



ELSEVIER

Contents lists available at ScienceDirect

Data in brief

journal homepage: www.elsevier.com/locate/dib



Data Article

Litho- and biostratigraphic data of lower-middle Miocene sections in the Transylvanian basin and SE Carpathian Foredeep (Romania)



K. Sant ^a, D.V. Palcu ^a, E. Turco ^b, A. Di Stefano ^c, N. Baldassini ^c,
T. Kouwenhoven ^d, K.F. Kuiper ^e, W. Krijgsman ^{a,*}

^a Paleomagnetic Laboratory Fort Hoofddijk, Utrecht University, Utrecht, the Netherlands

^b Department of Chemistry, Life Sciences and Environmental Sustainability, Parma University, Parma, Italy

^c Department of Biological, Geological and Environmental Sciences, Catania University, Catania, Italy

^d Department of Geosciences, Stratigraphy-Paleontology, Heidelberglaan 2, 3584 CS Utrecht, the Netherlands

^e Department of Earth Sciences, Vrije Universiteit Amsterdam, the Netherlands

ARTICLE INFO

Article history:

Received 31 August 2018

Received in revised form 16 March 2019

Accepted 26 March 2019

Available online 17 April 2019

Keywords:

Foraminifera

Calcareous nannofossils

Badenian flooding

Streptochilus

Paratethys

ABSTRACT

Litho- and biostratigraphic data are provided of 5 stratigraphic sections in Romania covering the “Badenian” marine flooding that occurred in the Central Paratethys during the middle Miocene (Langhian). The dataset includes stratigraphic logs and descriptions of the profiles, and biostratigraphic analyses on calcareous nannofossils and foraminifera. In addition, characteristic stratigraphic features and representative fossils, including tiny *Streptochilus* foraminifera in the Campinița section in the SE Carpathian Foredeep, are presented in photographs. The data show that the flooding is characterized by the sudden abundance of Langhian calcareous nannofossils and foraminifera with a strong Mediterranean affinity.

© 2019 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

* Corresponding author. Budapestlaan 17, 3584 CD Utrecht, the Netherlands.

E-mail address: w.krijgsman@uu.nl (W. Krijgsman).

Specifications table

Subject area	Geology
More specific subject area	Stratigraphy, Micropaleontology, Field geology
Type of data	Table, images, figures, descriptive text
How data was acquired	Stratigraphic logging Microscope: Zeiss Axioscope (nannoplankton), Nikon SMZ stereomicroscope (benthic foraminifera), Zeiss stereomicroscope (planktonic foraminifera) SEM.: JEOL JXA-8530 F field emission electron probe analyzer (benthic foraminifera), Jeol 6400 (planktonic foraminifera)
Data format	Raw and analyzed.
Experimental factors	Collection of data was focused on determining the age and mode of the Langhian marine flooding in the Transylvanian Basin and SE Carpathian Foredeep by litho-biostratigraphic constraints.
Experimental features	Documenting the lithology and fossils (planktonic and benthic foraminifera, calcareous nannofossils, ostracods) in five semi-parallel stratigraphic sections.
Data source location	Transylvanian basin and SE Carpathian Foredeep, Romania (see text for GPS coordinates of all localities).
Data accessibility	Data are included in this article and supplemented Excel file.
Related research article	A. de Leeuw, S. Filipescu, L. Maţenco, W. Krijgsman, K. Kuiper, M. Stoica, Paleomagnetic and chronostratigraphic constraints on the Middle to Late Miocene evolution of the Transylvanian Basin (Romania): Implications for Central Paratethys stratigraphy and emplacement of the Tisza–Dacia plate, <i>Glob. Planet. Change.</i> 103 (2013) 82–98.

