MICROPALAEONTOLOGIC CONTENT OF THE SARMATIAN FROM SOUTHERN MOLDAVIAN PLATFORM – A BACKBULGE DEPOZONE

MIHAI BRÂNZILĂ[1], GABRIEL CHIRILĂ[1] & MIHAELA JITARU[1]

Abstract. The southern part of the Moldavian Platform has developed under complex conditions, partially similar with the northern part, in a marine environment corresponding to the last stage of evolution of the Eastern Carpathians foreland basin with an obvious tectonic control. In Stănița-Vlădnicele borehole were identified microfauna taxa such as: *Cycloforina karreri, Elphidium macellum, E. minutum, E. punctatum, E. crispum, E. aculeatum, E. reginum reginum, E. reginum caucasica, Articulina problema, A. glabra, A. sarmatica,* and *Porosononion subgranosus.* This fauna confirms the presence of the Sarmatian, starting with Buglovian, Volhynian and including most of Bessarabian. The identified palynomorphs are represented by: *Pityosporites labdacus, Pityosporites alatus*, *Pityosporites insignis, Pinuspollenites miocaenicus, Abiespollenites* sp., *Myricipites bituitus, Tricolpopollenites liblarensis, Tricolporopollenites henrici*, *Carpinipites carpinoides*, *Engelhardtioides microcoryphaeus*, *Leiotriletes* sp. a.o. We used the "Coexistence approach" for paleoclimatic estimations; the values thus obtained are: MAT 16.5–17.2 °C, MAP 1300–1355 mm/yr, WMMT 23.6–28.5 °C, CMMT 9.6–12.5 °C.

Keywords: Sarmatian Moldavian Platform, backbulge, foraminifers, palynomorphs.

INTRODUCTION

This study aims to a better understanding of the environmental and climatic development during the Sarmatian and the beginning of the Badenian of the Moldavian Platform, based on a macropalaeontological study.

The analyzed samples were collected from Stănița-Vlădnicele borehole (Neamț County) located nearby the tectonic limit, Fălciu – Plopana fault, that divides the Moldavian Platform from the Bârlad Platform (Ionesi, 1994) (Fig. 1).

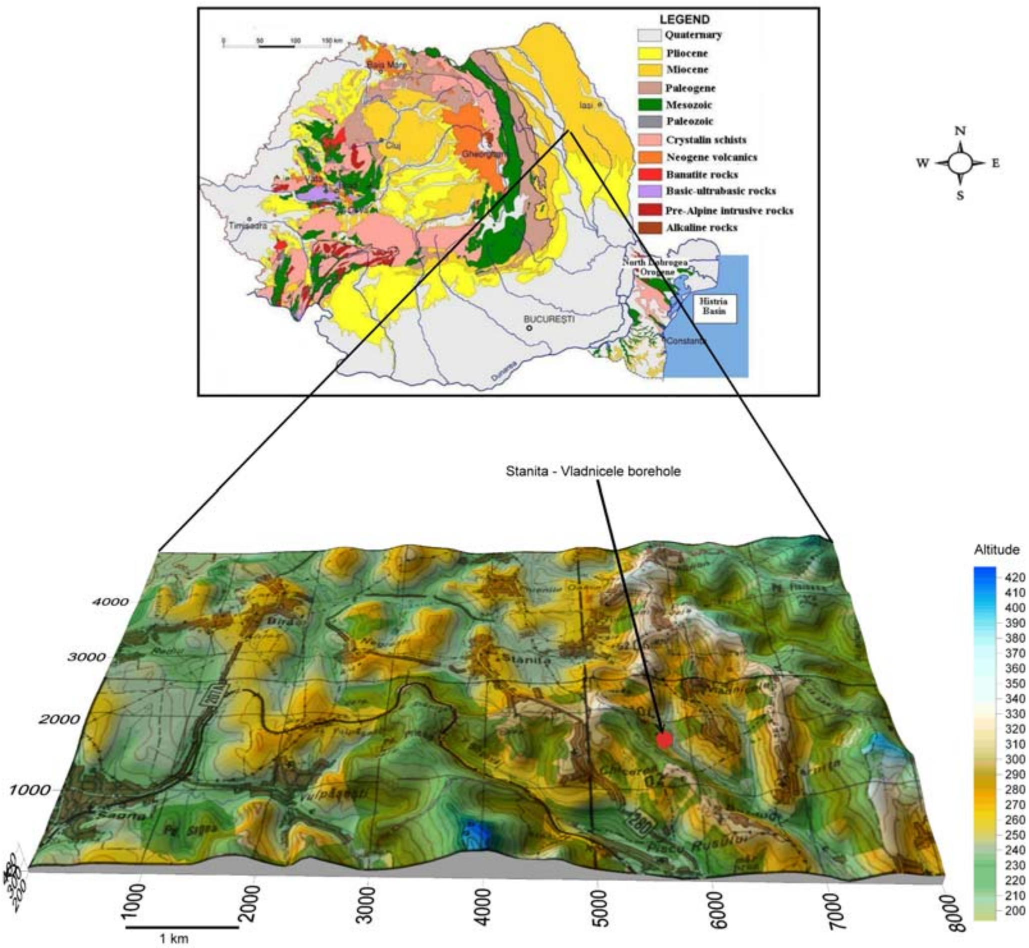

Fig.1 - Location of the Stănița-Vlădnicele borehole. 3D map of the Stănița-Vlădnicele area was achieved using Digimap and Surfer software, based on the L-35-31 (Iasi-1), 1:100,000 topographic map.

[1] University Al. I. Cuza" from Iaşi, Departament of Geology, Bd. Carol I, nr. 20A, 700505, Iasi, Romania, e-mail: mib@uaic.ro, gabiflogeoc@yahoo.com

The lithological log of the borehole has intercepted only Sarmatian deposits, from the limit with the anhydrite (Badenian) until the *Cryptomactra* clays (Lower Bessarabian - beginning of the Upper Bessarabian).

GEOLOGICAL SETTING

The Moldavian Platform underwent a foreland-type basin evolution during the Sarmatian, as the last phase of the transformation process of the Carpathian area. Characteristic depozones (wedge top, foredeep, forebulge and backbulge) have been identified, which due to particular facial conditions allowed the evolution of some specific faunal assemblages (Grasu et al., 2002). Among all non-biotic factors, the water salinity evolved towards a freshwater one, representing along with the sedimentary process the main factors that influenced the foraminiferals assemblages (Brânzilă, 2005). The same author suggested that the Intra-Volhynian tectogenesis, especially affecting the external zone of the Carpathians, has strongly influenced the evolution of the Paratethys basins (Grasu et al., 2002). In the terminal part of the Badenian, the Moldavian Platform has functioned as continental area, the sedimentation process lasting until the lower Sarmatian (Buglovian) (Brânzilă, 2005, Brânzilă & Țabără, 2005)

Beginning with the Lower Sarmatian, in the Eastern Carpathian foreland the advancement of the orogenic processes above the top of the Moldavian Platform led to the outlining of a series of characteristic depozones. From west to east, based on sedimentological criteria four depozones have been identified: wedge-top, foredeep depozone, forebulge and backbulge. The basinal waters had a significantly lower salinity as compared to that during the Badenian (Brânzilă, 1999; Grasu et al., 2002).

The southern part of the Moldavian Platform evolved under complex conditions, partially similar to those in the northern part; it was represented by a marine environment corresponding to the last stage of evolution of the foreland basin of the Eastern Carpathians, with an obvious tectonic control. Deposits of this interval belong to the first stage of evolution of the foreland basin where the subsidence - induced by the influence of the Carpathian thrust - was polarized from North-East to South-West (Ionesi, 1994, Ionesi et al., 2005). Under such conditions, we have interpreted the microfauna and paleoflora assemblage as corresponding to the backbulge depozone.

