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MICROFOSSILS ASSEMBLAGES FROM THE BADENIAN/SARMATIAN BOUNDARY IN BOREHOLES FROM THE MOLDAVIAN PLATFORM

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Abstract: Samples from the Upper Badenian – Sarmatian of five boreholes drilled in the eastern part of the Moldavian Platform (interfluve Jijia – Prut) have been analyzed. The boreholes from Truşeşti, Todireni, Şipote, Bivolari and Nicolina intercepted changes in macrofaunal assemblages (molluscs) at the depth from which the samples have been collected. The Badenian deposits are characterized by an assemblage with *Textularia ssp., Cibicides ssp., Globigerina*, a.o. The assemblages belonging to the Lower Sarmatian are characterised by a brackish fauna, with reworked taxons of *Globigerinoides*, *Globigerina*, *Gyroidina*. The calcareous nannofossil assemblages are rich in the Upper Badenian deposits (NN6 Biozone) from the boreholes of Truşeşti, Todireni, Şipote, and Nicolina. The assemblages consist mostly of *Coccolithus miopelagicus, Reticulofenestra pseudoumbilicus*, *Sphenolithus abies, S. moriformis, Calciosolenia murray, Rhabdosphaera pannonica, Syracosphaera histrica, Triquetrorhabdulus rugosus*, *Discoaster variabilis*, and *Braarudosphaera bigelowii*. The very poor calcareous nannofossil assemblages belonging to the Sarmatian deposits have been remarked in all these five boreholes, but typical for the Sarmatian. They consist of very frequent ascidian spicules and thoracospheres, and rare calcareous nannofossils, such as: *Calcidiscus macintyrei, Reticulofenestra pseudoumbilicus*, *Braarudosphaera bigelowii,* a. o.

Key-words: Late Badenian, Sarmatian, foraminifera, calcareous nannofossils, Moldavian Platform.

INTRODUCTION AND GEOLOGICAL SETTING

Several samples from five boreholes drilled in the eastern part of the Moldavian Platform, respectively the interfluve of Jijia – Prut have been analysed (Fig. 1, 2). The samples have been collected from the intervals in which changes in the faunal content were observed. These changes are evident, with marine assemblages in the deposits belonging to the Badenian and brackish ones in those of Sarmatian age.

This study is focused especially on foraminifera and calcareous nannofossils.

In the Upper Badenian (Kossovian) – Lower Sarmatian interval, the Moldavian Platform was subject to a series of paleogeographical changes in relationship with the Carpathian Orogeny.

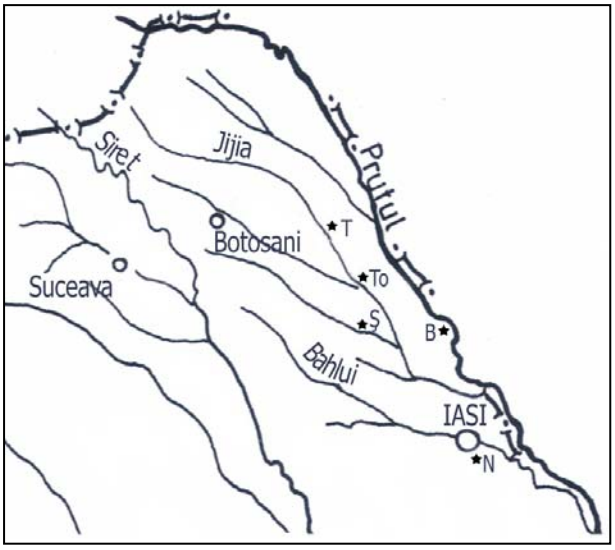

Fig. 1. Location of the studied boreholes. T – Truşeşti, To – Todireni, Ş – Şipote, B – Bivolari, N - Nicolina

The Intra-Volhynian tectogenesis, and possibly also effects of the intra-Badenian, especially taking part in the external zone of the Carpathians, have strongly affected the evolution of the Paratethys basins. In the terminal part of the Badenian, the Moldavian Platform has functioned as continental area, the sedimentation process lasting until the Lower Sarmatian (Upper Buglovian).

Beginning with the Lower Sarmatian, in the Eastern Carpathian foreland, because of the advancement of the orogeny above the top of the Moldavian Platform, a series of characteristic depozones were outlined. Based on sedimentological criteria, from west to east, four depozones have been identified: wedge-top, avanfose, foredeep depozone, forebulge and backbulge. The basinal waters have a much lower salinity as compared with that during the Badenian (Brânzilă, 1999; Grasu *et al.*, 2002).

