Distribution of benthic foraminifera in Lake Burullus, Egypt.

Sherif M. El Baz & Ahmed El Bahrawy
Damietta University, Faculty of Science, Geology Department, New Damietta, Egypt

ABSTRACT

A study of benthic foraminiferal assemblages was carried out in 30 surficial sediment samples collected from Lake Burullus to investigate the distribution, abundance and deformities of benthic foraminiferal species in the lake. Benthic foraminiferal diversity of the bottom sediments of Lake Burullus is very low. A total of 5 benthic foraminiferal species, belonging to 4 genera, is identified. *Ammonia tepida* is the most dominant species in the lake. It constitutes more than 90% of the total benthic foraminiferal assemblages in the bottom sediments of Lake Burullus. Out of the 5 species found in the study area, 3 species exhibited morphological abnormalities. The total percentage of abnormal foraminiferal specimen in each sample was calculated for each sample. Deformities increase near the eastern drains.

Key words: Foraminifera, distribution, diversity,abnormalities

1.Introduction

Lake Burullus lies on the eastern side of Rosetta branch of the Nile River, occupying a central position along the Mediterranean Nile delta coast of Egypt. It extends between longitude 30º 30' and 31º 10' E and latitudes 31º 21' and 31º 35' N (Fig. 1). It is the second largest lake of the Nile delta coastal lakes and is about 53km long, 13km wide. Lake Burullus is connected to the sea at its northeastern edge through the Burullus inlet, which is about 250 m wide and 5m deep. The Lake receives agricultural drainage water mostly from 8 drains (Burullus, Baltim, El Gharbia , Nasser, drains 7, 8, 9 and 11) and only one canal (Brimbal Canal) .

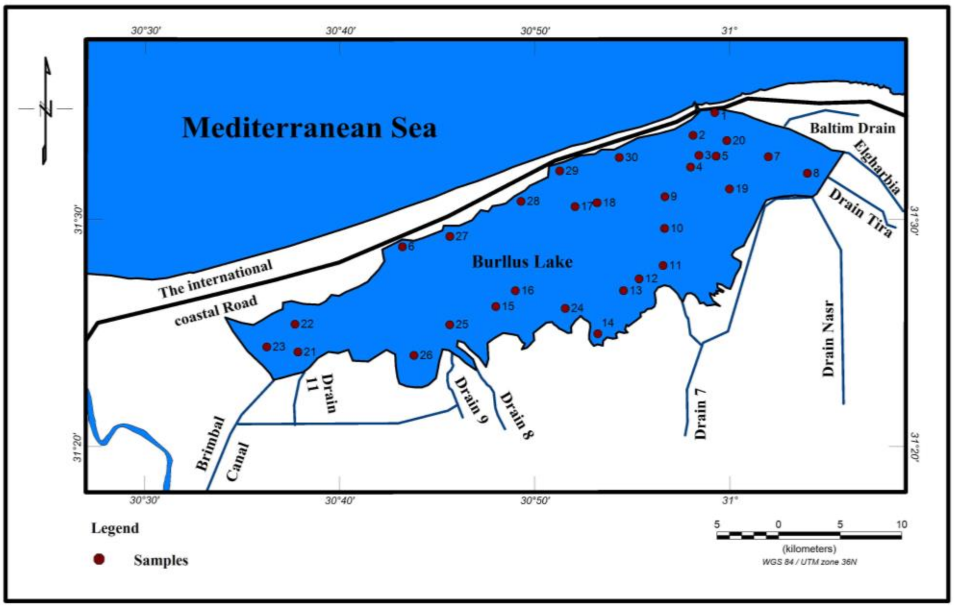

Fig. 1. Location map of the study area and sampling sites in Lake Burullus.

Benthic foraminifera are the most common microorganism found in the surface sediments in the shallow and marginal marine environments. They are very sensitive to slight environmental changes and can reflect the health of the ecosystem they inhabit. They are increasingly used as bioindicators for pollution at various levels of investigations. The impact of pollution on foraminifera is expressed not only as the modification of their assemblage, but also as the changes in their morphology, shell chemistry and metabolic activity. The principal objectives of this study are: to investigate the distribution, abundance and deformities of benthic foraminiferal species in the lake.