MICROPALAEONTOLOGICAL ASSEMBLAGE

The micropalaeontological assemblage identified in samples from Stănița-Vlădnicele borehole shows two specific aspects, distinctive for Miocene biofacies from the Moldavian Platform; firstly, a marine influence, and secondly, a brackish one. In sample 301 from m 975, located beneath the Badenian anhydrite, the micropalaeontological content is exclusively marine; it is represented by benthic and planktonic foraminifera including many taxa and individuals, which developed under normal salinity. From this sample were determined: *Uvigerina peronata, Bulimina elongata, Globigerina brevispira, Orbulina universa, Cibicides lobatulus, C. dutemplei, Entoselenia marginata, Melonis pompilioides, Pullenia bulloides, Sphaeroidina austriaca, Spiroplectamina* sp. and *Quinqueloculina* sp.

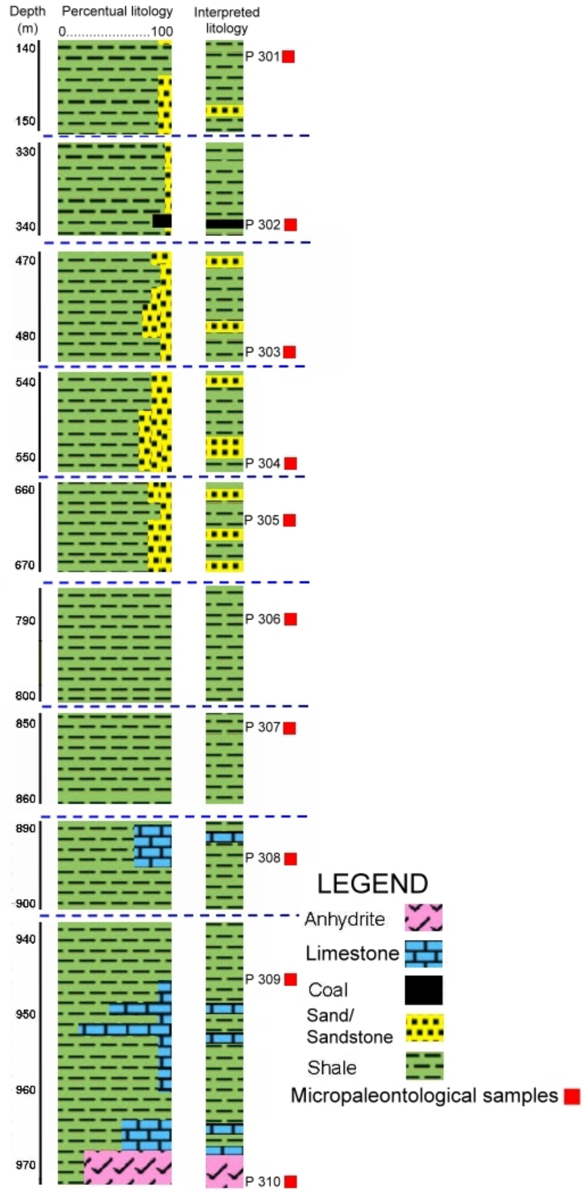

Fig. 2 - Lithological column of the Stanița-Vlădnicele borehole.

The deposits located above the Badenian anhydrite are mainly composed of shale, sands, and sandstones with thin limestone laminations. Samples P 301-309, from the 140-950 m interval are attributed to the Sarmatian. The micropalaeontological assemblage shows brackish characteristics, and the number of represented taxa is lower. *Anomalinoides* species (*Anomalinoides dividens, Lobatula lobatula*) are present only in sample 309 (950 m), alongside with some reworked ones: *Ammonia beccarii, Quinqueloculina* sp., and *Globigerina* sp. In the analyzed samples between 140 and 890 m, the micropalaeontological assemblage is poor and it is represented by miliolidae and unionidae: *Cycloforina karreri*, *Elphidium macellum*, *E. minutum, E. punctatum, E.crispum, E. aculeatum, E. regina regina, E. regina caucasica, Articulina problema, A. glabra, A. sarmatica*, and *Porosononion subgranosus*.

The micropalaeontological assemblage identified in the analyzed samples from Stănița-Vlădnicele borehole is assigned to the Badenian (sample P 310 from 975 m) and to the Sarmatian (samples P 301-309, in the 140–975 m interval); the fauna allows even an assignment according to stages.

Table 1 - Micropalaeontological assemblage in the analyzed samples from Stănița-Vlădnicele borehole.

Taxa	**P 301**	**P 302**	**P 303**	**P 304**	**P 305**	**P 306**	**P 307**	**P 308**	**P 309**	**P 310**
Uvigerina perornata PISHVANOVA										x
Bulimina elongata d'ORBIGNY										x
Globigerina brevispira SUBB.										x
Orbulina universa d'ORBIGNY										x
Heterolepa dutemplei (d'ORBIGNY)										x
Entoselenia marginata (W et B)										x
Melonis pompilioides FICHTEL ET MOLL										x
Pullenia bulloides (d'ORBIGNY)										x
Sphaeroidina austriaca d'ORBIGNY										x
Spiroplectamina sp.										x
Quinqueloculina sp.									x	x
Anomalinoides dividens LUCZKOWSKA									x	x
Anomalinoides badenensis LUCZKOWSKA									x	
Cycloforina karerri SEROVA							+	+`	+	
Quinqueloculina consobrina d'ORBIGNY						+	+	+	+	
Articulina problema BOGDANOWICZ				+		×	+	+	+	
Articulina sarmatica (KARRER)										
Articulina glabra (CUSHM.)						+	+	+		
Elphidium macellum (FICHTEL et MOLL)		+	×	×		+	+	+	+	
Elphidium minutum REUSS.			+	+		+	+	+	+	
Elphidium punctatum TERQUEM				+						
Elphidium crispum (LINNE)	+	+	+	+						
Elphidium aculeatum d'ORBIGNY		+	+	+		×	+	+	+	
Elphidium reginum reginum d'ORBIGNY	+		+	+		+	+	+		
Elphidium reginum caucasicum BOGDANOWICZ			+	+		+				
Porosononion subgranosus (EGGER)	+	+	+	×		+	+	+		
Porosononion martkobi BOGDANOWICZ	+		+	+		+				
Ammonia beccarii (LINNAEUS)			+	+		+		+	x	x
Legend × high frequency; + low frequency										

The assemblage determined from sample 309 (from 950 m) can be attributed to the Lower Sarmatian (Buglovian) based on *Anomalinoides dividens* zone (Popescu, 1995), samples P 305-308 (from 550-895 m) were assigned to the Volhynian based on *Elphidium reginum* zone (Popescu, 1995) and samples P 301-304 (from 140-550m) were attributed to the Bessarabian based on *Dogielina sarmatica* zone (Popescu, 1995).

MATERIAL AND METHODS

Palynological study

The analysis of the pollen content of geological samples is the main technique available to determine the vegetation response to past terrestrial environmental changes. The technique has been used for nearly a century, initially as a method for investigating past climatic changes. More recently, the effects of human impact, succession change and other biotic and abiotic factors on vegetation change have been recognized. Our palynological study was accomplished on 10 samples collected from Stănița-Vlădnicele borehole (RBN 4 borehole) in the 140–975 m interval (Fig. 2). About 50 g per sample have been investigated. The material has been treated with HCl (37 %) to remove the carbonate and afterwards with HF (48 %) to remove the silicate minerals. The separation of palynomorphs from the residue after chemical attack was done by centrifugation using heavy liquids (ZnCl2, with 2.00 g/cm^3 density). The organic fraction resulted was inserted into a mixture of glycerine and gelatine, 1-2 drops of the mix being mounted on the palynological slide. The visualisation of the palynomorphs was accomplished with a Leica DM1000 microscope with transmitted light, using x100, and x400 amplifications.

