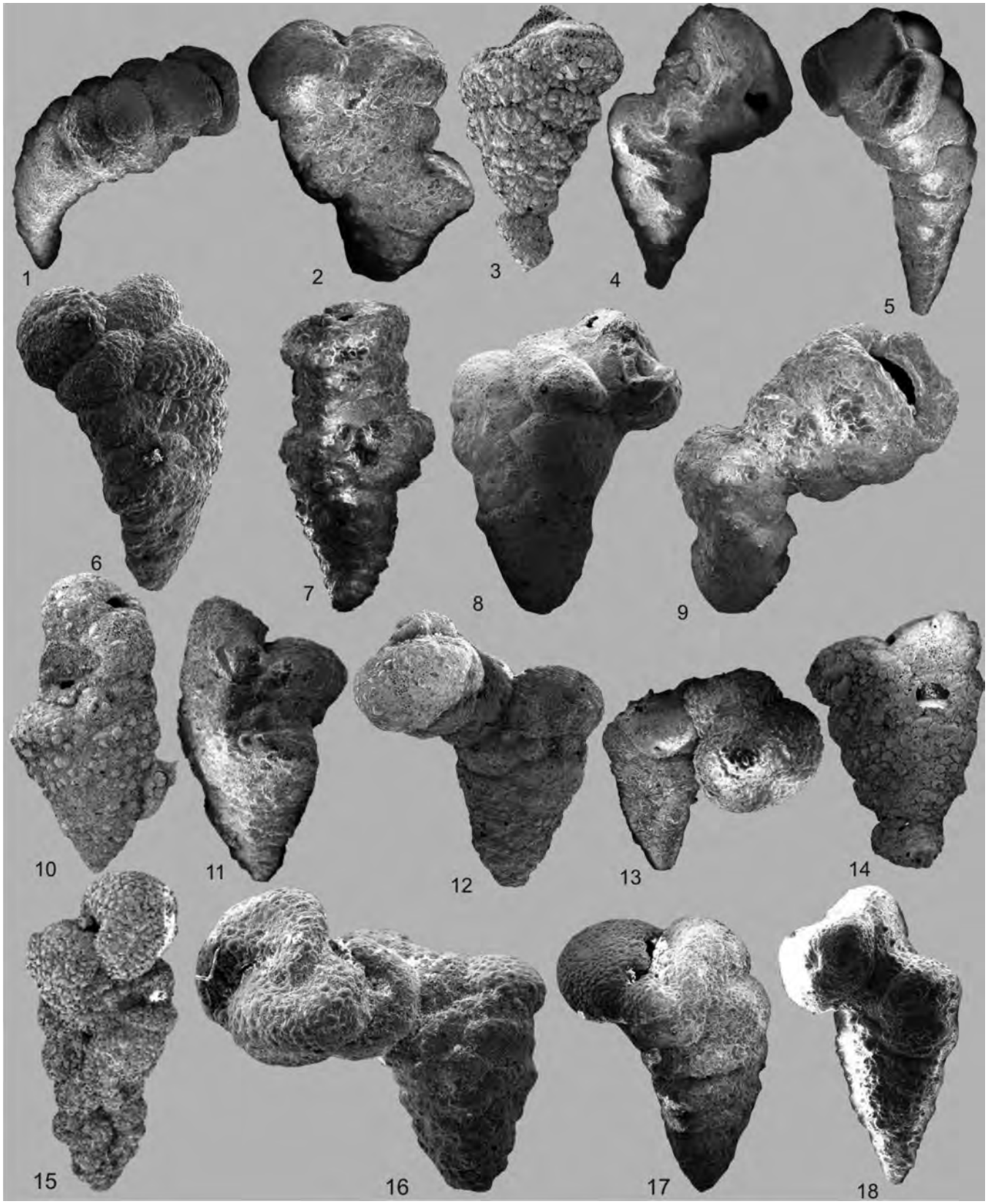
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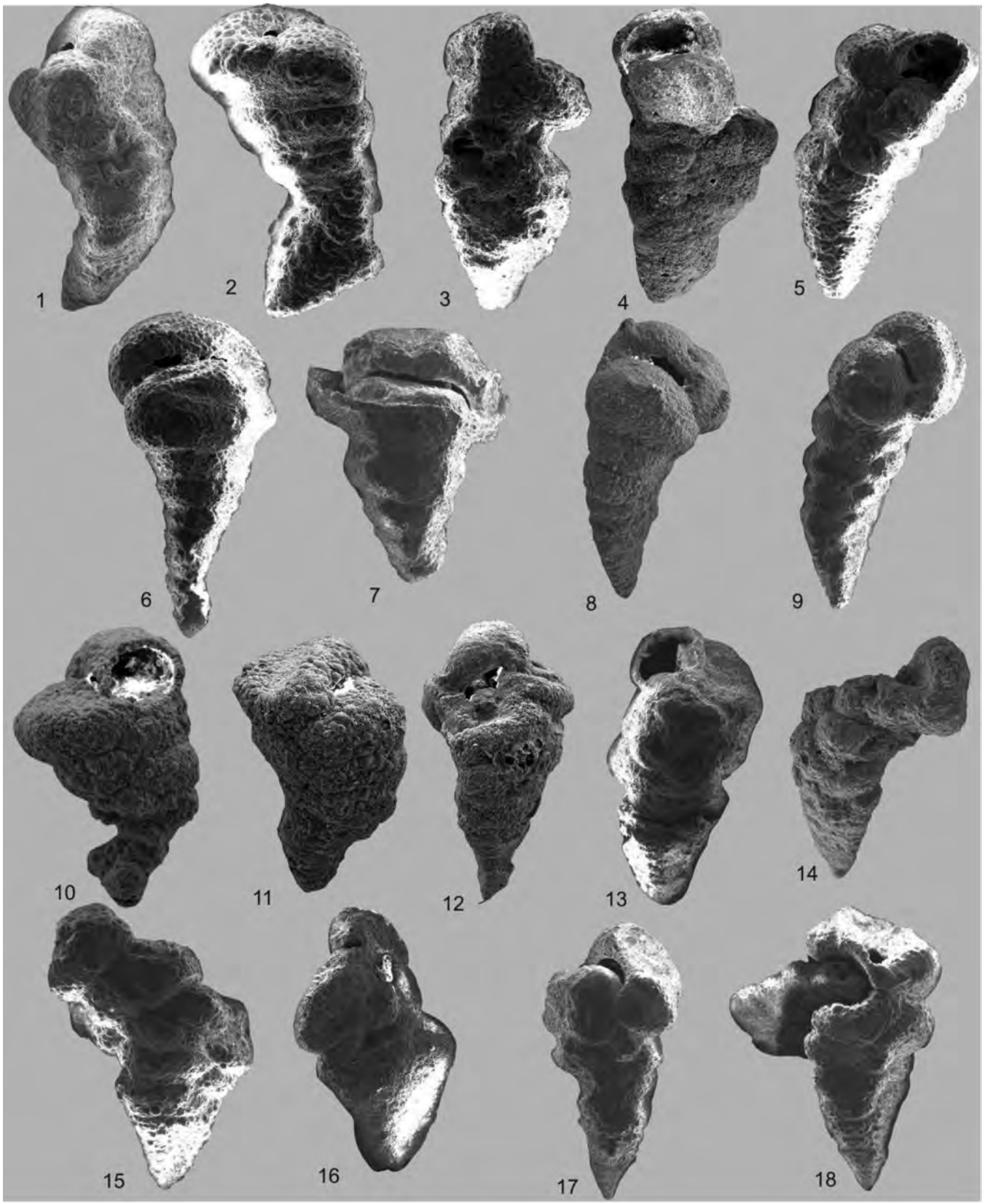
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PLATE 5