Under these circumstances, on the Moldavian Platform area deposits with a granulometric composition that reflects the function of the mentioned depozones – coarse deposits on the west and gradually finer deposits (pelites) on the east have been accumulated at the beginning of the Sarmatian. The Jijia – Prut interfluve, were the investigated boreholes were placed, belongs to the area in which fine deposits were accumulated (backbulge depozone). This zone maintained its sedimentological features until the Upper Basarabian.

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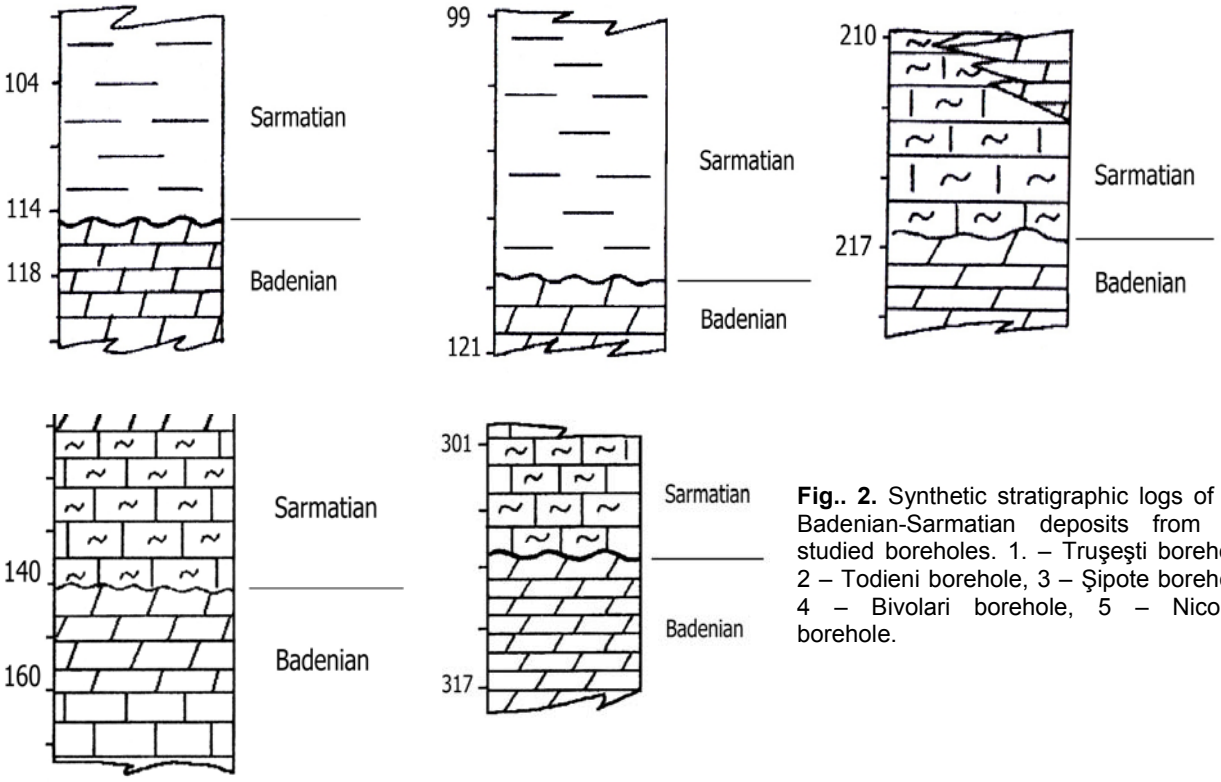

Fig.. 2. Synthetic stratigraphic logs of the Badenian-Sarmatian deposits from the studied boreholes. 1. – Truşeşti borehole, 2 – Todieni borehole, 3 – Şipote borehole, 4 – Bivolari borehole, 5 – Nicolina borehole.

FAUNAL ASSEMBLAGES: FORAMINIFERA AND MOLLUSCS

The Badenian deposits intercepted in the boreholes from Truşeşti, Şipote, Bivolari and Nicolina are characterized by faunal assemblages that are exclusively marine.

Macrofauna is dominated by taxons such as: *Chlamys gigas* Andr., *C. wolfi* Hilb., *C. scisa* Hilb., *C. lilli* (Pusch), *C. multistriata* Poli, *Loripes dujardini* Desh., and *Dentalium vitreum* Schroeter. Very frequent are also forms of *Lithothamnium*.

The microfaunal assemblage is very rich, consisting of benthonic and planktonic foraminifera: *Bigenerina aglutinans* d'Orb, *Spiroplectamina scaligera* Luczk, *Textularia concava flexua* (Karrer), *T. deperdita* d'Orb, *Bulimina elongata vagina* Pischw, *Uvigerina semiornata* Pischw, *U. perornata* Pischw, *Globigerina globosa* Pischw, *G. brevispira* Subb, *Pullenia bulloides* (d'Orb), *Cibicides boueanus crasus* Luczk, *C. dutemplei* (d'Orb), *C. menneri* Ser, *C. certus* Vengl, *Eponides turris* (Karrer), *E. heidingeri* (d'Orb), *Bolivina dilatata* Reuss, *Sphaeroidina austriaca* d'Orb, and *Ammodiscus incertus* (d'Orb).