Value of the data

- The calcareous nannofossil and planktonic foraminiferal bio-events from the study area can be compared to dated bio-events in the Mediterranean region in order to provide an age framework for the Paratethys region.
- The litho-biostratigraphic data can be incorporated in future chronostratigraphic and paleoenvironmental studies in the Paratethys region.
- The data provide the first report of tiny *Streptochilus/Bolivina* spp. foraminifera in the sections in the SE Carpathian Foredeep in Romania, allowing comparison to similar blooming events in other parts of the Paratethys Sea, Mediterranean and Atlantic Ocean.

1. Data

The litho- and biostratigraphic data from the sections document a shift from restricted brackish-marine deposits to open marine deposition by the sudden appearance of abundant Mediterranean planktonic foraminifera (Figs. 1 and 2). This transgressive interval was logged in detail in the Campinița and Brebu sections, located in the Carpathian bend area in the East Carpathian Foredeep, where both intervals share similar features (CX, BX; Fig. 2., Fig. 3a–c). In the SE Carpathian Foredeep, the onset of the open marine conditions is assigned to the planktonic foraminiferal zone MMi5b and calcareous nannofossil zones MNN4c–MNN5a. In the Transylvanian sections, the quality of the data is variable and the base of the flooding is in the range MMi4c to MMi5a (planktonic foraminifera) and MNN5a–MNN5b (calcareous nannofossils). The data can be used for a paleoenvironmental and chronostratigraphic interpretation of the research area.

2. Experimental design, materials, and methods**2.1. Sampling and analysis**

The stratigraphic profiles were logged at ~0.5–1 m resolution during a fieldwork campaign in May 2015. Biostratigraphic samples were taken with a resolution of 1–2 m from the Valea Dracului (DV), Ciceu-Giurgești (CG), Cepari (CP) and Campinița (CA) sections. Additionally, biostratigraphic samples were taken at an approximately 25 cm resolution in the intervals just below the marine transgression

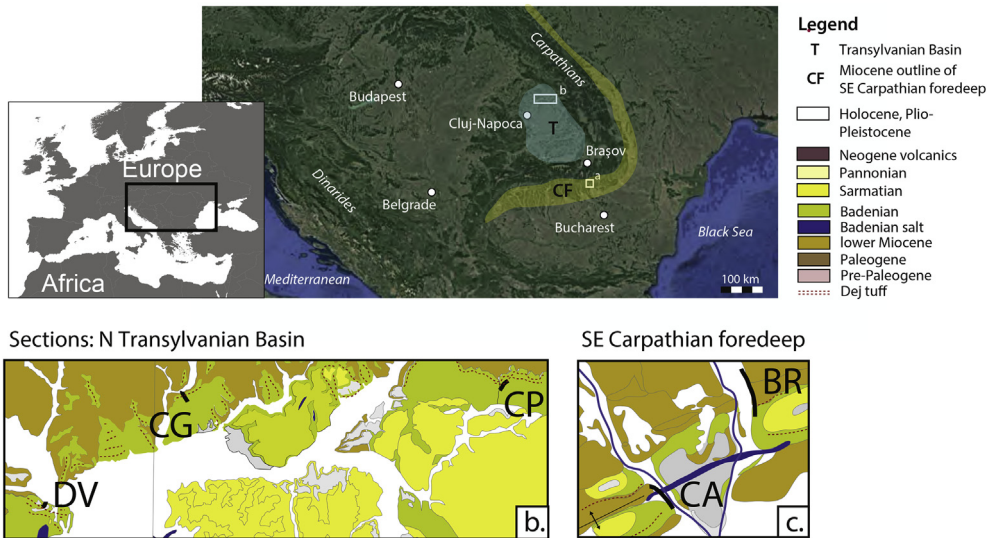


Fig. 1. Study area. a) Position of the Transylvanian Basin, Carpathian Foredeep and study areas; b, c) sections marked on the geological map. Map modified after [16].

in Valea Dracului, Campinița and Brebu. The resolution is lower (4 m or more) in intervals with a lot of coarse-grained material, such as sands and volcanic material.