(see page 266)

1 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kekova-Antalya, Station 86/15m.

2 *Textularia bocki* Höglund. Abnormal form, side view, ×26.5, Kekova-Antalya, Station 87/14.5m.

3 *Textularia bocki* Höglund. Abnormal form, side view, ×39, Kekova-Antalya, Station 87/14.5m.

4 *Textularia bocki* Höglund. Abnormal form, side view, ×72, Kekova-Antalya, Station 87/14.5m.

5 *Textularia bocki* Höglund. Abnormal form, side view, ×40.5, Kekova-Antalya, Station 88/5m.

6 *Textularia bocki* Höglund. Abnormal form, side view, ×60, Kekova-Antalya, Station 94/12m.

7 *Textularia bocki* Höglund. Abnormal form, side view, ×37.5, Kekova-Antalya, Station 95/24m.

8 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Kekova-Antalya, Station 95/24m.

9 *Textularia bocki* Höglund. Abnormal form, side view, ×28, Kekova-Antalya, Station 95/24m.

10 *Textularia bocki* Höglund. Abnormal form, side view, ×32, Kekova-Antalya, Station 96/12m.

11 *Textularia bocki* Höglund. Abnormal form, side view, ×24.5, Kekova-Antalya, Station 96/12m.

12 *Textularia bocki* Höglund. Abnormal form, side view, ×28, Kekova-Antalya, Station 101/15 m

13 *Textularia bocki* Höglund. Abnormal form, side view, ×33, Kekova-Antalya, Station 101/15m.

14 *Textularia bocki* Höglund. Abnormal form, side view, ×50, Kekova-Antalya, Station 101/18m.

15 *Textularia bocki* Höglund. Abnormal form, side view, ×32.5, Beşadalar-Antalya, Station 106/12m.

16 *Textularia bocki* Höglund. Abnormal form, side view, ×23, Beşadalar-Antalya, Station 107/24m.

PLATE 6

(see page 267)

1 *Textularia bocki* Höglund. Abnormal form, side view, ×22, Beşadalar-Antalya, Station 107/24m.

2 *Textularia bocki* Höglund. Abnormal form, side view, ×28, Beşadalar-Antalya, Station 107/24m.

3 *Textularia bocki* Höglund. Abnormal form, side view, ×22, Beşadalar-Antalya, Station 114/12m.

4 *Textularia bocki* Höglund. Abnormal form, side view, ×18, Beşadalar-Antalya, Station 114/12m.

5 *Textularia bocki* Höglund. Abnormal form, side view, ×16, Beşadalar-Antalya, Station 115/24m.

6 *Textularia bocki* Höglund. Abnormal form, side view, ×40, Üçadalar-Antalya, Station 123/12m.

7 *Textularia bocki* Höglund. Abnormal form, side view, ×15, Beşadalar-Antalya, Station 117/19m.

8 *Textularia bocki* Höglund. Abnormal form, side view, ×27, Üçadalar-Antalya, Station 123/20m.

9 *Textularia bocki* Höglund. Abnormal form, side view, ×23, Üçadalar-Antalya, Station 123/20m.

10 *Textularia bocki* Höglund. Abnormal form, side view, ×17, Üçadalar-Antalya, Station 124/20m.

11 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Üçadalar-Antalya, Station 124/27m.

12 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Üçadalar-Antalya, Station 125/12 m

13 *Textularia bocki* Höglund. Abnormal form, side view, ×20, Üçadalar-Antalya, Station 125/18m.

14 *Textularia bocki* Höglund. Abnormal form, side view, ×30, Üçadalar-Antalya, Station 126/17m.

15 *Textularia bocki* Höglund. Abnormal form, side view, ×28, Kaş-Antalya, Station 26/18m.

PLATE 7
(see page 268)

1 *Coscinospira hemprichii* Ehrenberg. Abnormal form, side view, ×58, Kaş-Antalya, Station 42/3m.

2 *Peneroplis arietinus* (Batsch). Abnormal form, side view, ×55, Kaş-Antalya, Station 37/15m.

3 *Peneroplis arietinus* (Batsch). Abnormal form, side view, ×45, Kekova-Antalya, Station 81/8m.

4 *Peneroplis pertusus* (Forskål). Abnormal form, side view, ×53.5, Kaş-Antalya, Station 44/6m.

5 *Peneroplis pertusus* (Forskål). Abnormal form, side view, ×45, Kaş-Antalya, Station 44/20m.

6 *Peneroplis pertusus* (Forskål). Abnormal form, side view, ×66, Kaş-Antalya, Station 58/7m.

7 *Peneroplis pertusus* (Forskål). Abnormal form, side view, ×54.5, Kekova-Antalya, Station 89/6m.

8 *Peneroplis pertusus* (Forskål). Abnormal form, side view, ×45, Kaş-Antalya, Station 63/2m.

9 *Peneroplis pertusus* (Forskål). Abnormal form, side view, ×62, Kaş-Antalya, Station 67/15m.

10 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×52, Kalkan-Antalya, Station 17/7m.