Palynological assemblage

The palynological assemblage identified in samples from the Stănita – Vlădnicele borehole (Table 2) is represented by scarce dinoflagellates (*Operculodinium*, *Spiniferites, Spirogyra, Tytthodiscus*) and a continental assemblage with Gymnospermatophytae (*Abiespollenites, Pityosporites, Cedripites, Inaperturopollenites, Podocarpidites, Zonalapollenites*), Angiospermatophytae (*Graminidites, Caryapollenites, Engelhardtioidites, Intratriporopollenites, Tricolporopollenite*s), and Pteridophytae (*Laevigatosporites, Leiotriletes, Polypodiaceoisporites, Verrucatosporites*). Among the continental assemblage, Gymnospermatophytae (Pityosporites) and Angiospermatophytae taxa (*Caryapollenites* and *Tricolporopollenites*) are dominant.

Dinoflagellate assemblage. More abundant and diverse dinoflagellate fauna is present in sample 303, from 485 m (Fig. 3). Operculodinium is generally reported as a cosmopolitan species that might have low relative abundances in the tropics and high relative abundances in regions with cold/temperate waters such as the North Atlantic (Wall et al. 1977; Marret & Zonneveld, 2003). This species is distributed within a very broad range of temperature (-2.1°C and 29.6°C), and salinity (16.1–36.8 $_0/^{00}$).

Continental assemblage. Ivanov et al. (2002, 2007) showed that the vegetation of the Middle and Upper Badenian of the Forecarpathian basin (central Paratethys, NW Bulgaria) was characterized by a regular occurrence and abundance of thermophilous species. According to the previously cited authors, during the Sarmatian subtropical elements like Engelhardia, Reevesia, Itea, Castanopsis, Symplocaceae, Arecaceae tend to decrease, while temperate elements such as *Alnus*, *Carpinus*, *Betula*, *Corylus*, *Fagus* have an increasing trend. A similar vegetation change is observed in the Sarmatian deposits from Stănița-Vlădnicele borehole. During the Sarmatian, favourable conditions existed in the Forecarpathian Basin for the development of mixed mesophytic forests - characterized by the dominance of warm-temperate and subtropical elements, together with many paleotropical elements. Based on the types of palynomorphs, we have separated the following biocenoses-related assemblages: swamp, mixed mesophytic forest, terrestrial herbs and ferns assemblage (Fig. 3).

Swamp assemblage. Aquatic plants like *Typha* indicate the presence of freshwater in the depositional environment. Swamp forest defines the lakeshore vegetation with moderate amounts of *Cupressaceae* and a low amount of riparian genus *Salix*.

Mixed mesophytic forest is well represented by species of fossil pollen, such as *Carpinus*, *Quercus*, *Ulmu*s, *Betul*a, and *Acer*. Pinaceae taxa are very abundant.

Ferns assemblage is represented by *Laevigatosporites, Leiotriletes, Polypodiaceoisporites, Stereisporites* a. o. The presence of the previously cited ferns indicates a wet environment.

Herbs assemblage. This assemblage consists of seven taxa mainly constituted of ground-cover vegetation in the mesophytic forest. Caryophyllaceae, and Chenopodiaceae are the dominant groups in this assemblage.

Table 2 - Palynological assemblage identified in Stănița-Vlădnicele borehole.

Phytoplancton	**P 301**	**P 302**	**P 303**	**P 304**	**P 305**	**P 306**	**P 307**	**P 308**	**P 309**	**P 310**
Deflandrea phosphoritica EISENACK, 1938 (reworked)			x							
Operculodinium sp.	x		x						x	
Spiniferites sp.			x					x		
Spirogyra sp.			x							
Tytthodiscus sp.			x					x		
Pteridophyta										
Cicatricosisporites sp.			x	x			x			
Echinatisporis sp.		x	x		x	x	x	x		
Echinatisporis wiesaënsis KRUTZSCH, 1963	x		x	x			x			

Laevigatosporites gracilis WILSON et WEBSTER, 1946						x	x	x		
Laevigatosporites haardti (POTONIÉ et VENITZ 1934) THOMSON et PFLUG, 1953 subsp. *haardti* KRUTZSCH, 1967			x	x		x	x			
Laevigatosporites sp.		x	x		x		x	x		
Leiotriletes sp.				x		x				x
Leiotriletes wolffi brevis KRUTZSCH,1962	x		x	x			x			
Leiotriletes wolffi wolffi KRUTZSCH,1962				x		x	x	x		
Polypodiaceoisporites saxonicus KRUTZSCH, 1967							x			
Polypodiaceoisporites sp.		x	x			x				
Stereisporites sp.	x				x				x	
Trilobosporites weylandi DÖRING, 1965	x					x				
Triplanosporites sinuosus (PFLUG 1952) THOMSON et PFLUG, 1953			x	x			x	x		
Verrucatosporites cf. *favus* POTONIÉ, 1931						x				
Gymnospermatophyta										
Abiespollenites absolutus THIERGART, 1937				x		x	x	x		
Abiespollenites cedroides (THOMSON 1953) KRUTZSCH,1971		x			x	x				
Abiespollenites latisaccatus (TREVISAN 1967) KRUTZSCH, 1971	x		x	x		x	x	x	x	
Abiespollenites maximus KRUTZSCH, 1971		x		x		x				
Abiespollenites sp.			x		x					
Cedripites lusaticus KRUTZSCH, 1971	x			x			x			
Cedripites miocaenicus KRUTZSCH, 1971		x	x	x		x		x		
Cedripites sp.							x			
Cupressacites bockwitzensis KRUTZSCH, 1971			x	x		x				
Cycadopites miocaenica NAGY, 1969		x	x		x	x	x	x		
Ginkgo sp.	x				x	x				
Inaperturopollenites concedipites (WODEHOUSE 1933) KRUTZSCH, 1971			x	x	x	x	x			
Inaperturopollenites hiatus (POTONIÉ 1931) THOMSON et PFLUG, 1953	+	+	+	+	+	+	+	+	x	
Inaperturopollenites microforatus KRUTZSCH, 1971	x		x	x						
Inaperturopollenites sp.		x	x	x			x	x		
Piceapollenites neogenicus NAGY, 1969			x	x						
Piceapollis praemarianus KRUTZSCH, 1971	x		x	x		x		x		
Piceapollis sp.			x	x			x			
Pinuspollenites longus NAGY, 1985		x		x	x	x				
Pinuspollenites miocaenicus NAGY, 1985	x		+	x			x	x		
Pityosporites alatus (POTONIÉ 1931) THOMSON et PFLUG, 1953		+	+	x	x	+			x	x
Pityosporites cedrisacciformis KRUTZSCH, 1971	x		x	x			x	x		
Pityosporites insignis (NAUMOVA ex BOLCHOVITINA 1953) KRUTZSCH, 1971		+	x			x	x	x		
Pityosporites labdacus (POTONIÉ 1931) THOMSON et PFLUG, 1953			+	x	x	x		x		x
Pityosporites microalatus (POTONIÉ 1931) THOMSON et PFLUG, 1953			x	x				x		
Pityosporites minutus (ZAKLINSKAJA 1957) KRUTZSCH, 1971			x	x		x		x		
Pityosporites sp.	+	+	+	+	+	+	+	+	x	x
Podocarpidites gigantea (ZAKLINSKAJA 1957) NAGY, 1985		x					x			
Podocarpidites nageiaformis (ZAKLINSKAJA 1957) KRUTZSCH, 1971			x	x	x	x				
Podocarpidites sp.		x				x	x			
Sciadopityspollenites serratus (POTONIÉ et VENITZ 1934) THIERGART, 1937					x	x		x		
Sciadopityspollenites sp.			x	x			x			
Sciadopityspollenites varius KRUTZSCH, 1971	x		+		x	x				
Sequoiapollenites minor KRUTZSCH, 1971				x			x	x		
Zonalapollenites minimus KRUTZSCH, 1971		+	x		+	x				
Zonalapollenites rueterbergensis KRUTZSCH, 1971	x		x	x			x	x		