The bionomic content of the Badenian deposits shows an assemblage developed under normal salinity conditions.

The Sarmatian deposits, located on the top of the Badenian ones are characterised by a brackish fauna, with reworked taxons that resisted to the decrease in salinity (Luczkowska, 1985).

The faunal assemblages belonging to the Lower Sarmatian are poor comparative with the Badenian ones. A drastic decrease of the number of genera and also of the individuals both in the macro- and microfaunal assemblages was remarked (by Bobrinskaia, 1981, too).

The assemblages belonging to the Lower Sarmatian are characterised by a brackish fauna, with reworked taxons of *Globigerinoides trilobus* (Reuss), *Globigerina* sp., and *Gyroidina* sp.

Most frequent are the assemblages with *Obsoletiforma lithopodolica* Dub., *O. ruthemica* Hilb., *Inaequicostata inopinata* Grisch., *I. pia* Zhizh., *Abra reflexa* Eichn., *Donax dentiger* Eichn., *Spaniodontella sokolovi* Sinz, *Mohrensternia sarmatica* Friedb., *Articulina problema* Bogd., *Quinqueloculina fluviata* Vengl., *Q. reussi* Bogd., *Porosononion martkobi* Bogd., *Elphidium macellum* (F. & M.), *Cibicides badenensis* d'Orb., and *C. boueanus* d'Orb.

The macrofauna of the Lower Sarmatian from the boreholes of Truşeşti, Şipote, Bivolari and Nicolina is characterised by the prevalence of the bivalves on the gastropods. The Cardiaceae are frequent: *Obsoletiforma lithopodolica* Dub, *O. ruthenica* Hilb, *O. sarmatica* Barbot, *Inaequicostata inopinata* Grisch, than the taxons of *Ervilia* (*E. trigonula* Sok, *E. dissita* Eichw, *E. podolica* Eichw) and *Mactra* (*M. eichwaldi* Lask, *M. andrussowi* Kol). Among the gastropods, species of *Mohrensternia* (*M. inflata* Andrs, *M. styriaca* Hilb, *M. multicostata* Senes) prevail.

The microfaunal assemblage found in the deposits of the Lower Sarmatian (Upper Buglovian) in the five mentioned boreholes is characterized by the presence of a large number of miliolids. The taxon *Cibicides (Anomalinoides)* was recorded with a high frequency in the lower part of the Sarmatian deposits in the detriment of miliolids. Reworked

taxons from the Badenian deposits and also older deposits occur, such as *Globigerina bulloides* d'Orb. and *Globigerinoides trilobus* (Reuss).

The highest frequency in the microfaunal assemblage is recorded by: *Articulina problema* Bogd., *A. bidentata costata* Didk., *Quinqueloculina fluviata* Vengl., *Q. karreri karreri* Reuss, *Q. karreri ovata* Ser., *Q. reussi* Bogd., *Q. gracilis* Karrer, *Q. sarmatica* Karrer, *Ammonia beccarii* (Linne), *Nonion bogdanowiczi* Volosh, *Elphidium reginum* d'Orb., *E. minutum* Reuss, *Cibicides badenensis* (d'Orb.), *C. lobatulus* W.et J, and *C. boueanus* d'Orb.

NANNOFLORAL ASSEMBLAGES: CALCAREOUS NANNOFOSSILS

Previous studies on the calcareous nannofossils from boreholes of the Moldavian Platform

Previous studies concerning the Badenian - Sarmatian calcareous nannofossils from the north-eastern Moldavian Platform – between Jijia and Prut valleys - have been performed by Mărunțeanu (in Brânzilă & Mărunțeanu, 2001). Samples from four boreholes have been investigated, which indicate an alternation in time and space of two types of assemblages, for the Sarmatian: the pannonic and the mediterranean one.

It was considered that NN7 Biozone corresponds to Sarmatian, while the Kossovian – Volhynian boundary corresponds to NN6/NN7 (according to Martini zonation, 1971).

The calcareous nannofossils assemblages with *Coccolithus pelagicus, Calcidiscus leptoporus, C. macintyrei, Reticulofenestra pseudoumbilicus, H. carteri, Pontosphaera multipora, Sphenolithus moriformis, Calcidiscus pataecus, Scapholithus fossilis,* and *Triquetrorhabdulus rugosus*, were assigned to NN6 – Upper Badenian (Kossovian).