11 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×60, Üçadalar-Antalya, Station 128/20m.

12 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×42, Kalkan-Antalya, Station 5/12m.

13 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×52, Kalkan-Antalya, Station 17/7m.

14 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×35, Kaş-Antalya, Station 32/12m.

PLATE 8
(see page 269)

1 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×51.5, Kaş-Antalya, Station 32/12m.

2 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×45, Kaş-Antalya, Station 33/13m.

3 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×70, Kaş-Antalya, Station 42/3m.

4 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×45.5, Kaş-Antalya, Station 79/12m.

5 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×52, Kaş-Antalya, Station 42/3m.

6 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×50, Kaş-Antalya, Station 43/6m.

7 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×40, Kaş-Antalya, Station 43/21m.

8 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×36.5, Kaş-Antalyaa, Station 49/14m.

9 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×54, Kaş-Antalya, Station 49/14m.

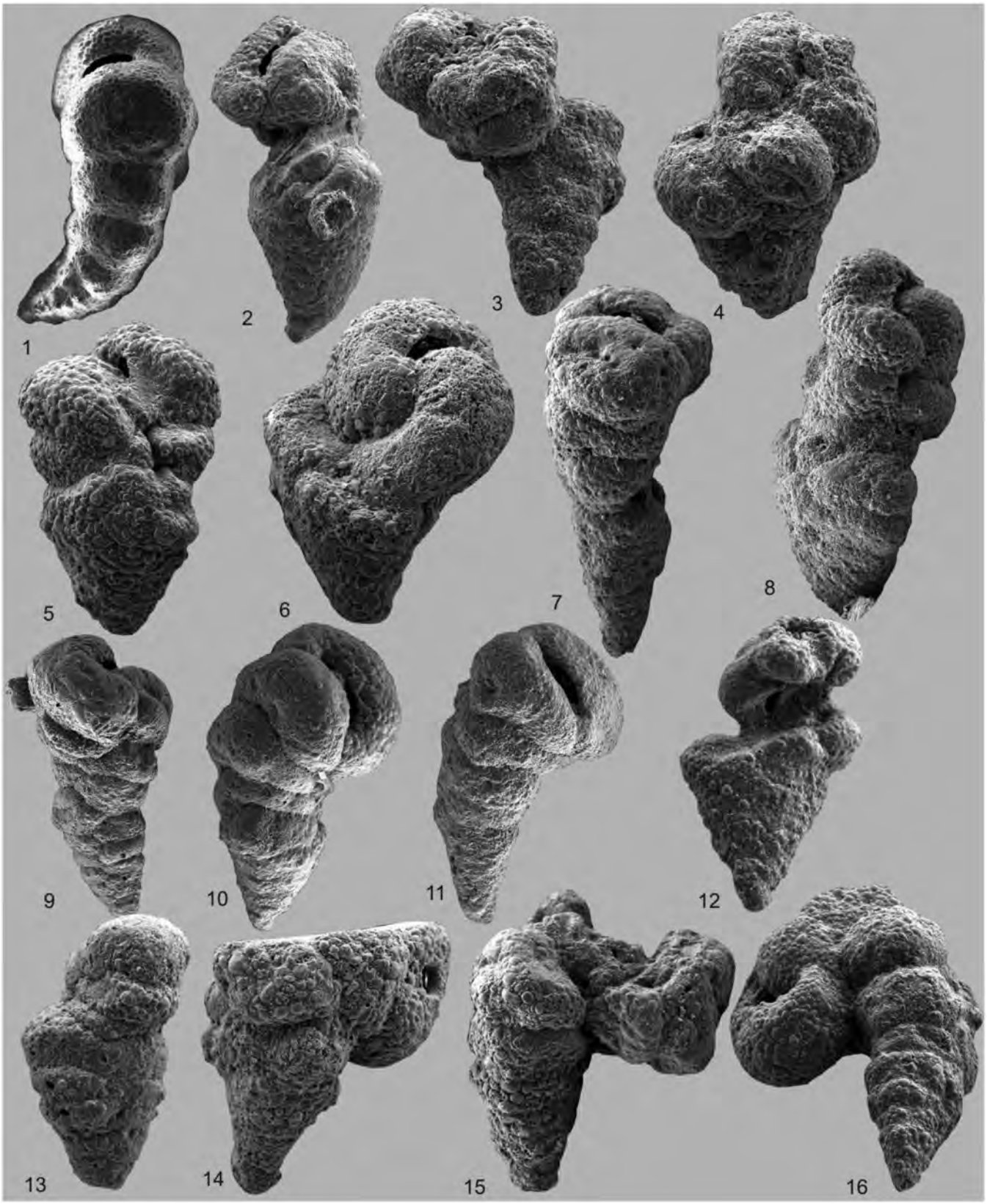
10 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×47, Kaş-Antalya, Station 50/14m.

11 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×47, Kaş-Antalya, Station 52/14m.

12 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×38, Kaş-Antalya, Station 51/14m.

13 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×87, Kaş-Antalya, Station 58/7m.