Zonalapollenites sp.	x		x	x		x	x			
Zonalapollenites verrucatus KRUTZSCH 1971			+							
Angiospermatophyta. Monocotyledonatae										
Arecipites sp.			x			x		x		
Graminidites media (COOKSON 1947) POTONIÉ, 1960				x	x		x			
Graminidites sp.	x	x	x	x				x		
Monocolpopollenites sp.				x	x		x		x	
Monocolpopollenites tranquillus (POTONIÉ 1934) THOMSON et PFLUG, 1953	x		x	x		x		x		
Typha angustifolia LESCHIK,1956			x			x		x		
Angiospermatophyta. Dicotyledonatae										
Aceripollenites rotundus NAGY, 1969				x						
Aceripollenites sp.		x	x	x	x		x			
Alnipollenites verus (POTONIÉ 1931) POTONIÉ, 1934	x			x						
Betulaepollenites betuloides (PFLUG 1953) NAGY, 1969		+	x		x			x		
Carpinipites carpinoides (PFLUG 1953) NAGY 1985	x			x				x		
Caryapollenites simplex (POTONIÉ 1931) KRUTZSCH, 1960	+	+	+	+	+	+	+	+		x
Caryapollenites sp.	+	+	+	+	+	+	+	+		
Chenopodipollis multiplex (WEYLAND et PFLUG 1957) KRUTZSCH, 1966			+	+	x	x	x			
Cyrillaceaepollenites exactus (POTONIÉ 1931) POTONIÉ, 1960				x		x	x			
Cyrillaceaepollenites megaexactus (POTONIÉ 1931) POTONIÉ, 1960			x				x			
Engelhardtioidites microcoryphaeus (POTONIÉ 1931) THOMSON et THIERGART ex POTONIÉ, 1960	+	+	+	+	+	+	x	x	x	
Ericipites ericius (POTONIÉ 1931) POTONIÉ 1960		x		x		x				
Eucommiapollis eucommi (PLANDEROVA 1990) PETRESCU, 1999	x	x	x	x		x	x	x		
Faguspollenites minor NAGY, 1969				x						
Faguspollenites sp.	x		x				x	x		
Ilexpollenites margaritatus (POTONIÉ 1931) POTONIÉ, 1960			x		x		x			
Intratriporopollenites instructus (POTONIÉ 1931) THOMSON et PFLUG, 1953		x		x		x		x		
Juglanspollenites maculosus (POTONIÉ 1931) NAGY, 1985			x	x						
Juglanspollenites sp.	x			x		x	x	x		
Liquidambarpollenites sp.			x		x					
Magnolipollis sp.			x		x	x				
Momipites punctatus (POTONIÉ 1931) NAGY, 1969				x				x		
Myricipites bituitus (POTONIE 1931) NAGY, 1969	+		+	+	+	+	+	+		
Platycaryapollenites sp.	x	x	x		x		x			
Porocolpopollenites vestibulum (POTONIÉ 1931) THOMSON et PFLUG, 1953			x					x		
Pterocaryapollenites stellatus (POTONIÉ 1931) THIERGART, 1937	+	+	x	+	+	+	+	+	x	
Quercopollenites granulatus NAGY, 1969		x	x							
Quercopollenites petrea NAGY, 1969	x	x		x		x	x			
Quercopollenites robur NAGY, 1969	x		x				x	x		
Quercopollenites sp.		x		x	x					
Salixipollenites helveticus NAGY, 1969			x	x		x	x			
Tricolpopollenites liblarensis (THOMSON 1950) THOMSON et PFLUG, 1953 subsp. *liblarensis*	x		x	x		x		x		
Tricolporopollenites cingulum (POTONIÉ 1931) THOMSON et PFLUG, 1953 subsp. *pusillus* (POTONIE 1934) THOMSON et PFLUG, 1953		x		x	x		x	x		
Tricolporopollenites henrici (POTONIÉ 1931) KRUTZSCH, 1960			x	x	x	x	x	x		
Tricolporopollenites marcodurensis PFLUG			x	x		x	x	x		

et THOMSON 1953										
Tricolporopollenites microhenrici (POTONIÉ 1930) KRUTZSCH, 1960			x	x		x		x	x	
Tricolporopollenites sp.	+	+	+	+	+	+	+	+	x	x
Ulmipollenites undulosus WOLFF, 1934	x		x	x		x	x			
Zelkovaepollenites potoniéi NAGY, 1969		+			+	x		x		
Zelkovaepollenites sp.	x	+	x	+	+	x	x	+		
Zelkovaepollenites thiergarti NAGY, 1969	+	+	+	+	+	+	+	+		
Gombaspora (*Hyphomycetes*)(Fung)				x						
Legend: x low frequency + high frequency										

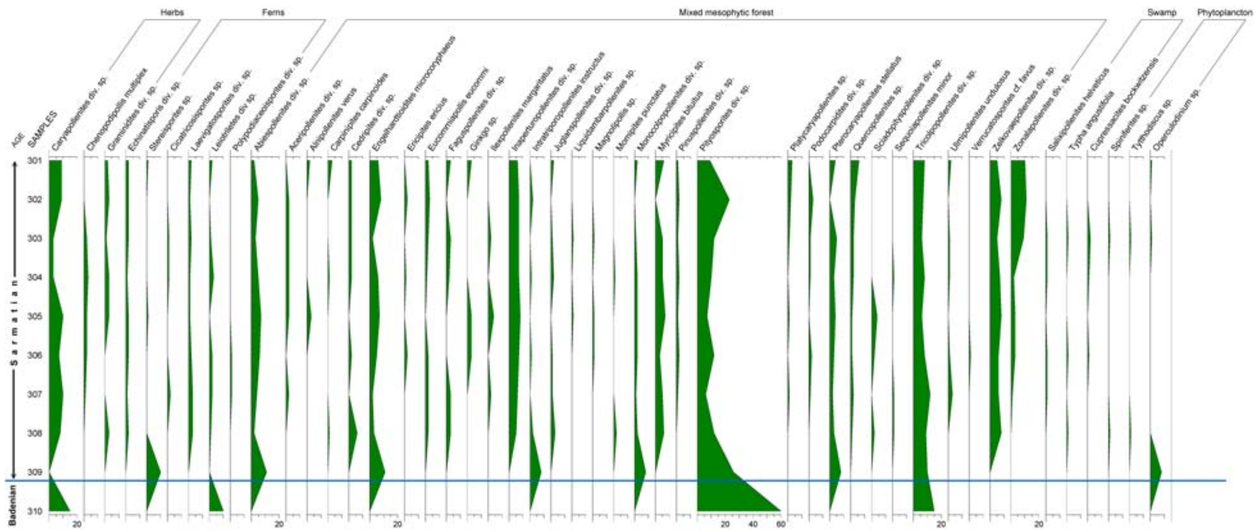

Fig. 3 - Simplified pollen diagram for the analyzed samples from Stanița-Vlădnicele borehole (Diagram accomplished with Tilia graph 2.0.2).