2. Materials and methods

The materials of this study were collected from Lake Burullus during August 2013. These materials consist of 30 bottom sediment samples. The coordinates of these samples, and the ecological variables (pH , salinity, dissolved oxygen, water depth and temperature) were measured.

2.1. Sediment sampling

Surficial sediments samples were collected using a grab sampler from 30 sites within the entire lake area. The sample sediment was immediately saved in a plastic jar and stained by Rose Bengal Stain. The stained samples were taken to the laboratory for micropaleontologic analyses.

Table 1. Coordinates of the studied samples and their measured environmental parameters.

Sample number	X Easting (Lat.)	Y Easting (long.)	Water depth (cm)	Temperature (°C)	pH	Salinity (g/l)	Dissolved oxygen (surface)
1	31.5789	30.9875	85	30.4	8.46	5.2	0.09
2	31.5622	30.9689	95	30.1	8.47	5.18	0.65
3	31.5475	30.9739	105	29.9	8.35	4.9	2.8
4	31.5389	30.9667	75	30.7	8.17	4.3	6.1
5	31.5469	30.9886	80	30.3	8.41	3.1	10.7
6	31.4805	30.7201	170	30	8.67	6.2	9
7	31.5464	31.0333	70	31.6	8.44	3.5	6
8	31.5342	31.0667	86	31.7	8.51	2.5	4.7
9	31.5172	30.9447	106	31.2	7.85	5.55	5.5
10	31.4939	30.9444	135	31.5	8.19	8.83	5.7
11	31.4667	30.9431	140	31	8.34	10.18	4.6
12	31.4569	30.9225	126	31.1	8.51	8.83	4.3
13	31.4483	30.9092	115	31.3	8.37	8.42	4.1
14	31.4167	30.8872	110	31.4	8.45	5.51	4.5
15	31.4367	30.8	120	31.5	8.46	6.49	4.6
16	31.4483	30.8167	125	31.2	8.43	6.40	5.1
17	31.51	30.8678	128	31.3	8.54	6.15	4.8
18	31.5128	30.8867	123	31	8.66	4.88	2.3
19	31.5228	31	126	31.1	8.58	3.30	2.5
20	31.5583	30.9978	128	31.2	8.64	3.52	2.1
21	31.4032	30.6309	0.88	30.5	8.03	1.23	7.8
22	31.4236	30.6283	0.83	30.3	8.4	1.75	8.2
23	31.4069	30.6042	0.74	30.7	8.6	1.8	7.3
24	31.4353	30.8594	0.87	30.1	8.04	1.13	9
25	31.4233	30.7606	0.95	30.6	8.3	1.15	8.5
26	31.4008	30.73	0.86	30.4	8.27	2.4	7.9
27	31.4881	30.7607	160	30.6	8.62	6.5	9
28	31.5138	30.8216	166	30.7	8.67	7.4	9.5
29	31.5362	30.8547	165	30.2	8.58	7.1	8.7
30	31.546	30.9057	150	30.6	8.51	8.4	8.5

2.2. Field measurements

At each site, the methods described in the American Public Health Association (APHA, 1992) were used for determination of some parameters such as pH, surface water dissolved oxygen and temperature.

2.3. Micropaleontological analyses

The foraminifera were identified following the generic classification of Loeblich & Tappan (1988). Density of foraminifera was calculated in addition to sample diversity. All deformed tests, whenever present, were picked from each sample and morphologically examined. The recorded foraminiferal species were photographed using a Scanning Electron Microscope (SEM).

3. Results and discussion

3.1.Ecological parameters

The measured ecological parameters (pH , salinity, dissolved oxygen, water depth and temperature) were listed in table 1.