14 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×31, Kekova-Antalya, Station 80/19m.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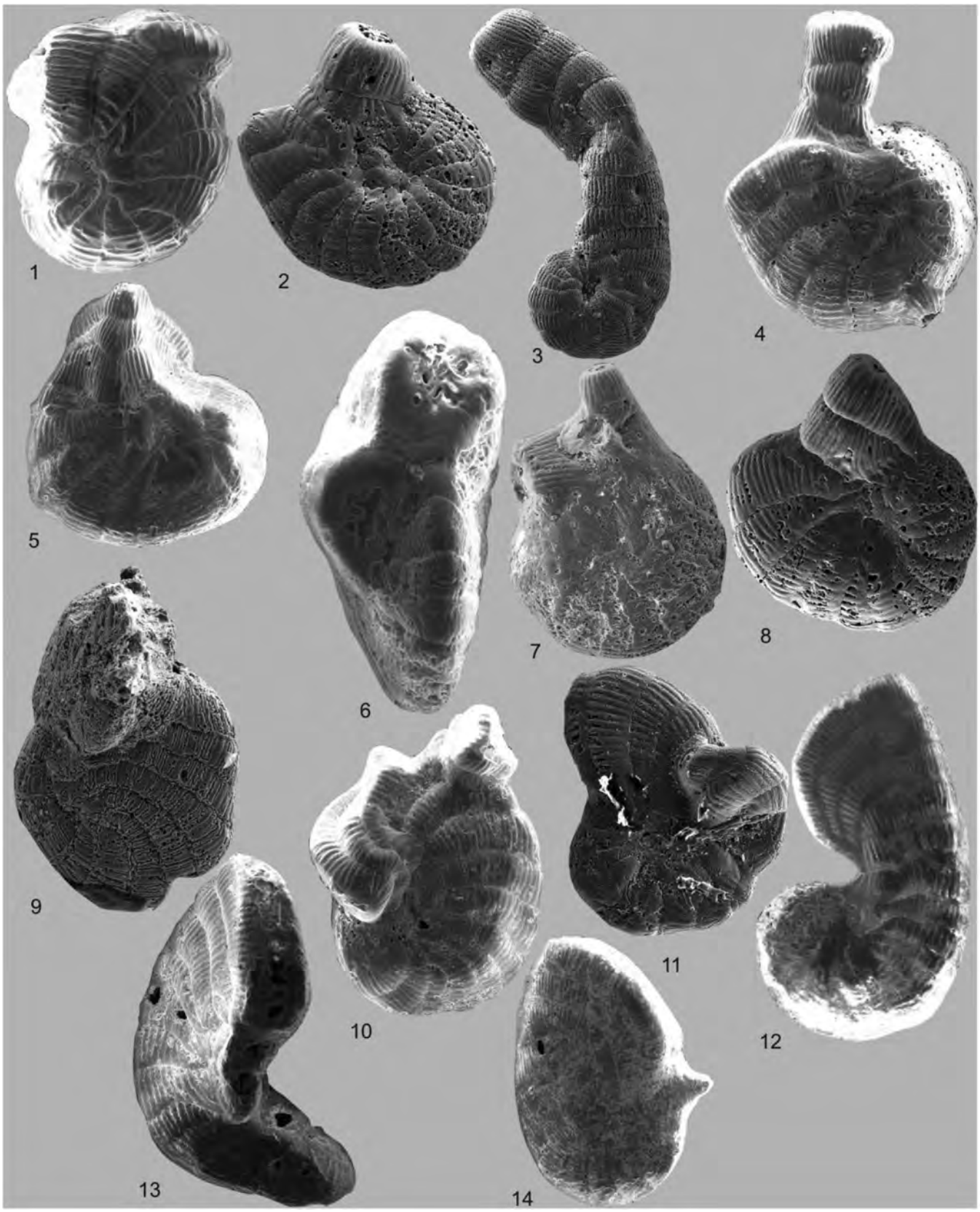
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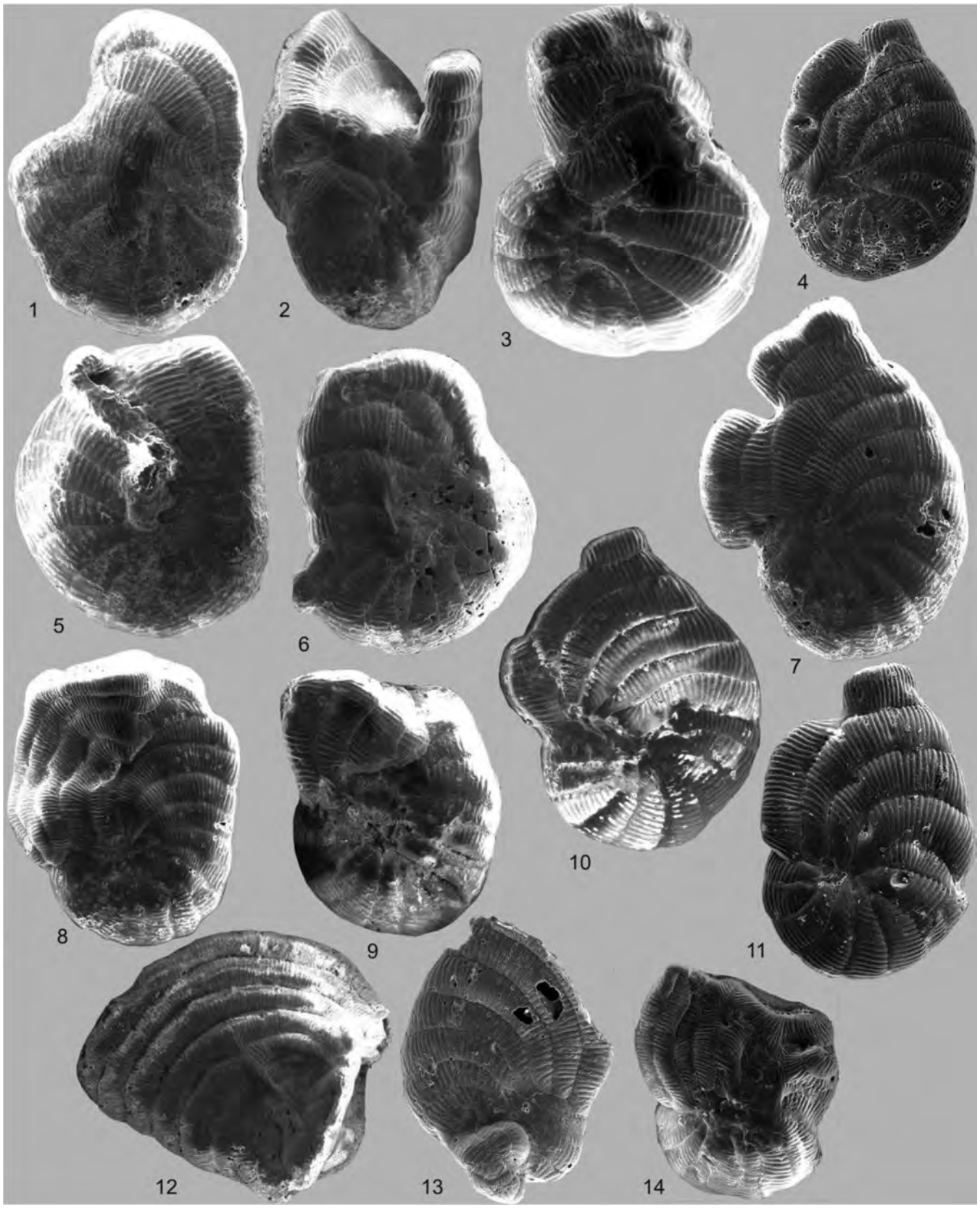
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PLATE 9

(see page 272)

1 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×37.5, Kaş-Antalya, Station 58/24m.