PALEOCLIMATIC INTERPRETATION BASED ON PALYNOLOGICAL ASSEMBLAGE

The method we used for paleoclimatic estimations is the „Coexistence approach” (CA), described by Mosbrugger and Utescher (1997). This method was frequently used for reconstruction of the European Tertiary paleoclimate. The determination of the coexistence approach for all taxa results in establishing the relative life conditions (NLR - Nearest Living Relative) and the climate of tolerance (maximum and minim values) for the fossil flora, by taking into account variations of the climatic parameters (MAT, MAP, CMMT, WMMT) etc.

Four palaeoclimatic parameters have been considered for the present study: mean annual temperature (MAT), mean annual precipitation (MAP), warmest month mean temperature (WMMT) and coldest month mean temperature (CMMT). The values calculated by us, using the Coexistence approach method, are (Fig. 4): MAT 16.5–17.2 °C, MAP 1300–1355 mm/yr, WMMT 23.6–28.5 °C, CMMT 9.6–12.5 °C.

The upper and lower limits for the above climatic parameters are listed in table 3. The lower limit for MAT (16.5 °C) is given by the Cycadaceae, and the upper limit (17.2 °C) is marked by *Juglans*. The lower MAP limit (1300 mm/yr) is given by *Sciadopitys verticil* while the upper limit (1355 mm/yr) belongs to *Carpinu*s. The lower limit for WMMT (23.6 °C) is given by Sapotaceae, while the upper limit (28.5 °C) is attribued to *Magnolia*. For the CMMT the lower limit (9.6 °C) belongs to Mastixiaceae and the upper limit (12.5 °C) is given by Cedrus. Our data are similar with those presented by Chirilă and Țabără (2008) for the Volhynian deposits from Râşca Valley: MAP 16.5–17.2 °C, MAP 1300–1355 mm/yr. Also, for samples collected from Moisea watercourse of Volhynian age Chirilă (2008) has established the following parameters: MAT 15.3–17.2 ^{o}C and MAP 1300–1520 mm/yr). The same author has calculated the following values from Baia borehole samples: MAT 16.5–16.6 ^{o}C and MAP 1300–1355 mm/yr. For Bessarabian deposits from Stan Hill–Bozieni area, Țabără et al., (2009) have calculated MAT: 15.3–16.6 °C and MAP between 1300–1520 mm/yr.

Table 3 - Climate parameters for the flora from Stăniţa-Vlădnicele borehole derived from microfloristic record. The taxa responsible for the minimum and maximum value are listed.

Climate parameter	Min -value	Taxon min-value	Max -value	Taxon max-value
MAT [°C]	16.5	Cycadaceae	17.2	*Juglans*
MAP [mm/yr]	1300	*Sciadopitys verticil*	1355	*Carpinus*
WMMT [°C]	23.6	Sapotaceae	28.5	*Magnolia*
CMMT [°C]	9.6	Mastixiaceae	12.5	*Cedrus*

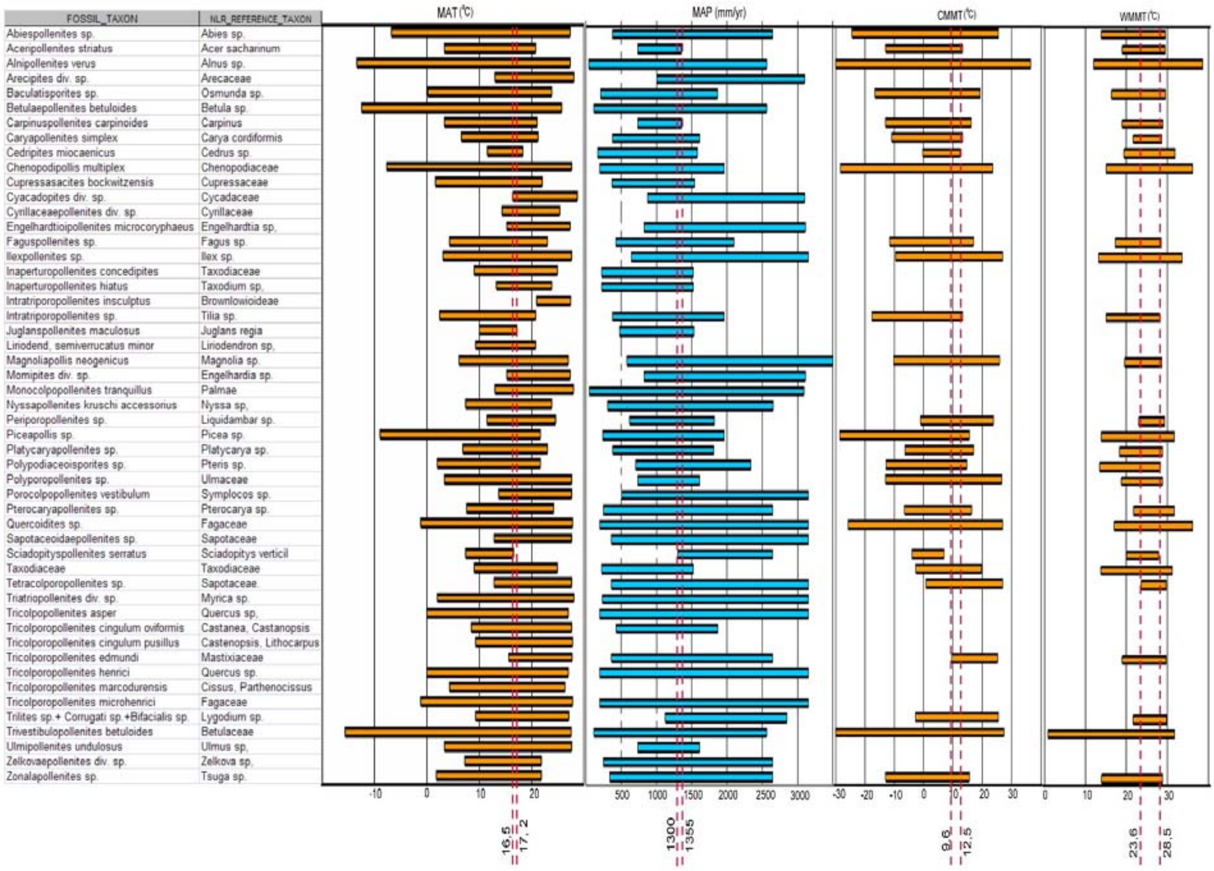

Fig. 4 - Estimation of the MAT, MAP, CMMT, and WMMT values using the Coexistence approach method.

CONCLUSIONS

The micropalaeontological assemblage identified in the analyzed samples from Stăniţa-Vlădnicele borehole is assigned to the Badenian (sample P 310, at m 975) and to the Sarmatian (samples P 301-309 from the 140–975 m interval). The distribution according to stages was also possible: the assemblage determined from sample 309 (from 950 m) can be attributed to the Lower Sarmatian (Buglovian) based on *Anomalinoides dividens* zone (Popescu, 1995), samples P 305-308 (from 550-895 m) are assigned to the Volhynian based on *Elphidium reginum* zone (Popescu, 1995), while samples P 301-304 (from the 140-550 m interval) are attributed to the Bessarabian based on *Dogielina sarmatica* zone (Popescu, 1995).