3.2. Classification of Benthic foraminifera

A total of 5 benthic foraminiferal species, belonging to 4 genera, is identified. These species have been classified following Loeblich & Tappan (1987). The identified species are *Quinqueloculina bosciana*, *Quinqueloculina seminulum*, *Triloculina trigonula*, *Cribroelphidium excavatum* and *Ammonia tepida*

3.3. Foraminiferal Density (FD)

Foraminiferal density means the number of specimens per 1 gm of dry sediment. FD ranges from 2 - 4419 tests per gram with average 2361 tests per gram. Density of benthic foraminifera showing great increase in the northern and central parts of the lake (Fig. 2). These highest benthic foraminiferal density in Lake Burullus could be due to the occurrence of frequent stressed conditions. These stressed conditions are only in favor of *Ammonia tepida* that reproduced rapidly in the lake and attains a large biomass within a short time (Gooday, 1993; Abu-Zied et al., 2007; Ameen etal., 2013).

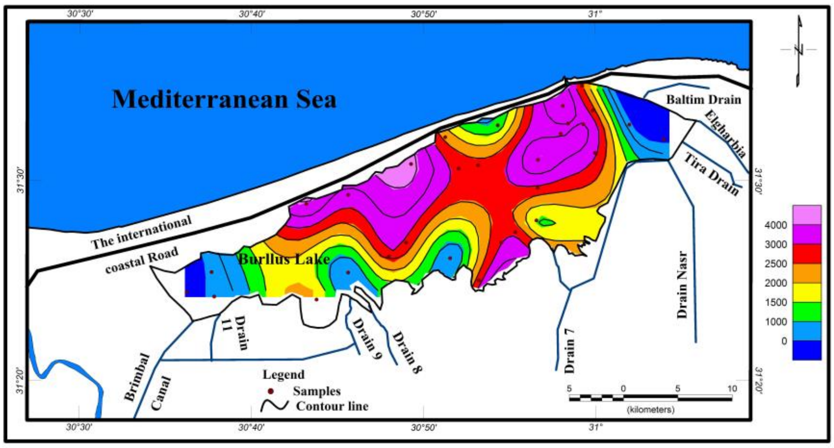

Fig. 2. Benthic foraminiferal Density during August 2013.

3.4. Foraminiferal Diversity (S)

It means the total number of species per sample. Benthic foraminiferal diversity of the bottom sediments of Lake Burullus is very low. It ranges from 1 to 5 species per sample. It increases near El-Boughaz inlet (Fig. 3).

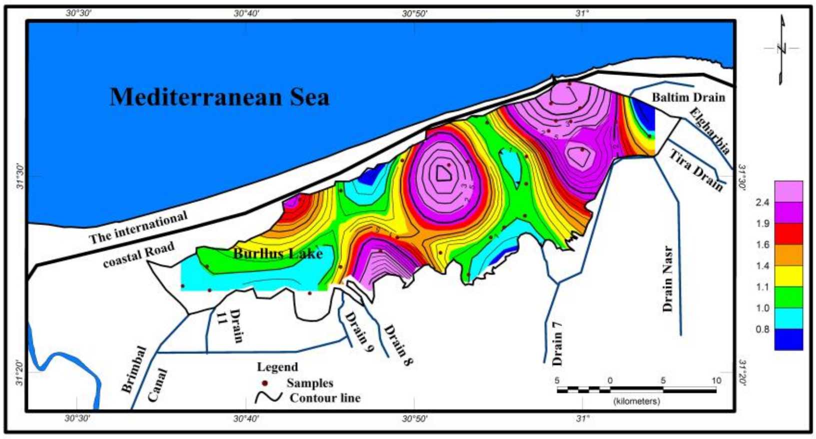

Fig. 3. Benthic foraminiferal Diversity during August 2013.

3.5. Distribution of benthic foraminifera

Ammonia tepida Distribution

Ammonia tepida is the most dominant species in the lake. It constitutes more than 90% of the total benthic foraminiferal assemblages in the bottom sediments of Lake Burullus, reflecting its tolerance to very low salinity. Frequency distribution of *Ammonia tepida* varies from 69 to 100%, showing maximum numbers in the eastern and central parts of the lake. (Fig.4).