A total of 81 calcareous nannofossil smear slides were prepared for calcareous nannofossil analysis using standard methods [1,2] and analyzed with a Zeiss Axioscope microscope under magnification 1000× at Catania University. According to the counting methodologies proposed by Refs. [2,3], targeted counts of biostratigraphically significant taxa were performed, in order to obtain relative abundances. Specifically, 30 and 50 specimens within the genera *Sphenolithus* and *Helicosphaera* were counted, respectively.

A total of 88 samples for the analysis of foraminiferal assemblages were prepared partly at the Geolab of the Faculty of Geosciences of Utrecht University and partly at the Micropaleontology Laboratory of the University of Parma. Samples (about 250 g) were dried in an electric oven at 40 °C for approximately 2 days, were processed with H₂O₂ (3%), and washed over 63 and 125 μm sieves. A qualitative analysis of planktonic foraminiferal assemblages was carried out on the >125 μm fraction of the washed residues focusing on the biostratigraphic marker species and on the >63 μm fraction specifically for *Streptochilus* spp; representative taxa were picked and mounted on micropaleontological slides. The biostratigraphic scheme for the Mediterranean by Ref. [4] emended in Ref. [5] was adopted. The foraminiferal content of the samples is highly variable, from (nearly) absent to very abundant. The preservation is also variable, from very poor to good. The samples containing benthic foraminifera (>125 μm size fraction) were qualitatively examined and representative taxa were mounted on micropaleontology slides for reference.

2.2. Lithostratigraphy

2.2.1. SE Carpathian Foredeep: Campinița and Brebu

The Miocene sediments in the SE Carpathian bend area were deposited in a former piggyback basin and subsequently incorporated into the Tarcău nappe. Similar deposits are found in the Râmnicu Vâlcea – Câmpulung – Câmpina – Slănic areas [e.g.,6,7]. In the study area, the Slănic tuff with *Globigerina* Marls that mark the Badenian flooding are known as the Campinița Formation [8].

The **Campinița** (CA; 45.136799°N, 25.711042°E) section is 155 m thick and located on the southern flank of an anticline along the western bank of the Prahova river. The outcrop covers the upper part of