Based on the palynological assemblage we have separated the following biocenoses for continental palynomorphs: swamp, mixed mesophytic forest, terrestrial herbs and ferns assemblage. The dinoflagellate assemblage is represented by *Operculodinium*, *Spiniferites*, *Spirogyra* and a few reworked species of Phytoplankton; the most abundant and diverse association is present in sample 303, at 485 m. The climate parameters calculated by using the Coexistence approach method on our samples are (Fig. 4): MAT 16.5–17.2 °C, MAP 1300–1355 mm/yr, WMMT 23.6–28.5 °C, and CMMT 9.6–12.5 °C.

Acknowledgments

This work has been supported by the Romanian Ministry of Education, Research and Innovation under PN-II-IDEI No. 975/2008 research grant, Director Prof. dr. Mihai Brânzilă. Gabriel Chirilă thanks Dr. Daniel Ţabără for his help with the preparation and determination of the palynomorphs.

REFERENCES

Brânzilă, M., 1999. Geologia părții sudice a Câmpiei Moldovei. Ed. Corson, Iaşi, 221 p.

Brânzilă, M., Țabără D., 2005. The palynological content of Lower Basarabian (The clays with Cryptomactra) on the Moldavian Platform. *Anal. Şt. Univ. „Al. I. Cuza" Iaşi, Geologie*, XLIX – L (2003-2004), 277 – 291, Iaşi.

Brânzilă, M., 2005. Foraminifera assemblages of the backbulge depozone from the Moldavian Platform - the Basarabian. *Acta Palaeontologica Romaniae,* IV, 45 - 54.

Chirilă, G., 2008. Studiul paleofloristic al Sarmațianului din bazinul Văii Râşca. Teză de doctorat, Univ. „Al. I. Cuza" Iaşi, 246 p.

Chirilă, G., Țabără, D., 2008. Palaeofloristic study of the Volhynian from Râşca (Moldavian Platform) - Palaeoclimatic and palaeoenvironment implications. *Acta Palaeontologica Romaniae*, VI, 29 - 42.

Grasu, C., Brânzilă, M., Miclăuş, C., Boboş, I., 2002. Sarmațianul din sistemul bazinelor de foreland ale Carpaților Orientali. Ed. Tehnică, Bucureşti, p. 407.

Ionesi, L., 1994. Geologia unităților de platformă şi a Orogenului Nord - Dobrogean, Ed. Tehnică, Bucureşti, 280 p.

Ionesi, L., Ionesi, B., Lungu, A., Roşca, V., Ionesi, V., 2005. Sarmațianul mediu şi superior de pe Platforma Moldovenească. Editura Academiei Române, p. 558.

Ivanov, D., Ashraf, R., Mosbrugger, V., Palamarev, E., 2002. Palynological evidence for Miocene climate change in the Forecarpathian Basin (central Paratethys,NWBulgaria), *Palaeogeography, Palaeoclimatology, Palaeoecology,* 178, 19–37.

Ivanov, D., Ashraf, A., Mosbrugger, V., 2007. Late Oligocene and Miocene climate and vegetation in the Eastern Paratethys area (northeast Bulgaria), based on pollen data. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 255, 342–360.

Marret, F., Zonneveld, K., A., F., 2003. Atlas of modern organic-walled dinoflagellate cyst distribution. *Review of Palaeobotany and Palynology*, 125, 1–200.

Mosbrugger, V., Utescher, T., 1997. The coexistence approach - a method for quantitative reconstructions of Tertiary terrestrial palaeoclimate data using plant fossils. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 134, 61-86.

Popescu, Gh., 1995. Contributions to the knowledge of the Sarmatian foraminifera of Romania. *Romanian Jornal of Palaeontology*, 76, 85-98.

Țabără, D., 2008. Palinologia Sarmațianului mediu şi superior din Platforma Moldovenească. Editura Universității „Al. I. Cuza" Iaşi, 319 p., 23 pl.

Țabără, D., Chirilă, G., Paraschiv, V., 2009. The Sarmatian macro- and microflora from Stan's Hill – Bozieni (Moldavian Platform). *Anal. Şt. Univ. „Al. I. Cuza" Iaşi*, *Geologie*, LV, 2, 2009, 19-37.

Wall, D., Dale, B., Lohman, G., P., Smith, W., K., 1977. The environmental and climatic distribution of dinoflagellate cysts in the North and South Atlantic Oceans and adjacent seas. Mar. *Micropaleontology*, 2, 121-200.

PLATES

PLATE I

1-3. *Melonis pompilioides* (FICHTEL et MOLL, 1789). 1. Side view; 2. Detail view of fig. 1; 3. Edge view.
4. *Pullenia bulloides* (d'ORBIGNY, 1826). Edge view.
5. *Sphaeroidina austriaca* d'ORBIGNY, 1846.
6. *Cibicides pachidermus* RZEHAK, 1886. Side view.
7. *Ammonia beccarii* (LINNE, 1758). Side view.

PLATE II

1, 2, 3. *Anomalinoides dividens* LUCZKOWSKA, 1976. 1. Side view, 2. Edge view, 3. Dorsal view.
4-6. *Cycloforina karerri* (SEROVA, 1955) (4. Apertural view; 5. Side view; 6. Detail of fig 5)
7. *Articulina problema* BOGDANOWICZ. Side view.
8. *Elphidium minutum* (REUSS, 1865). Side view.
9. *Elphidium macellum* (FICHEL et MOLL, 1803). Side view.
10. *Elphidium crispum* (LINNE, 1758). Side view.

PLATE III

1-3. *Porosononion subgranosus* (EGGER, 1857). 1, 3, Side view, 2. Edge view.
4. *Elphidium aculeatum* (d'ORBIGN,Y 1846). Side view.
5. *Elphidium reginum caucasicum* BOGDANOWICZ, 1932. Side view.
6. *Elphidium reginum reginum* d'ORBIGNY, 1846. Side view.
7. *Porosononion martkobi* (BOGDANOWICZ). Side view.

PLATE IV

1.*Tytthodiscus* sp.
2.*Zonalapollenites verrucatus* KRUTZSCH, 1971
3-6.*Zonalapollenites neogenicus* KRUTZSCH, 1971
7. *Abiespollenites latisaccatus* (TREVISAN 1967) KRUTZSCH, 1971
8. *Pityosporites labdacus* (POTONIÉ 1931) THOMSON et PFLUG, 1953

PLATE V

1.*Quercopollenites robur* NAGY, 1969
*2.*Quercopollenites petrea* NAGY, 1969
3, 5-8. *Quercopollenites* sp.
4. *Quercopollenites robur* NAGY, 1969
9. *Pityosporites macroinsignis* KRUTZSCH, 1971
10. *Pityosporites pristinipollinius* (TREVISAN 1955) KRUTZSCH, 1971
11. *Pityosporites insignis* (NAUMOVA ex BOLCHOVITINA 1953) KRUTZSCH, 1971
12. *Pityosporites labdacus* (POTONIÉ 1931) THOMSON et PFLUG, 1953
13. *Podocarpidites gigantea* (ZAKL. 1957) NAGY, 1985
14. *Podocarpidites piniverrucatus* KRUTZSCH, 1971