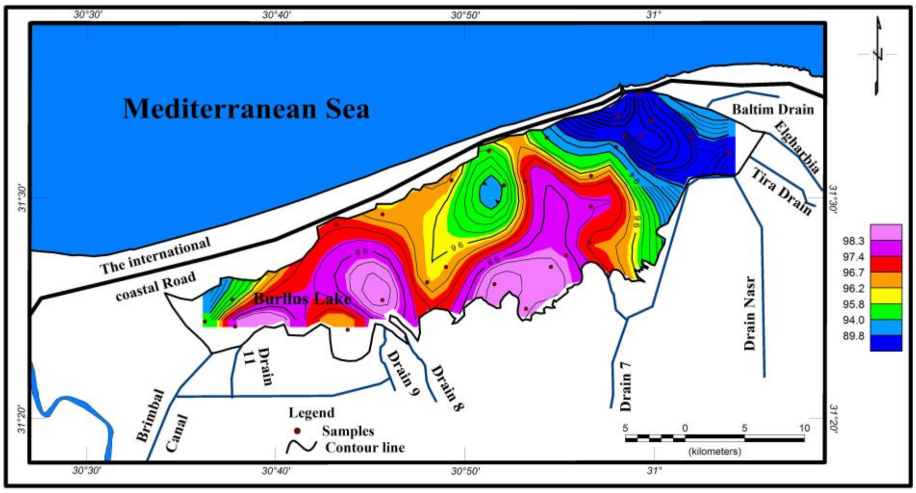

Fig. 4. Distribution of *Ammonia tepida* in lake Burullus during August 2013.

Cribroelphidium excavatum distribution

In general, *Cribroelphidium excavatum* occurs with low numbers in bottom sediments of Lake Burullus. It is nearly absent from the southern and western parts of the lake. It shows the highest values (22.08 %) near El-Boughaz inlet and at the eastern side of the lake (Fig.5). *Crirbroelphidium excavatum* is controlled by salinity and water depth as indicated by its increase towards El-Boughaz inlet where salinity and water depth increases. *Ammonia* pH survival range is 3.0-9.3, while *Cribroelphidium* pH survival range is 7.3-8.1 (Bardshaw,1957). This may illustrate why *Ammonia* is the most widely distributed species in the lake bottom sediments, while the other species *Cribroelphidium* come to the second order.

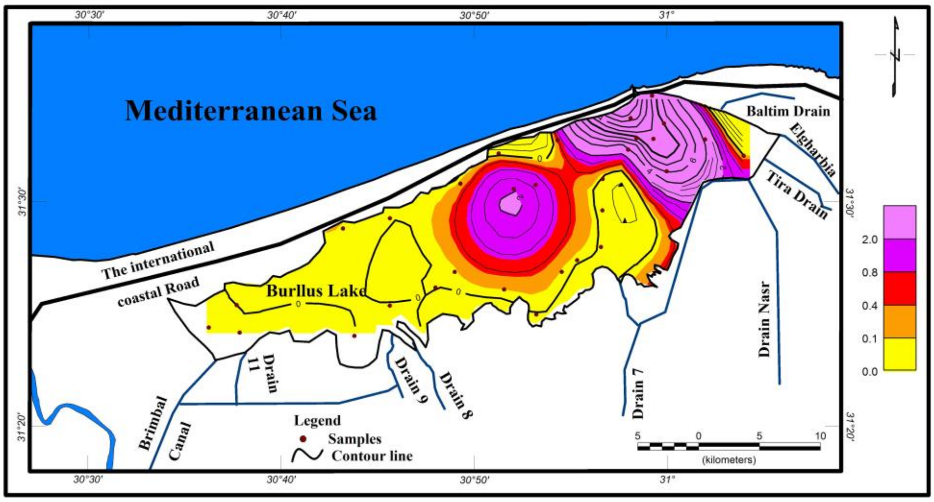

Fig. 5. Distribution of *Cribroelphidium* in lake Burullus during August 2013.