Sarmatian endemic assemblages, of pannonian type, with few species in a large number, with numerous morphostructural changes, contain rare *Discoaster* species, and frequent *Calcidiscus leptoporus*, *C. macintyrei, Reticulofenestra pseudoumbilicus, R. gelida, Rhabdosphaera poculi, R. pannonica, Umbilicosphaera jafari,* and *Helicosphaera walbersdorfensis.*

The assemblages which contain *Rhabdosphaera poculi, R. pannonica* and *Calcidiscus leptoporus centrovalis* were considered to belong to NN7 biozone, while the assemblages which contain *Umbilicosphaera jafari,* and *Helicosphaera walbersdorfensis* were considered to belong to NN8 – Volhynian/Basarabian (Mărunțeanu, 1997, Mărunțeanu in Brânzilă & Mărunțeanu, 2001).

Sarmatian nannofossils of mediterranean type were characterised by assemblages with a great number of species but a small number of individuals, the lack of the interspecifical variations, the great development of the *Discoaster* species and the absence of the species characteristic to the Central Paratethys. Several samples were considered as showing mediterranean and pannonian characteristics. This fact proves the succesive paleogeographical connections between this area and the Central Paratethys and even with the Tethys. The Sarmatian deposits start with NN7, and the Kosovian/ Volhynian boundary correspond to NN6/NN7 (Mărunțeanu in Brânzilă & Mărunțeanu, 2001).

Ionesi *et al.* (2005) made some comments concerning these assemblages.

Upper Badenian calcareous nannofossils from Truşeşti, Todireni, Şipote, Bivolari and Nicolina boreholes

Upper Badenian deposits from the boreholes of Truşeşti (m 114, 118), Todireni (m 121), Şipote (m 217), and Nicolina (m 317) have been analysed.

The assemblages consist of *Coccolithus miopelagicus, Reticulofenestra pseudoumbilicus, Sphenolithus abies, S. moriformis, Calciosolenia murray*, *Rhabdosphaera pannonica, Syracosphaera histrica, Triquetrorhabdulus rugosus*, *Discoaster variabilis, Braarudosphaera bigelowii, Helicosphaera carteri*, a. o. (Tab.1).

Sarmatian calcareous nannofossils from Truşeşti, Todireni, Şipote, Bivolari and Nicolina boreholes

Very poor calcareous nannofossil assemblages of Sarmatian age have been remarked at the following depths: m 104 (Truşeşti), m 99 (Todireni), m 210 (Şipote), m 90, 140, 160 (Bivolari), m 301 (Nicolina).

Very frequent ascidian spicules and thoracospheres, and rare calcareous nannofossils, such as: *Calcidiscus macintyrei, Reticulofenestra pseudoumbilicus*, *Braarudosphaera bigelowii*, a. o. were identified; also reworked forms were present

CONCLUSIONS CONCERNING CALCAREOUS NANNOFOSSILS

Samples from 5 boreholes of the eastern Moldavian Platform have been investigated, from the intervals in which changes of the faunal content were observed.

About 20 species of calcareous nannofossils are present in the Upper Badenian deposits from the boreholes of Truşeşti, Todireni, Şipote and Nicolina, and only about 10 species of calcareous nannofossils of pannonian type are present in the Sarmatian deposits from the five investigated boreholes, most frequent being the ascidian spicules and thoracospheres.

The calcareous nannofossil assemblages are rich in the Upper Badenian deposits from the boreholes of Truşeşti (m 114, 118), Todireni (m 121), Şipote (m 217), and Nicolina (m 317).The

assemblages belong to NN6 Biozone (Martini, 1971) and consist especially of *Coccolithus miopelagicus* Bukry, *Reticulofenestra pseudoumbilicus* Gartner (Gartner), *Sphenolithus abies* Deflandre, *Sphenolithus moriformis* (Broennimann & Stradner) Bramlette & Wilcoxon, *Calciosolenia murray* Deflandre, *Rhabdosphaera pannonica* Baldi-Beke, *Syracosphaera histrica* Kamptner, *Triquetrorhabdulus rugosus* Bramlette & Wilcoxon, *Discoaster variabilis* Martini & Bramlette, *Braarudosphaera bigelowii* (Gran & Braarud) Deflandre, *Helicosphaera carteri* (Wallich) Kamptner, a. o.

Table 1. Calcareous nannofossils identified in the borehole samples from Truşeşti, Todireni, Şipote, Bivolari and Nicolina (according to the classification of Young & Bown, 1997) (B = Upper Badenian, S = Sarmatian).