PLATE I

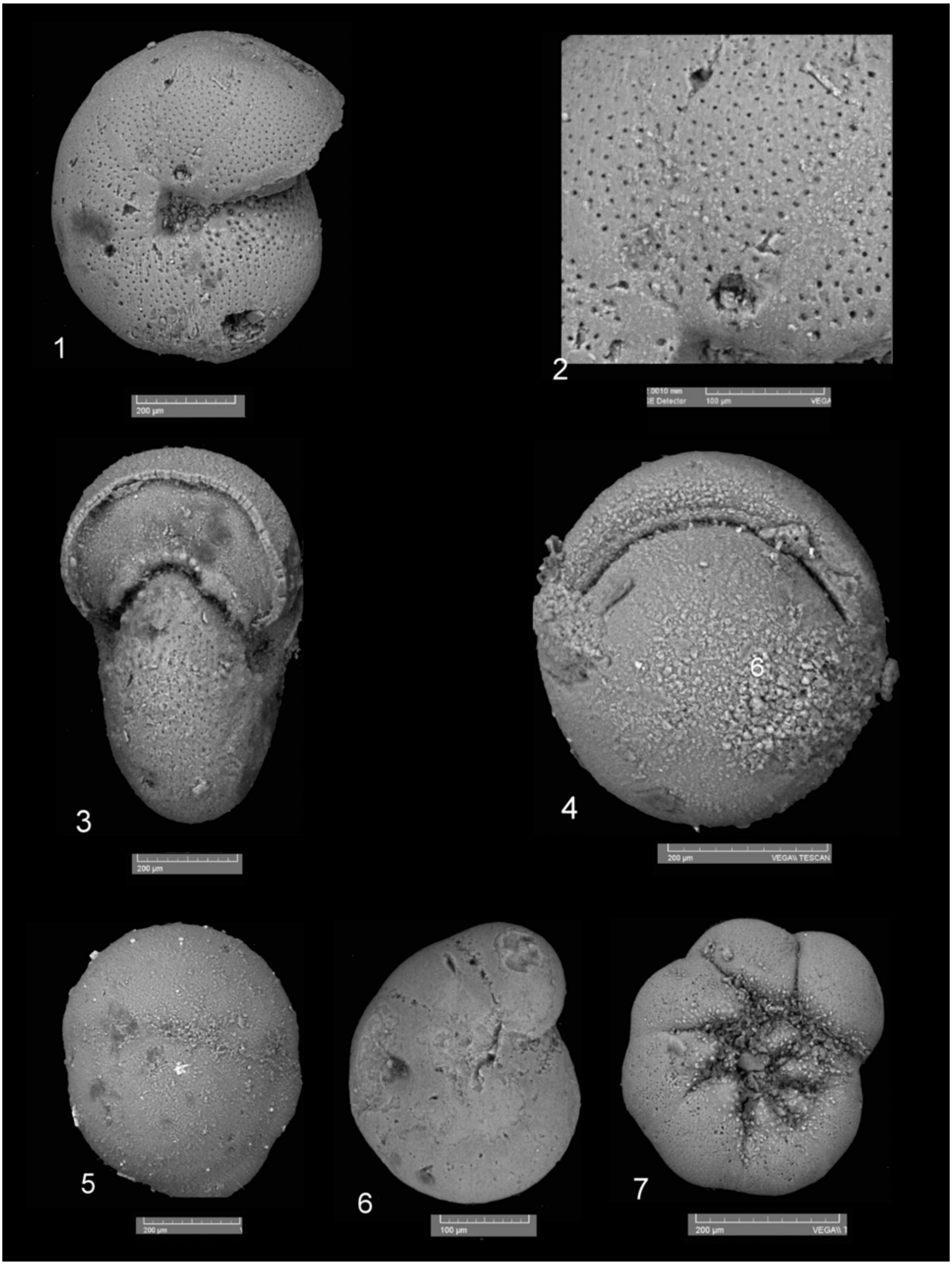
1
200 µm
2
100 µm
VEGA
3
200 µm
4
6
200 µm
VEGA\\ TESCAN
5
200 µm
6
100 µm
7
200 µm