Milliolids distribution

Milliolids of the Lake Burullus bottom sediments includes species such as *Triloculina trigonula*, *Quinqueloculina boscian* and *Q. seminula.* Total miliolids in lake bottom sediments is very rare and vary from 0 to 0.8 % . Milliolids are very rare or completely absent from the western and southern parts of the lake. They show highest frequency at the far east part of the lake, nearly close to El-Boughaz inlet (Fig.6).

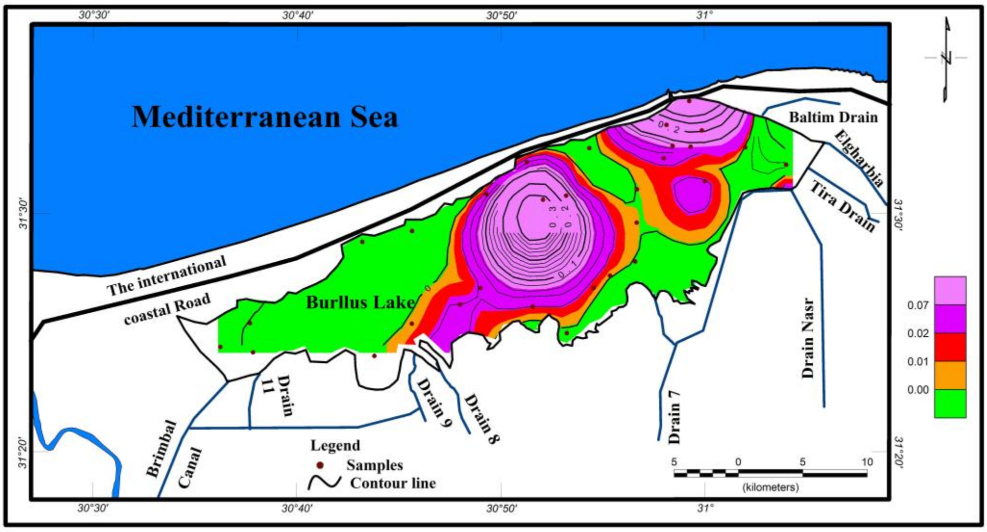

Fig. 6. Distribution of Milliolids in Lake Burullus sediments during August 2013.

3.6. Distribution of deformed foraminiferal tests

Out of the 5 species found in the study area, 3 species exhibited morphological abnormalities. The FAI corresponding to the total percentage of abnormal foraminiferal specimen in each sample was calculated for each sample (Table 8). It ranges from 1.2 % (at site 12) - 13.33% (at site 8). Deformities increase near the eastern drains (Fig. 7).The recorded morphological abnormalities were manifested as: high spire giving spiroconvex test (Pl. 1, Figs. 7, 8), additional chamber (Pl. 1, Figs.

9-11), twisted tests (Pl. 1, Figs. 13-16), reduced chambers (Pl. 1, Figs. 17-18), aberrant chamber shape and size (Pl. 1, Figs. 19-20; Pl. 2, Figs. 1-4), twinning (Pl. 2, Figs. 8-16) , and complex deformities(Pl. 2, Figs. 17-20). Miliolids are the least affected species in the assemblage. *Ammonia tepida* and *Cribroelphidium excavatum* show a great morphological variability and most of the specimens of these species are megalospheric. The high percentage of megalosheric forms recognized in Lake Burullus appear to be related to the stress conditions occurring there. Because of, trace elements and stressful conditions, sexual reproduction would be the most common mode of reproduction within these forms (Frontalini et al., 2009).