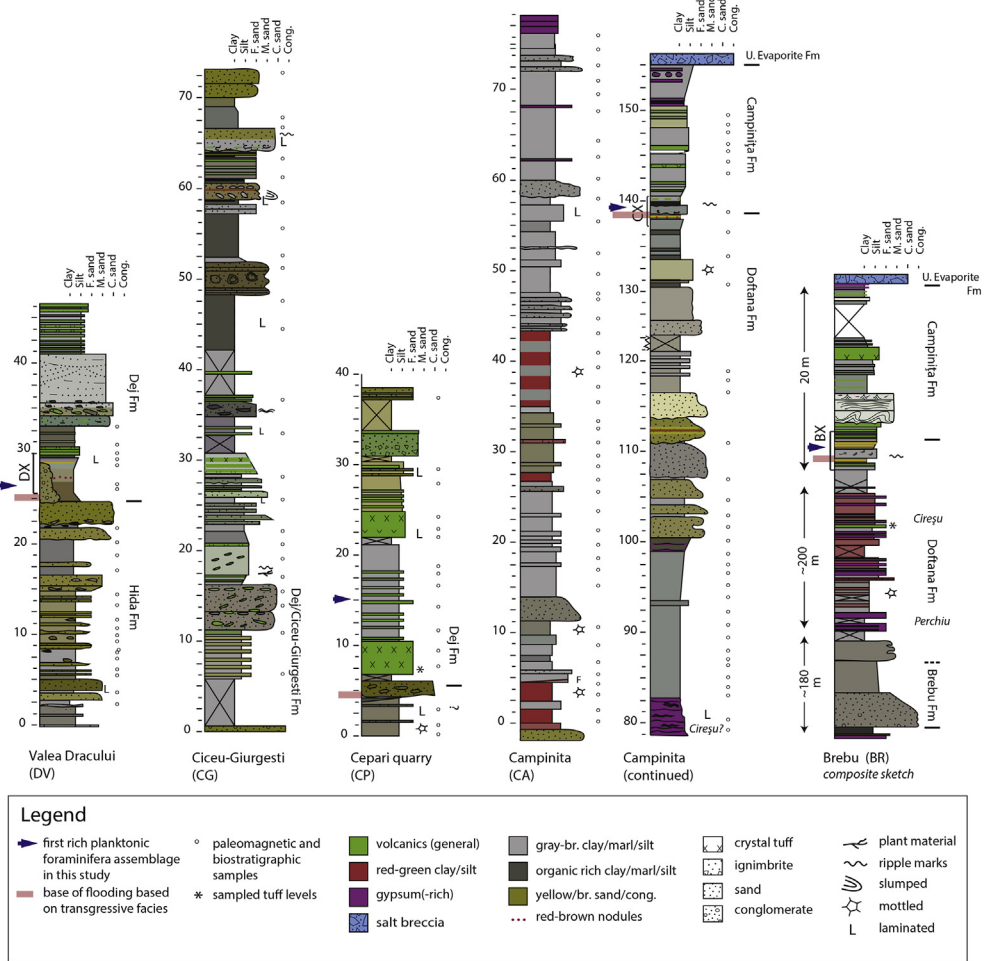


Fig. 2. Studied sections. Lithology, formations and sample levels from five sections in the N Transylvanian Basin (DV, CG, CP) and SE Carpathian Foredeep (CA, BR). See legend for symbol explanation.

the Doftana, Campinița and Upper Evaporite Formations (Fig. 2). The lithology is dominated by brown- and green-gray clays and silts with occasional wavy bedded sandy levels. Continental mottled red and green clays mark the basal part (Fig. 3f). Thin gypsum levels appear from 60 m upwards. Around 80 m a prominent interval with wavy gypsum lamina intercalating with mm-scale organic rich shales is present, which likely represents the Cireșu gypsum [1] (Fig. 3). Thick yellow-gray fine to coarse mica-rich sand bodies stand out between 100 and 117 m (Fig. 3g). Some have current structures at their base and they often alternate with reddish marls in layers of 30–50 cm. Findings of vertebrate footprints and traces of raindrops suggest shallow water to intertidal conditions for part of the environment [9]. The base of the Campinița Fm is at 138 m (Fig. 1). The formation is dominated by an about 10 m-thick sequence of gray tuffaceous marls with three biotite-bearing tuffs (5–10 cm thick) with large middle Miocene planktonic foraminifera. The section is sealed by a sequence of sapropels, gypsum-rich conglomerates and salt breccia.

The 400 m-thick **Brebu** (BR; 45.185498°N, 25.775669°E) profile is found along a NE striking tributary of the Doftana river and covers almost the complete early Miocene succession including the uppermost Lower Gypsum, Cornu(?), Brebu and Doftana Formations (Fig. 2). After a basal interval of