NANNOFOSSIL SPECIES	Truşeşti		Todireni		Şipote		Bivolari		Nicolina	
	B	S	B	S	B	S	B	S	B	S
CALCAREOUS NANNOPLANKTON: HETEROCOCCOLITS **Family Helicosphaeraceae**										
Helicosphaera carteri (WALLICH, 1877) KAMPTNER (1954)	X	X	X		X				X	
Helicosphaera cf. *wallichii* (LOHMAN, 1902) OKADA & MCINTYRE (1997)					X					
Helicosphaera mediteranea (MUELLER, 1974)		X								
Helicosphaera walbersdorfensis (MUELLER, 1974)					X					
Family Pontosphaeraceae										
Pontosphaera multipora (KAMPTNER, 1948) ROTH (1970)	X	X			X					
Family Calciosoleniaceae										
Calciosolenia murrayi DEFLANDRE IN DEFLANDRE & FERT (1954)	X	X			X			X		
Family Syracosphaeraceae										
Syracosphaera histrica KAMPTNER (1941)	X				X			X		
Family Rhabdosphaeraceae										
Rhabdosphaera pannonica BALDI-BEKE (1960)	X				X					
Family Noelaerhabdaceae										
Reticulofenestra pseudoumbilicus (GARTNER, 1967) GARTNER (1969)	X	X	X	X	X	X		X	X	X
Cyclicargolithus floridanus (ROTH & HAY *in* HAY *et al.*, 1967) BUKRY (1971)	X				X					
Family Coccolithaceae										
Coccolithus miopelagicus BUKRY (1971)	X	X	X		X			X	X	
Coccolithus pelagicus (WALLICH, 1877) SCHILLER (1930)	X									
Family Calcidiscaceae										
Calcidiscus macintyrei BUKRY & BRAMLETTE1969) LOEBLICH & TAPPAN (1978)					X			X		
Umbilicosphaera jafari MÜLLER (1974)								X		
NANNOLITHS **Family Braarudosphaeraceae**										
Braarudosphaera bigelowii (GRAN & BRAARUD, 1935) DEFLANDRE (1947)	X		X							X
Family Sphenolithaceae										
Sphenolithus moriformis (BRÖNNIMANN & STRADNER, 1960) BRAMLETTE & WILCOXON (1967)	X		X		X					
Sphenolithus abies DEFLANDRE *in* DEFLANDRE & FERT (1954)	X		X		X				X	
Family Triquetrorhabdulaceae										
Triquetrorhabdulus rugosus BRAMLETTE & WILCOXON (1967)	X		X	X				X		
CALCAREOUS DINOFLAGELLATES										
Thoracosphaera heimii (LOHMANN 1919) Kamptner 1941	X		X		X			X		X

The very poor calcareous nannofossil assemblages belonging to the Sarmatian deposits have been remarked in these boreholes at the following depth: m 104 (Truşeşti), m 99 (Todireni), m 210 (Şipote), m 90, 140, 160 (Bivolari), m 301 (Nicolina).

Besides ascidian spicules and thoracospheres, rare calcareous nannofossils are present, too, such as: *Calcidiscus macintyrei* Bukry & Bramlette, *Reticulofenestra pseudoumbilicus* Gartner (Gartner), *Braarudosphaera bigelowii* (Gran & Braarud) Deflandre a. o. Also reworked forms are present.

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PLATE CAPTIONS

PLATE I: Badenian microfaunal association:
Fig. 1: *Textulartia concava flexua* (Karrer) (x83)
Figs. 2,3: *Spiroplectamina scaligera* Luczk. (x92)
Fig. 4: *Bulimina elongata vagina* Pischw (x126)
Figs. 5,6: *Uvigerina semiornata* d'Orb (x179)
Figs. 7,8: *Uvigerina perornata* Pischw (x186)
Fig. 9: *Globigerina globosa* Pischw (x250)
Fig. 10: *Globigerina brevispira* Subb (x250)
Fig. 11: *Pullenia bulloides* (d'Orb) (x210)
Fig. 12: *Cibicides boueanus crasus* Luczk (x190)
Fig. 13: *Cibicides dutemplei* (x97)
Fig. 14: *Eponides turris* (Karrer) (x115)

PLATE II: Sarmatian microfaunal association:
Fig. 1: *Nonion bogdanowiczi* Volosh (x70)
Figs. 2,3: *Ammonia beccarii* (Linne) (x200)
Figs. 4,5,6: *Articulina problema* Bogd. (x150)
Fig. 7: *Articulina bidentata costata Didk.* (x150)
Fig. 8: *Quinqueloculina karreri ovata* Ser. (x300)
Fig. 9: *Quinqueloculina karreri karreri Reuss* (x250)
Fig. 10: *Quinqueloculina reussi* Bogd. (x300)
Figs.11,12: *Cibicides badensis* (d'Orb) (x140)
Fig. 13: *Elphidium reginum* d'Orb (x75)