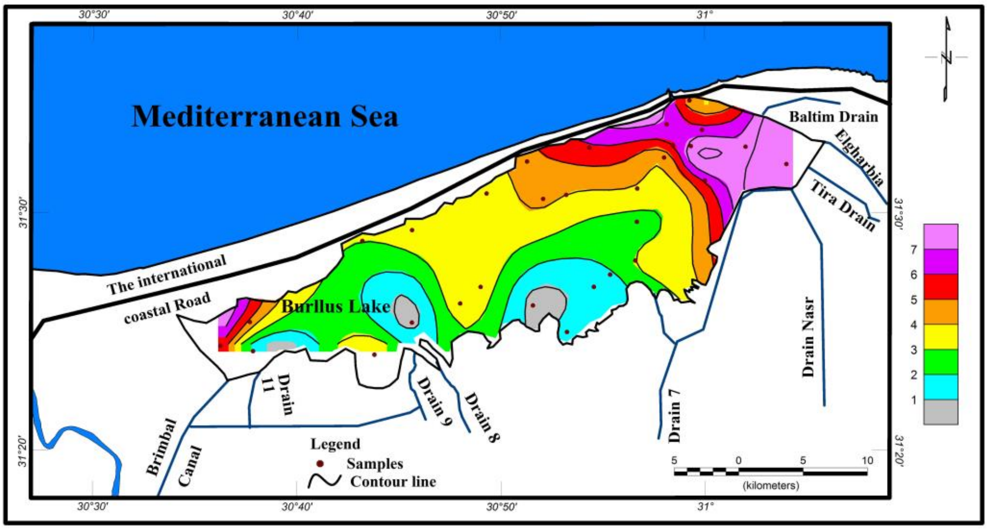

Fig. 7: Distribution of deformed foraminiferal tests in Lake Burullus during August 2013.

4.6. Deformed tests as indicators of polluted environments

Mode of test deformation depends on the degree of pollution and type of pollutants. Forms having corrosion, cavity development, broken peripheries and reduction in the overall growth are associated with high trace metal levels (Pati & Patra, 2012). Twinned and reduced chamber size forms, which represent the minimal response of benthic foraminifera to pollution, occur largely in sites subjected to agricultural drainage water. Alve & Olsgard (1999) performed a colonisation experiment for 32 weeks period with Cu- contaminated sediments and found out that Cu contaminated sediments alone do not seem to promote development of deformed foraminiferal test beyond normal range. Frontalini & Coccioni (2008) have pointed out that, *Ammonia tepida* and *A. parkinsoniana* can be reciprocally considered good bioindicators of heavy metal pollution as sensitive and opportunistic species. They concluded that increased concentrations of Cu lead to a lowering of foraminiferal density and diversity and an increased occurrence of abnormalities respectively. X-ray microanalysis by Samir & El-Din (2001) reveals that living deformed specimens contain higher levels of heavy metals (Pb, Zn, Cu, Cr, and Cd) than non-deformed ones. This strongly suggests that heavy metals are responsible for the abnormalities in foraminiferal tests. On the Mediterranean margin of Israel , trace metal contamination (e.g., Hg and Cd) caused a decrease in the number of species and specimens, a decrease in size of one of the most commonly occurring species (*Ammonia tepida*) and frequent test deformations (Alve, 1995). Benthic foraminifera are more sensitive to industrial wastes containing heavy metals than agricultural waste (Samir, 2000).

The industrial pollution, especially by heavy metals, has a deleterious effect upon benthic foraminifera, e.g. reduced population diversity and density, increase in percentage dominance, stunting of the adult tests, and the frequent presence of deformed tests (Samir & El Din, 2001). Higher concentrations of Cu and Zn in deformed than in non-deformed tests of *Ammonia beccarii* suggested a connection between test deformation and heavy metal contamination (Sharifi etals., 1991 in Alve, 1995).

5. Conclusion

The present study deals with the foraminiferal distribution in the bottom sediments of Lake Burullus. The abundance of *Ammonia tepida* reflectts its tolerance to very low salinity. Deformities increase near the eastern drains. *Ammonia tepida* and *Cribroelphidium excavatum* show a great morphological variability. Miliolids are the least affected species in the assemblage.