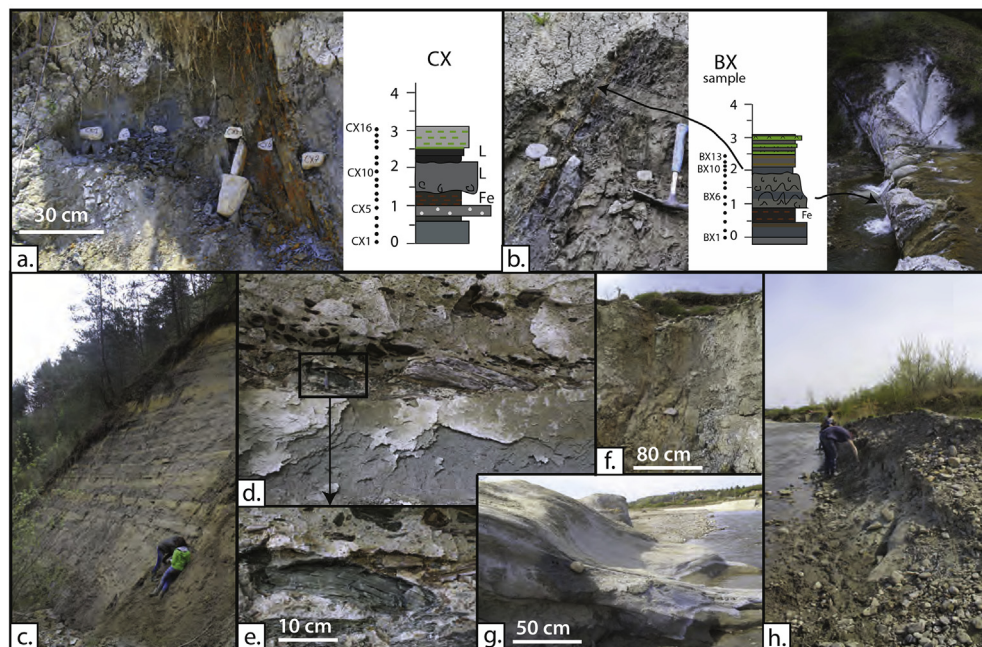


Fig. 3. Images of transgressive boundary sections. a) CX: Campinița section, b) BX: Brebu section) and other characteristic intervals of the sections (c–h): c) Pre-flooding facies in Valea Dracului (DV), d,e) Intraclasts in sand channel in the top of DV. f, g, h) Characteristic elements of the Campinița river section: red layers (f), sand bodies (g) and gray silty clay (h).

gypsum and black shales (about 50 m; Lower Evaporite Fm), the lower part of the stratigraphy is dominated by conglomerates and sands (Brebu Fm) gradually passing into microconglomerates and clays of the Doftana Fm. Sands of the Brebu Fm are sourced from the Perșani mountains, which currently form the internal part of the East Carpathians suggesting a low Carpathian topography at that time of deposition [6].

The upper part of the Brebu section is dominated by gray, green and red mottled clays and sandy silts including several gypsum layers (Doftana Fm). This part is poorly to non-exposed due to mudslides and vegetation, and was studied in more detail in the Campinița section. Two notable evaporitic intervals could be recognized; the Perchiu gypsum at the base of the Doftana Fm, and the Cireșu gypsum towards the top, serving as regional evaporitic marker levels (Fig. 3b). Another notable feature is a biotite-bearing tuff layer (20–50 cm thick) followed by a prominent gypsum bed. The middle Miocene Slănic tuff level is clearly visible in the top of the main Brebu profile. The transgressive boundary between the Doftana Fm and Campinița Fm is exposed in a parallel section towards the west next to the Brebu Manastirei cemetery (Fig. 3b). It can be summarized by about 15 m of tuffitic clays and tuffites. The Brebu section is topped by a layer of salt breccia.

The transgressive intervals in Campinița and Brebu sections both start with blue-gray clay and silt layers, followed by a dark sapropelic silt or clay interval full with orange-weathered iron oxides and barren in fossils. In both sections, this is followed by sands bearing water escape structures. The first rich planktonic foraminiferal assemblages appear within or just on top of these sand packages. In Brebu, the succession is followed by another resistant and prominent thick fine-to-medium green-white three-layered disturbed sand package with wavy lamination and iron coated 'knobs' at its base (Fig. 3b).

2.2.2. NW Transylvanian Basin: Valea Dracului, Ciceu-Giurgestți and Cepari

The Valea Dracului (DV), Ciceu-Giurgestți (CG) and Cepari (CP) sections cover (parts of) the upper Hida Fm and Dej Fm in the NW Transylvanian basin (Fig. 1). In this region, several studies defined the

Table 1

Qualitative biostratigraphic results and associated biozonations for calcareous nannofossils, planktonic and benthic foraminifera for all studied samples.