2 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×54, Kaş-Antalya, Station 60/21m.

3 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×34, Kekova-Antalya, Station 80/19m.

4 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×60, Kekova-Antalya, Station 80/19m.

5 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×47.5, Kekova-Antalya, Station 81/24m.

6 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×40, Kekova-Antalya, Station 82/5m.

7 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×46, Kekova-Antalya, Station 82/26m.

8 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×54, Kekova-Antalya, Station 83/6m.

9 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×36, Kekova-Antalya, Station 83/24m.

10 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×27, Kekova-Antalya, Station 84/14m.

11 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×33, Kekova-Antalya, Station 89/6m.

12 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×52, Kekova-Antalya, Station 99/24m.

13 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×31, Kekova-Antalya, Station 91/24m.

PLATE 10

(see page 273)

1 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×86, Kekova-Antalya, Station 89/6m.

2 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×99.5, Kekova-Antalya, Station 99/24m.

3 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×67, Kekova-Antalya, Station 99/24m.

4 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×38, Kekova-Antalya, Station 100/12m.

5 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×68.5, Beşadalar- Antalya, Station 106/12m.

6 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×60, Üçadalar-Antalya, Station 125/12m.

7 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×58, Üçadalar-Antalya, Station 125/12m.

8 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×54, Kekova-Antalya, Station 89/12m.

9 *Peneroplis planatus* (Fichtel and Moll). Abnormal form, side view, ×64, Kaş-Antalya, Station 45/6m.

PLATE 11 (see page 274)

1 *Amphisorus hemprichii* Ehrenberg. Abnormal form, side view, ×17, Kekova-Antalya, Station 81/8m.

2 *Amphisorus hemprichii* Ehrenberg. Abnormal form, side view, ×16, Kekova-Antalya, Station 81/8m.

3 *Amphisorus hemprichii* Ehrenberg. Abnormal form, side view, ×16.5, Kekova-Antalya, Station 81/8m.

4 *Amphisorus hemprichii* Ehrenberg. Abnormal form, side view, ×15, Kekova-Antalya, Station 81/8m.

5 *Amphisorus hemprichii* Ehrenberg. Abnormal form, side view, ×12, Kekova-Antalya, Station 81/8m.

6 *Amphisorus hemprichii* Ehrenberg. Abnormal form, side view, ×14, Kekova-Antalya, Station 81/8m.

7 *Sorites* cf. *S. orbiculus* Ehrenberg. Abnormal form, side view, ×24, Kaş-Antalya, Station 44/20m.

8 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×62, Kaş-Antalya, Station 47/12m.

9 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×80, Kaş-Antalya, Station 76/24m.

10 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×60, Kekova-Antalya, Station 99/24m.

11 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×57, Kaş-Antalya, Station 132/6m.

12 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×53, Kekova-Antalya, Station 96/12m.

PLATE 12 (see page 275)

1 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×37.5, Kekova-Antalya, Station84/12m.

2 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×51, Kekova-Antalya, Station94/6m.

3 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×48, Kaº-Antalya, Station 74/6m.

4 *Sorites orbiculus* Ehrenberg. Abnormal form, side view, ×42.5, Kekova-Antalya, Station89/6m.

5 *Sorites variabilis* Lacroix. Abnormal form, side view, ×35, Kalkan-Antalya, Station 20/6m.

6 *Sorites variabilis* Lacroix. Abnormal form, side view, ×25, Kalkan-Antalya, Station 20/6m.

7 *Sorites variabilis* Lacroix. Abnormal form, side view, ×19, Kalkan-Antalya, Station20/12m.

8 *Sorites variabilis* Lacroix. Abnormal form, side view, ×27, Kaş-Antalya, Station 21/12m.

9 *Sorites variabilis* Lacroix. Abnormal form, side view, ×15, Kaş-Antalya, Station 23/24m.

10 *Sorites variabilis* Lacroix. Abnormal form, side view, ×15, Kaş-Antalya, Station 32/12m.

11 *Sorites variabilis* Lacroix. Abnormal form, side view, ×19, Kaş-Antalya, Station 37/15m.

12 *Sorites variabilis* Lacroix. Abnormal form, side view, ×22, Kaş-Antalya, Station 21/12m.

PLATE 13 (see page 276)

1 *Sorites variabilis* Lacroix. Abnormal form, side view, ×42, Kaş-Antalya, Station 52/7m.

2 *Sorites variabilis* Lacroix. Abnormal form, side view, ×25, Kaş-Antalya, Station 58/14m.

3 *Sorites variabilis* Lacroix. Abnormal form, side view, ×24, Kaş-Antalya, Station 65/6m.

4 *Sorites variabilis* Lacroix. Abnormal form, side view, ×20, Kaş-Antalya, Station 65/6m.

5 *Sorites variabilis* Lacroix. Abnormal form, side view, ×27, Kaş-Antalya, Station 37/15m.

6 *Sorites variabilis* Lacroix. Abnormal form, side view, ×60, Kaş-Antalya, Station 131/12m.

7 *Sorites variabilis* Lacroix. Abnormal form, side view, ×21.5, Kaş-Antalya, Station 132/6m.

8 *Spiroloculina* sp. Abnormal form, side view, ×62, Kekova-Antalya, Station 92/6m.