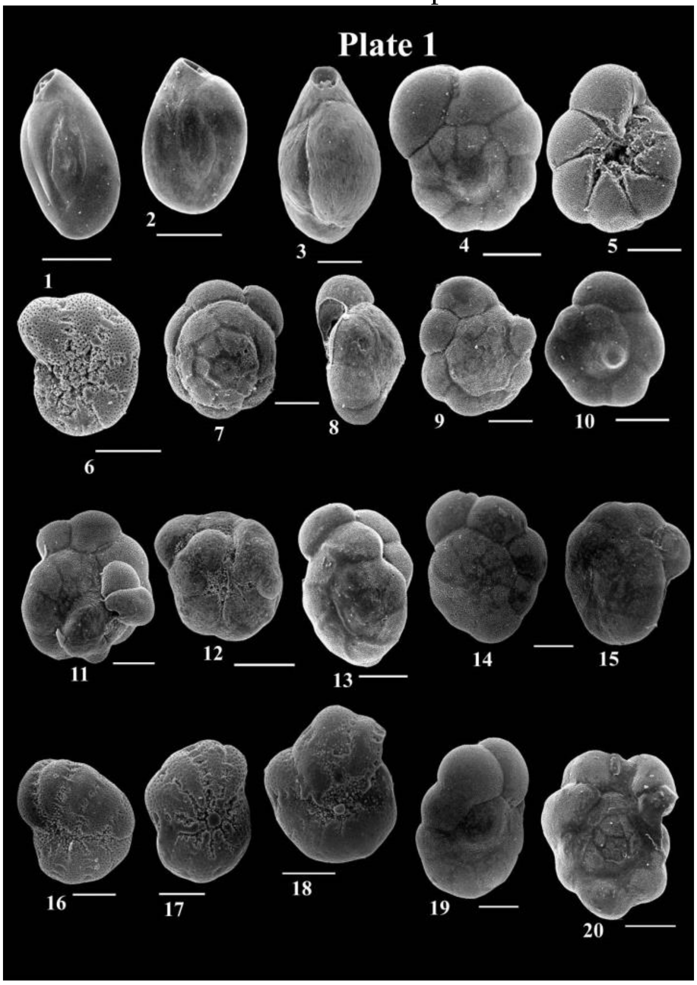

Plate 1

Scale bar = 50 µm, except for 12= 100 µm.

Fig.1: *Quinqueloculina bosciana* d'Orbigny, side view of normal test, site 1.

Fig.2: *Quinqueloculina seminulum* (Linnaeus),side view of normal test,site 1.

Fig.3: *Triloculina trigonula* (Lamarck), side view of normal test, site 1.

Figs. 4-5: *Ammonia tepida* (Cushman), spiral and umbilical views of normal tests, site 3.

Fig. 6: *Cribroelphidium excavatum* (Terquem), side view of normal test, site 1.

Figs. 7, 8: *Ammonia tepida* (Cushman), spiral and Peripheral views show abnormal high spire giving spiroconvex tests, site 1.

Figs. 9-11: *Ammonia tepida* (Cushman), spiral views show abnormal additional chamber, site 9.

Fig. 12: *Ammonia tepida* (Cushman), umbilical view show distorted chamber arrangement, site 1.

Figs. 13-15: *Ammonia tepida* (Cushman), spiral views show twisting of the entire test, sites 5, 2, 28.

Fig. 16: *Cribroelphidium excavatum* (Terquem), side view of abnormal test shows twisting of the entire test, site 2.

Figs. 17-18: *Cribroelphidium excavatum* (Terquem), side view of abnormal test show aberrant chamber size, site 1.

Figs. 19, 20: *Ammonia tepida* (Cushman), side views of abnormal test show aberrant chamber size and shape, sites 13, 27.