PLATE II

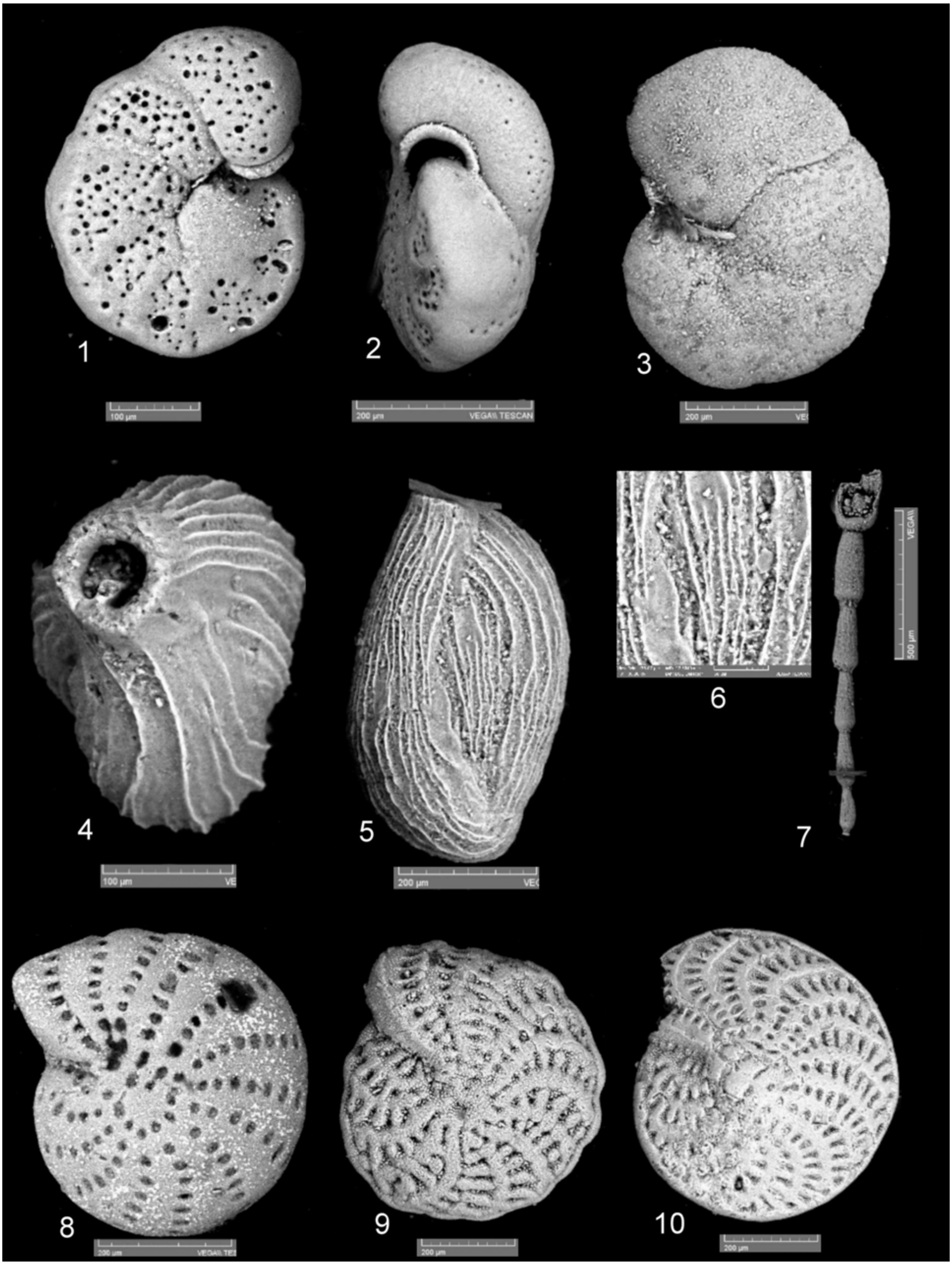

PLATE III

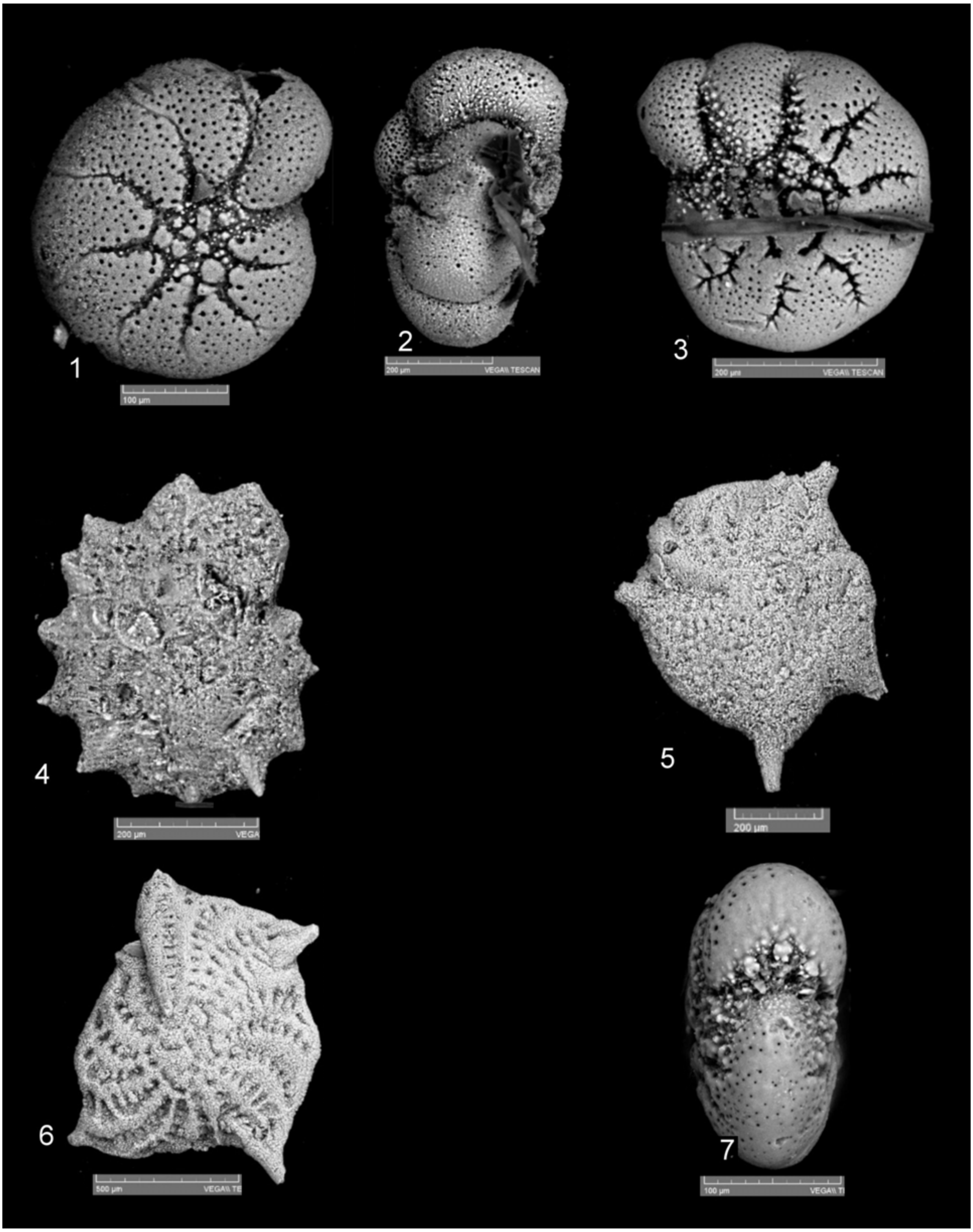
1
100 µm
2
200 µm
VEGA\\ TESCAN
3
200 µm
VEGA\\ TESCAN
4
200 µm
5
200 µm
6
500 µm
7
100 µm

PLATE IV

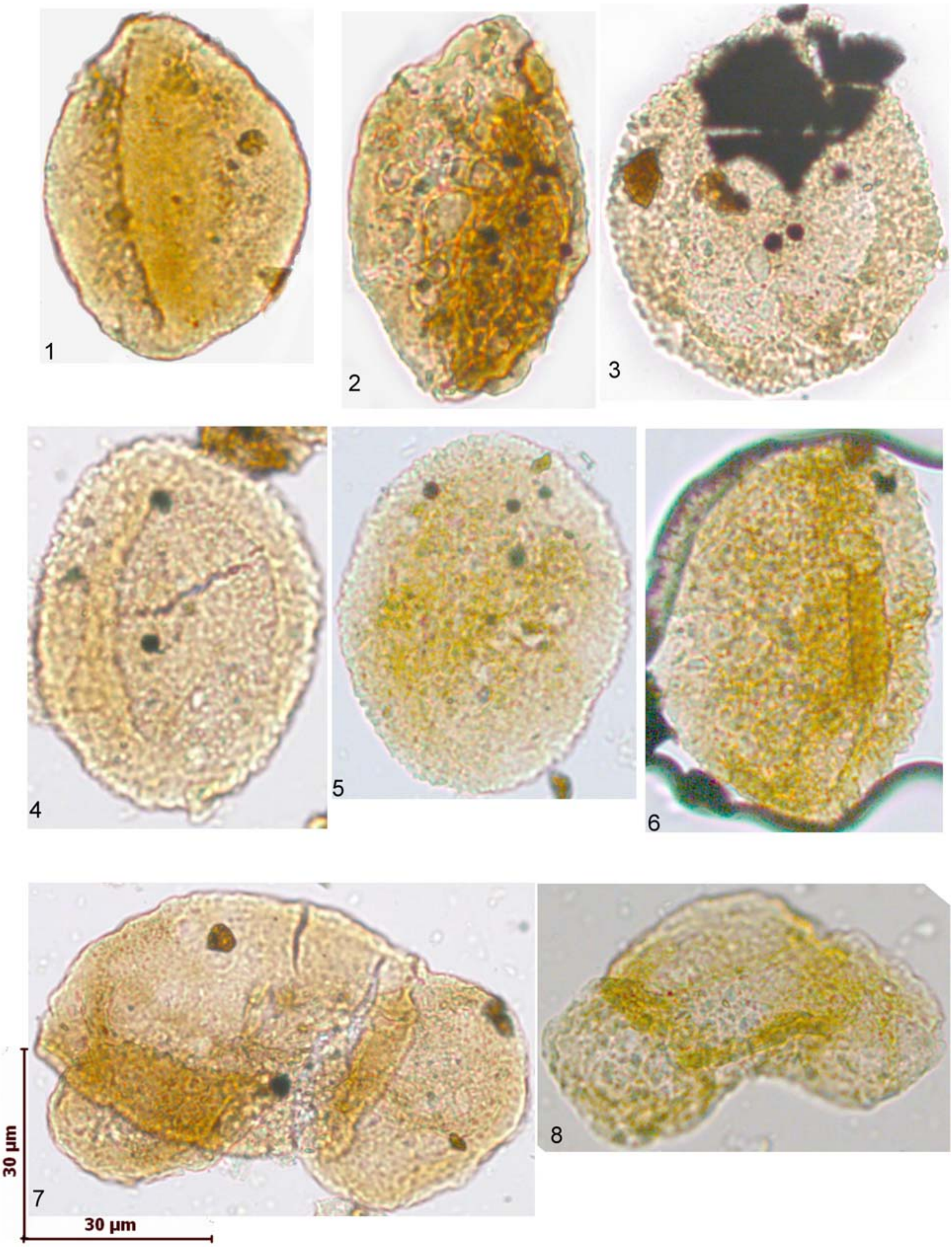

PLATE V