PLATE III (x 2000)
Figs. 1a, b: *Cyclicargolithus floridanus* (Roth & Hay *in* Hay *et al.*, 1967) Bukry (1971) (Truşeşti borehole, m 104)
Figs. 2a, 2b: *Calcidiscus macintyrei* (Bukry & Bramlette 1969) Loeblich & Tappan (1978) (Truşeşti borehole, m 104)
Figs. 3, 4: *Calciosolenia murray* Deflandre in Deflandre & Fert (1954) (Şipote borehole, m 217)
Figs. 5a, b: *Helicosphaera carteri* (Wallich, 1877) Kamptner (1954) (Şipote borehole, m 217)
Figs. 6a,b: *Helicosphaera* cf. *wallichii* (Lohman, 1902) Okada & McIntyre (1997) (Şipote borehole, m 217)
Figs. 7a, b, 8a, b: *Helicosphaera walbersdorfensis* (Mueller, 1974) (Şipote borehole, m 217)
Figs. 9a, b: *Pontosphaera multipora* (Kamptner, 1948) Roth (1970) (Şipote borehole, m 217)
Figs. 10a, b: *Rhabdosphaera pannonica* Baldi-Beke (1960) and *Reticulofenestra* cf. *pseudoumbilicus* (Gartner, 1967) Gartner (1969) (Şipote borehole, m 217)
Figs. 11a, b: *Syracosphaera histrica* Kamptner (1941) (Şipote borehole, m 217)
Figs. 12a, b: *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner (1969) (Todireni borehole, m 99)
Fig. 13: *Helicosphaera carteri* (Wallich, 1877) Kamptner (1954), *Cyclicargolithus floridanus* (Roth & Hay *in* Hay *et al.*, 1967) Bukry (1971), *Calcidiscus macintyrei* (Bukry & Bramlette 1969) Loeblich & Tappan (1978), and *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner (1969) (Şipote borehole, m 217)
Figs. 14a, b: Ascidian Spicules (Şipote borehole, m 210)

PLATE IV (x 2000)

Figs. 1a, b, 2a, b: *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner (1969) (1a, b - Nicolina, m 315; 2a, b – Şipote, m 215)

Figs. 3a, b: *Coccolithus pelagicus* (Wallich, 1877) Schiller (1930) (Şipote borehole, m 217)

Figs. 4a, b: Coccosphere of *Coccolithus pelagicus* (Wallich, 1877) Schiller (1930) (Truşeşti borehole, m 118)

Fig. 5: *Sphenolithus abies* Deflandre *in* Deflandre & Fert (1954) (Nicolina borehole, m 315)

Fig. 6: *Sphenolithus moriformis* (Broennimann & Stradner, 1960) Bramlette & Wilcoxon (1967) (Şipote borehole, m 217)

Figs. 7a, b: *Coccolithus miopelagicus* Bukry (1971) (Şipote borehole, m 217)

Figs. 8a, b: *Reticulofenestra* cf. *pseudoumbilicus* (Gartner, 1967) Gartner (1969), *Coccolithus pelagicus* (Wallich, 1877) Schiller (1930), and *Helicosphaera carteri* (Wallich, 1877) Kamptner (1954) (Nicolina borehole, m 315)

Figs. 9a, b, 10a, b: *Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre (1947) (9a, b - Truşeşti borehole, m 118; 10a, b - Todireni borehole, m 121)

Fig. 11: *Thoracosphaera heimii* (Lohmann, 1919) Kamptner 1941 (Şipote borehole, m 217)

Figs. 12a, b: *Thoracosphaera* sp. (Truşeşti borehole, m 118).