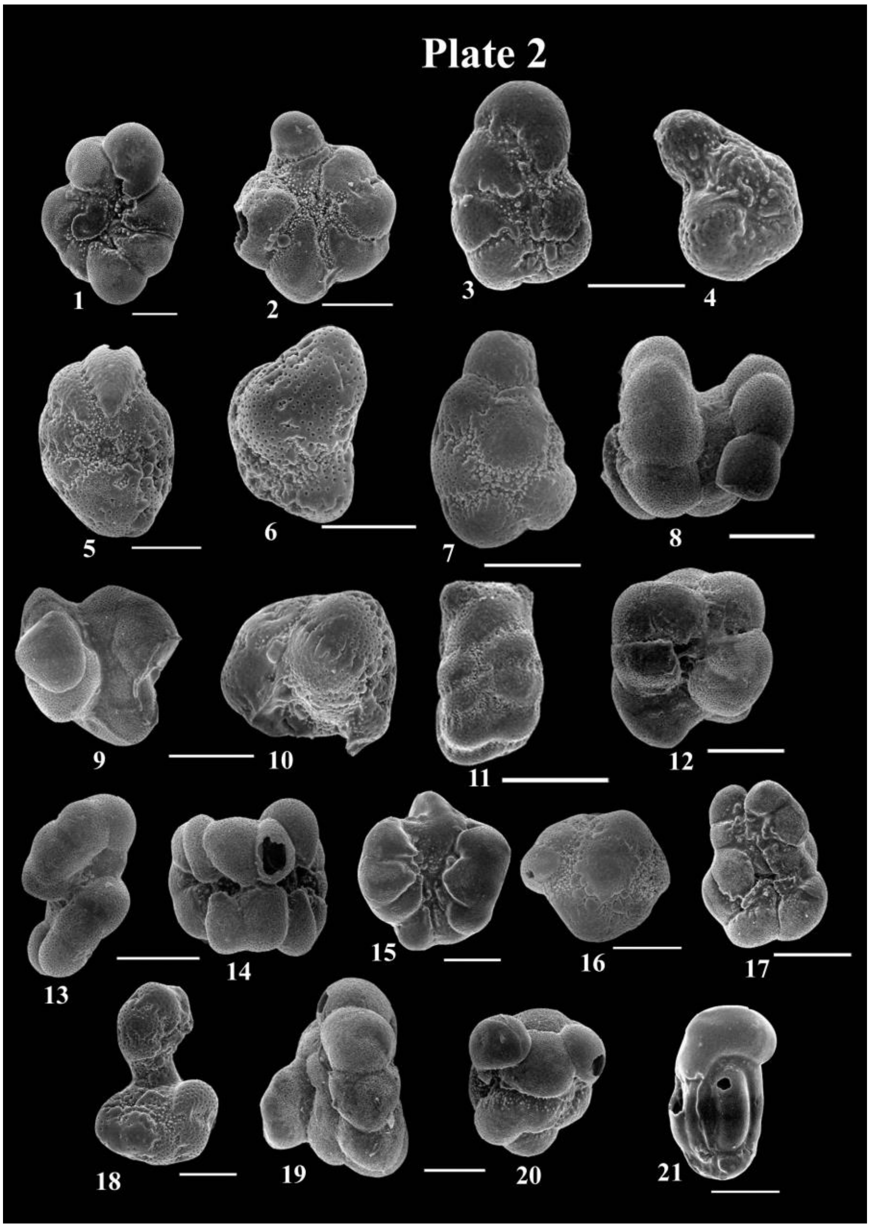

Plate 2

Scale bar = 50 μm.

Figs. 1, 2: *Ammonia tepida* (Cushman), umbilical views of abnormal tests show aberrant chamber size and shape, site 20.

Figs. 3-6: *Cribroelphidium excavatum* (Terquem), side views of abnormal tests show aberrant chamber size and shape, site 2.

Fig. 7: *Cribroelphidium excavatum* (Terquem), side view of abnormal test show undeveloped test, site 19.

Figs. 8-16: Siamese twins, site 1.

Figs. 17-20: Complex forms, site 9, 17, 1, 2.

Fig. 21: Deformed miliolid test, site 2.

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