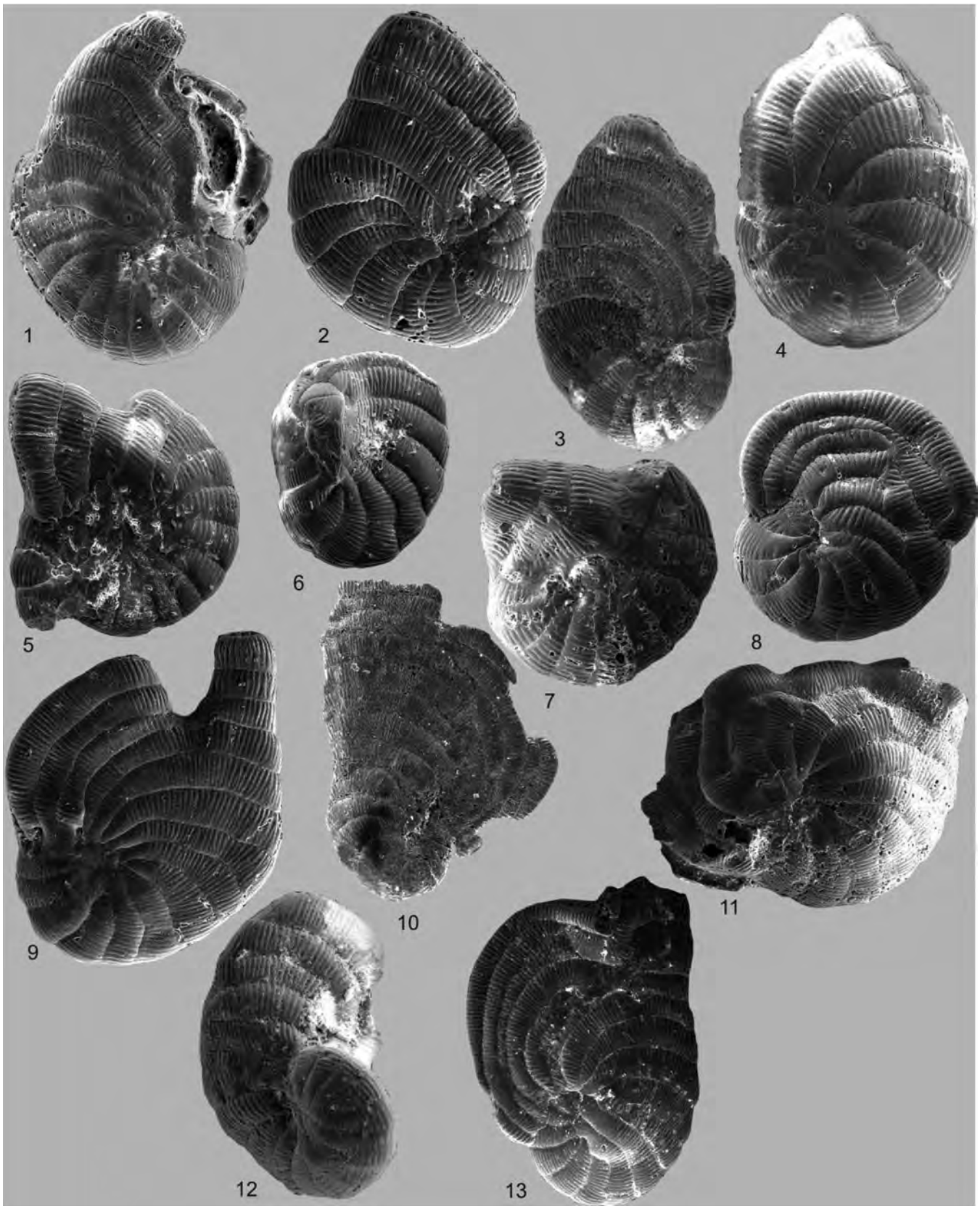
9 *Spiroloculina* cf. *S. angulata* d'Orbigny. Abnormal form, side view, ×44, Kekova-Antalya, Station, 84/20m.

10 *Spiroloculina* cf. *S. angulata* d'Orbigny. Abnormal form, side view, ×60, Kekova-Antalya, Station, 83/24m.

11 *Spiroloculina* cf. *S. angulata* d'Orbigny. Abnormal form, side view, ×48, Kekova-Antalya, Station, 99/24m.

12 *Spiroloculina* cf. *S. angulosa* Terquem. Abnormal form, side view, ×80, Kaş-Antalya,Station, 55/14m.