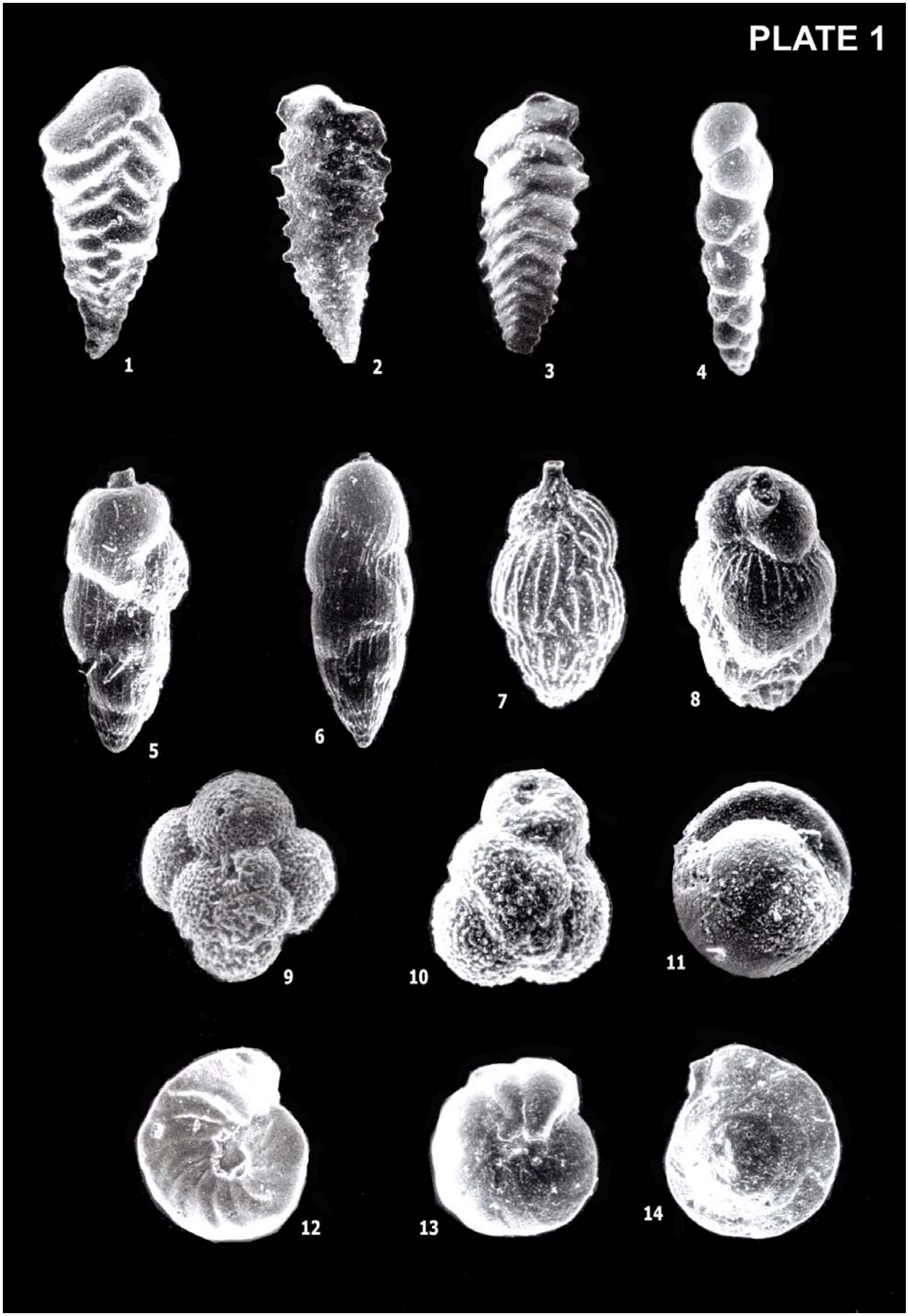
PLATE 1
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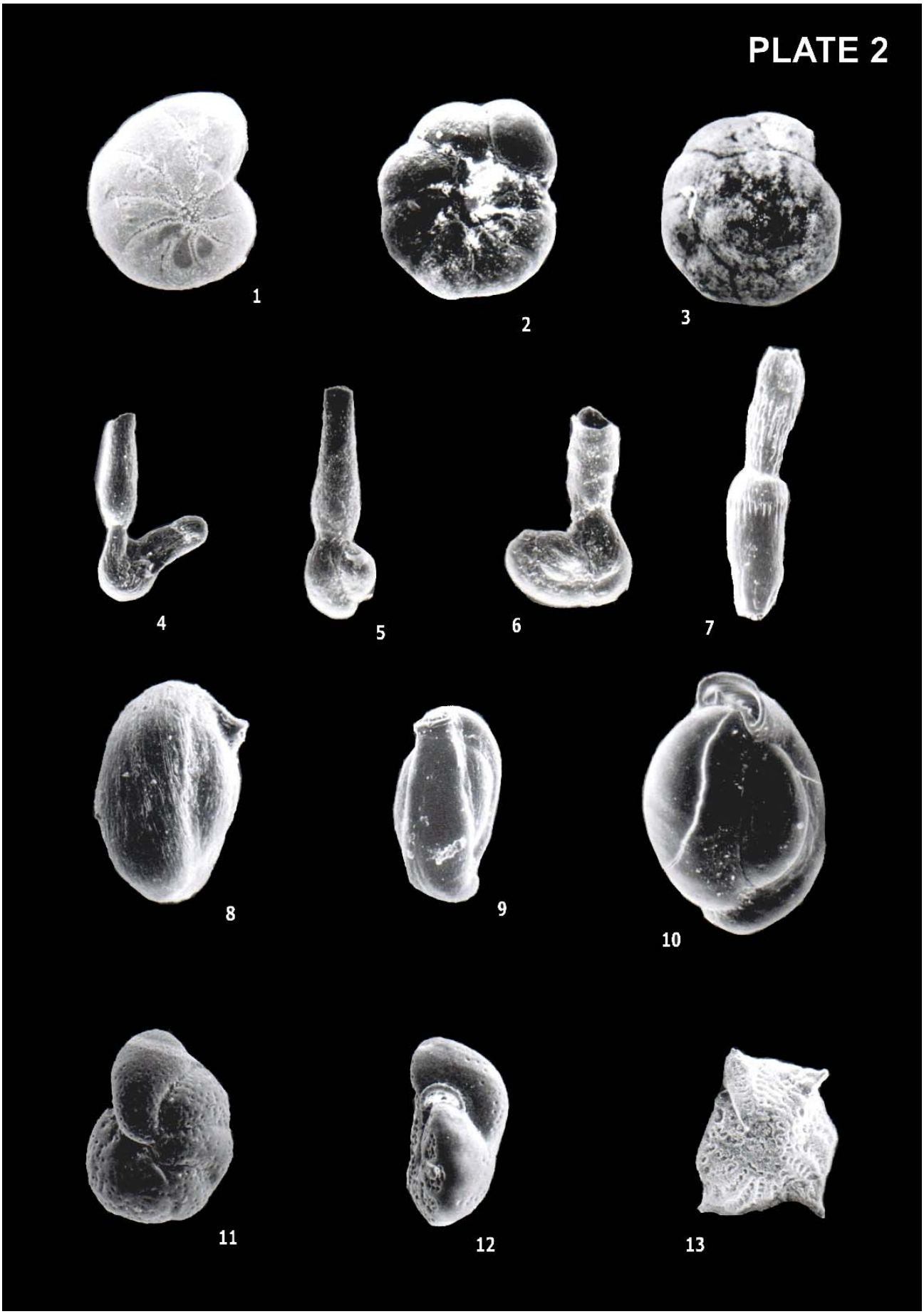
PLATE 2
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PLATE III


1a


1b


2a

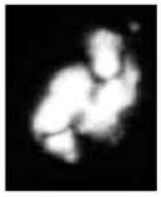

2b


3


5a


5b


6a

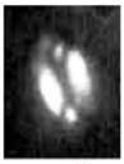

6b


4


7a


7b


8a


8b


9a

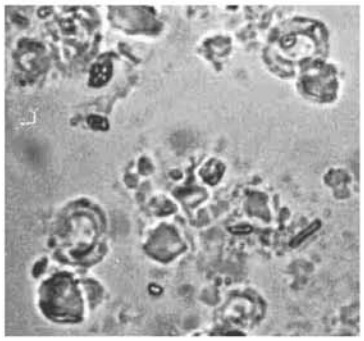

10a

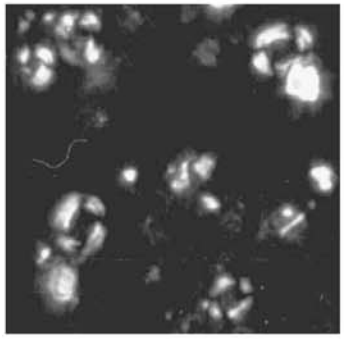

10b

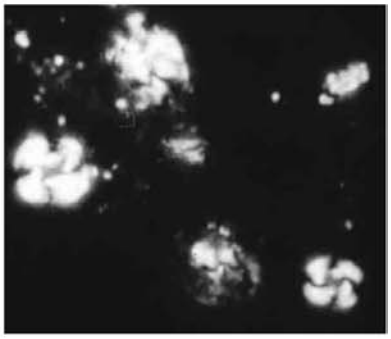

11a

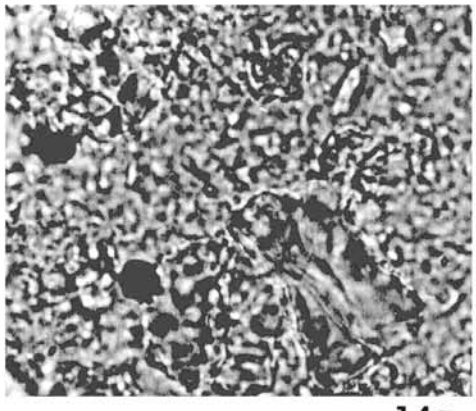

11b


9b


12a


12b


13


14a

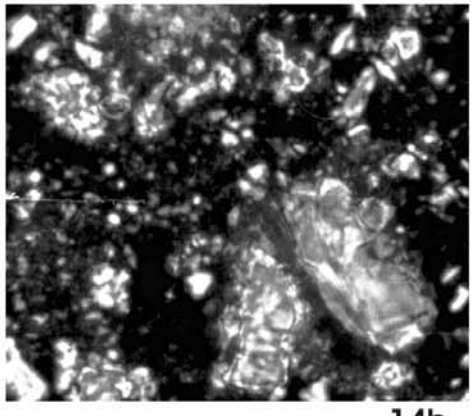

14b

PLATE IV