13 *Cibicidella variabilis* (d'Orbigny). Abnormal form, side view, ×49, Kekova-Antalya, Station 99/12m.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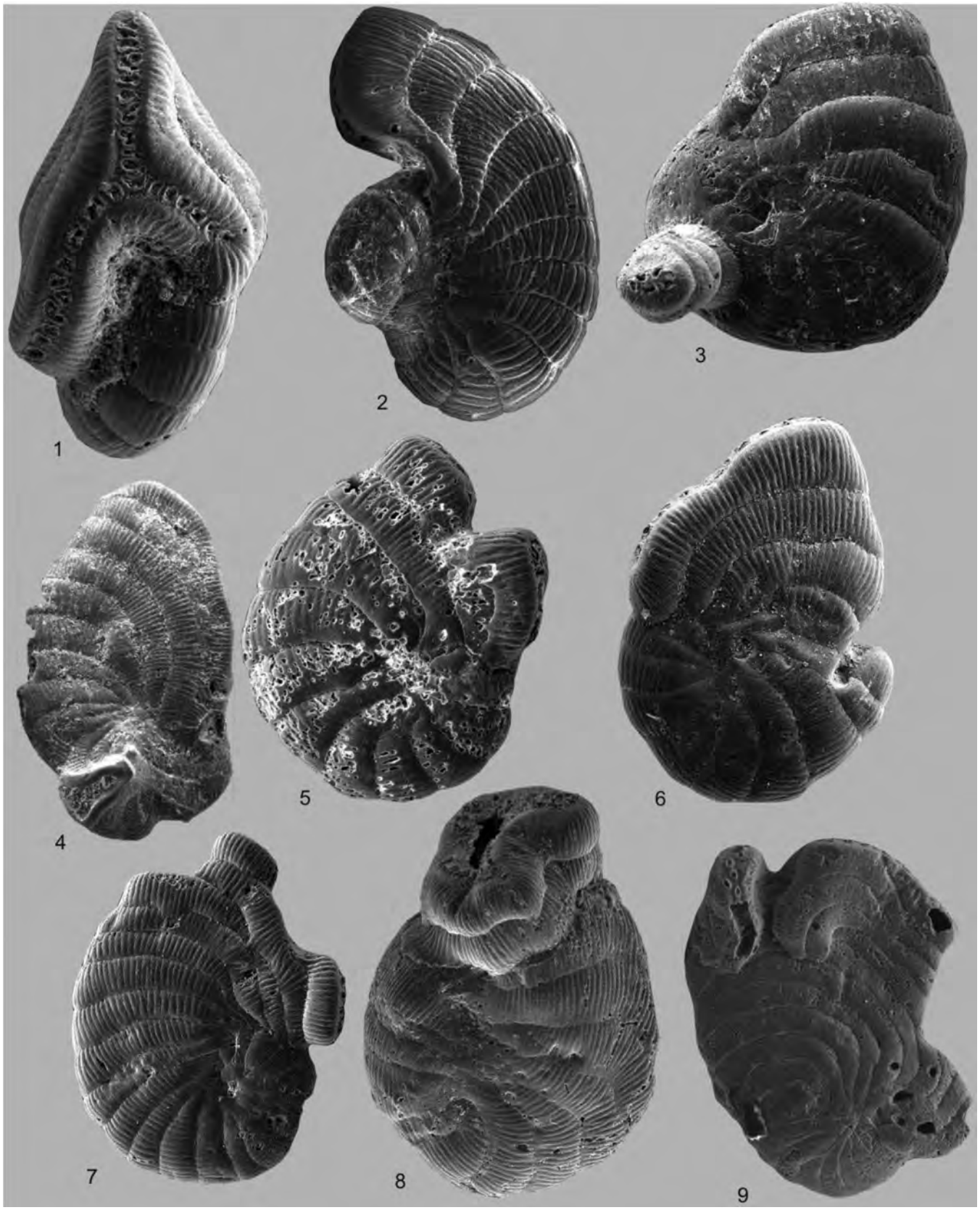
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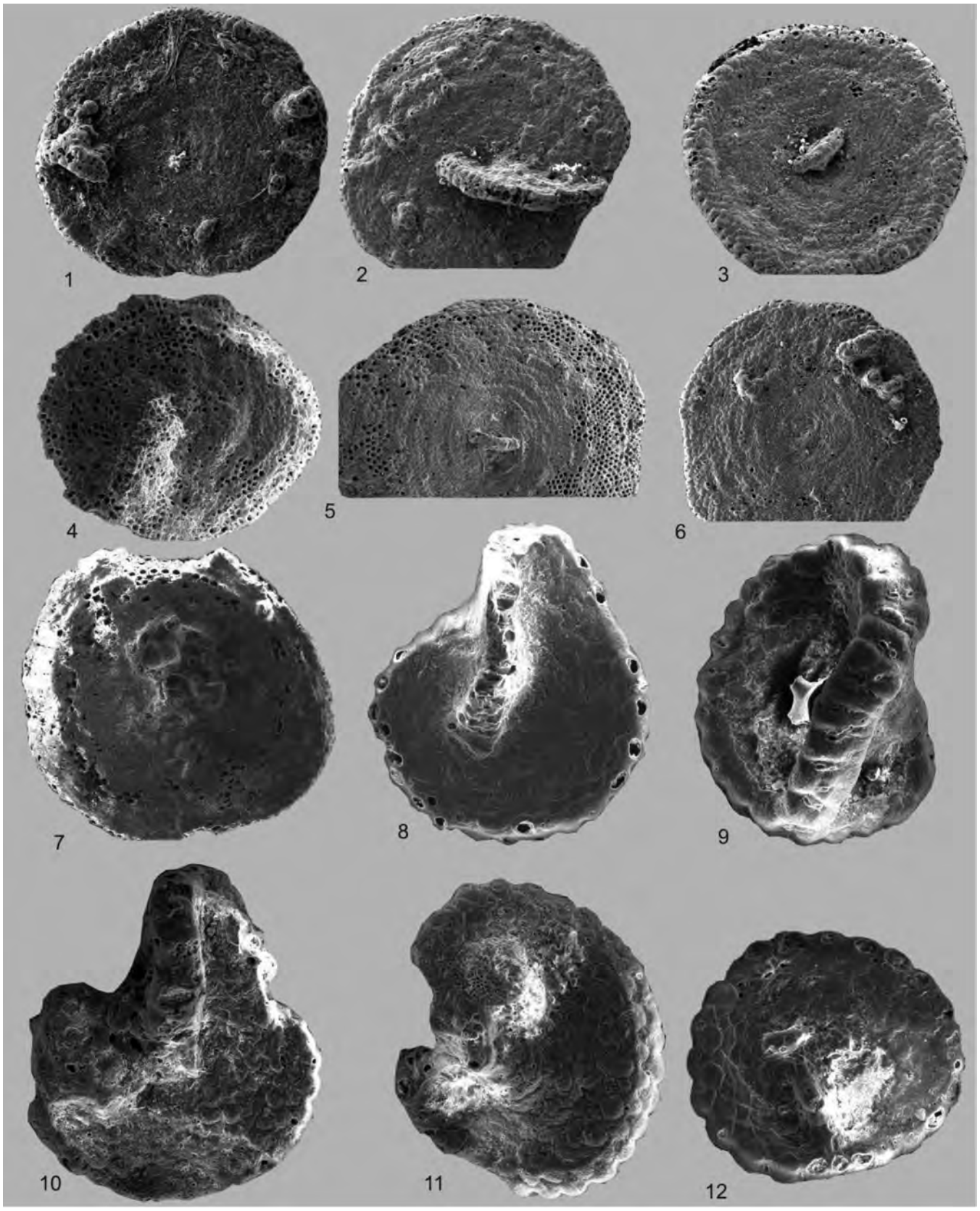
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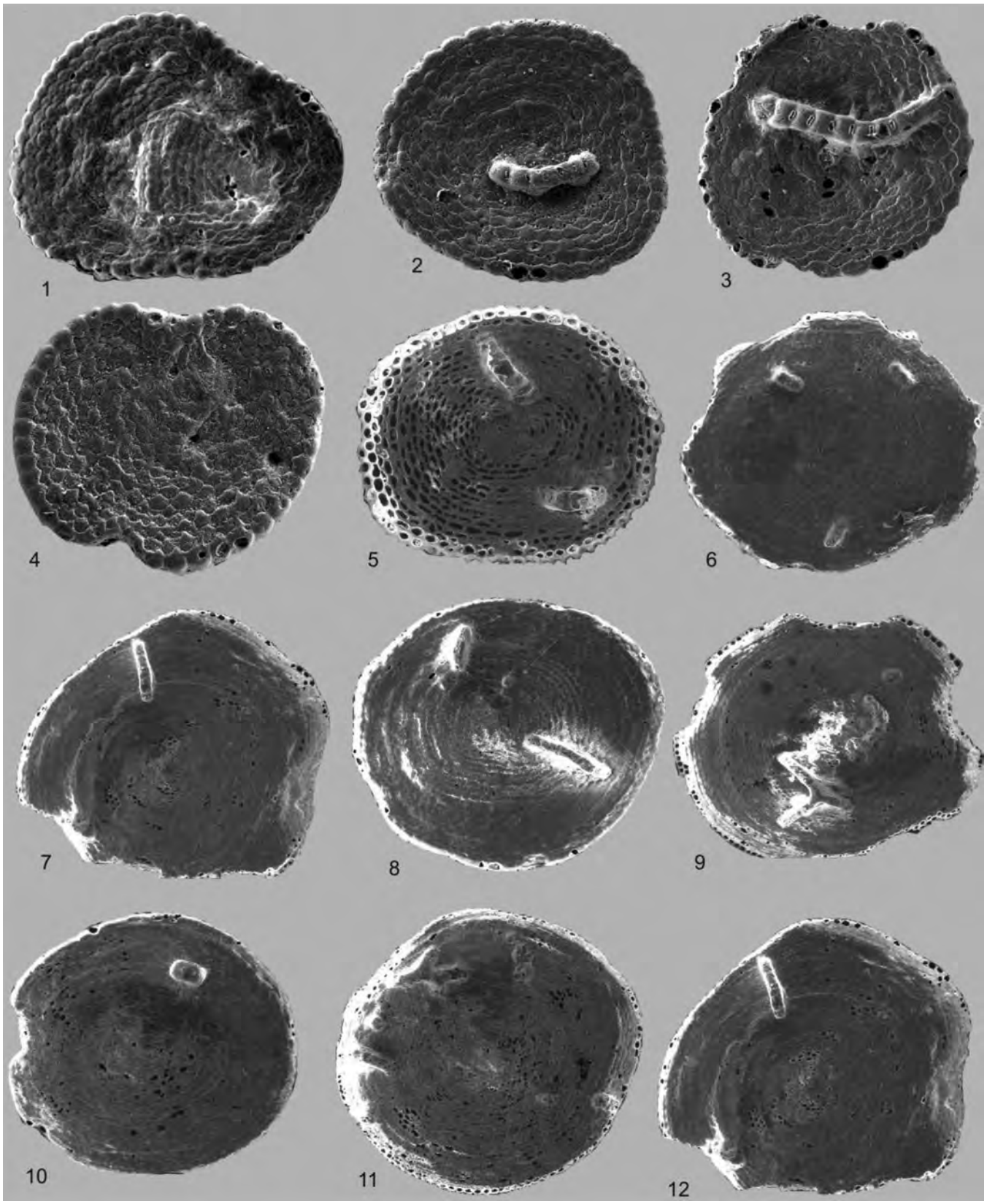
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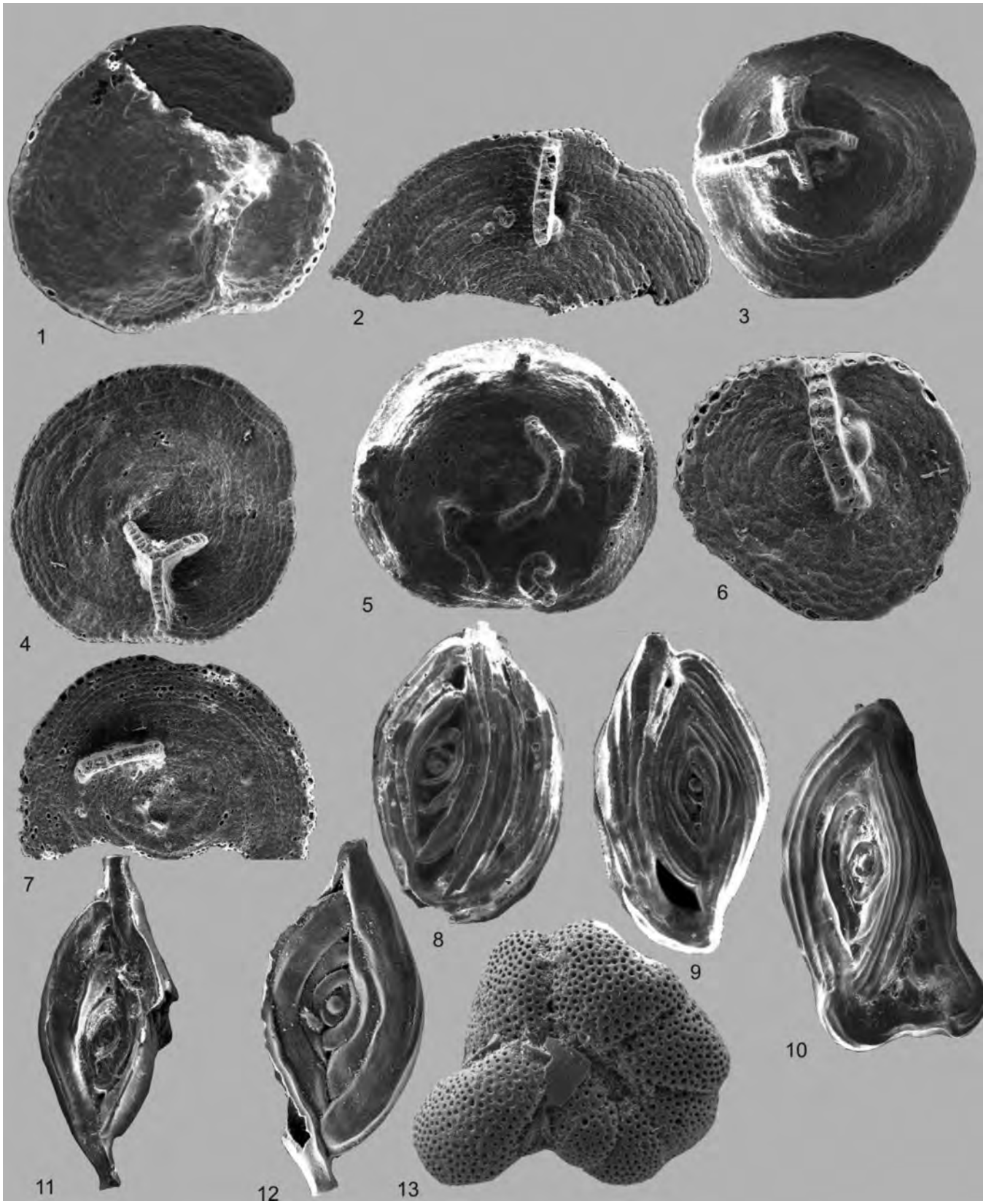
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