Campinița section		Calcareous nannofossils		Planktonic foraminifera	marker species in biozone		Benthic foraminifera	Ostracods
Sample	Level (m)	Preservation	Main taxa	Biozone	Residue description	Main taxa	Biozone	Notes
CF17	151.8				very fossiliferous, made up of planktonic foraminifera. Preservation good	assemblage is dominated by small-sized specimens of globorotalids		No markers
CF16-1	150.7	good	<i>Sphenolithus moriformis</i> (A), <i>Helicosphaera carteri</i> (A), <i>H. mediterranea</i> (C), <i>H. eupratis</i> (R), <i>S. heteromorphus</i> (R).	MNN5b	very fossiliferous, made up of planktonic foraminifera. Preservation moderate (recrystallized and very often deformed)	assemblage is dominated by globigerinids		No markers
CF14	150				terrigenous component < fossil content. Planktonic foraminiferal preservation moderate (recrystallized)	<i>Globigerinoides trilobus</i> , <i>Globorotalia praescitula</i>		No markers
CA7	149.4	?	<i>H. carteri</i> and <i>S. heteromorphus</i> abundant	MNN5b	very fossiliferous, made up of planktonic foraminifera. Preservation good	assemblage of fraction >125µm is dominated by Orbulinids. <i>Orbulina suturalis</i> , <i>O. suturalis/universa</i> transition, <i>O. universa</i>	MMi5b	
CF12-1	149.2	good	<i>Sphenolithus moriformis</i> (C/A), <i>S. heteromorphus</i> (C), <i>Helicosphaera carteri</i> (A)	MNN5b				
CF11.2	148.3	good	<i>H. carteri</i> and <i>S. heteromorphus</i> abundant	MNN5b	very fossiliferous, made up of planktonic foraminifera. Preservation good even if slightly oxidized, often deformed and fragmented	assemblage dominated by <i>Globigerinoides trilobus</i> (larger size) and small-sized specimens of globorotalids (<i>Globorotalia praescitula</i> , <i>Globorotalia</i> spp.)		No markers
CA5	147.4	?	<i>H. carteri</i> abundant, <i>S. heteromorphus</i> common; very few <i>H. ampliapertura</i> : Biozone MNN4b	MNN4b (MNN5b if <i>H. ampliapertura</i> is reworked)	very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed	<i>Dentoglobigerina</i> spp. (A), <i>Globigerinoides trilobus</i> (R), <i>Globorotalia</i> spp., <i>Praeorbulina glomerosa glomerosa</i> , <i>P. glomerosa circularis</i> , <i>Orbulina suturalis</i>	MMi5a	Praeorbulina/Orbulina group common

CA3	145.4	good	<i>H. carteri</i> and <i>S. heteromorphus</i> abundant; <i>H. walbersdorffensis</i> present; <i>C. premacintyreii</i> , <i>G. rotula</i> common	MNN5c	very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed and fragmented	<i>Globigerinoides trilobus</i> , <i>Globigerinoides cf. sicanus</i> , <i>Globorotalia praescitula</i> , <i>Globorotalia</i> spp.	No markers
CF9	144.8				very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed and sometimes fragmented	<i>Globigerinoides trilobus</i> , <i>MMi5a</i> <i>Globigerinoides sicanus</i> , <i>Paragloborotalia siakensis</i> (sin.)(R), <i>Globorotalia praescitula</i> , <i>Globorotalia</i> spp., <i>Præorbulina glomerosa</i> circularis (also evolute specimens), <i>Orbulina suturalis</i>	<i>Præorbulina</i> / <i>Orbulina</i> very rare and deformed
CF8	143.5				very fossiliferous, made up of planktonic foraminifera. Preservation moderate (slightly recrystallized and often deformed)	<i>Globigerinoides trilobus</i> , <i>MMi5a</i> <i>Globigerinoides cf. sicanus</i> , <i>Paragloborotalia siakensis</i> (sin.)(R), <i>Globorotalia</i> spp., <i>Præorbulina glomerosa</i> circularis (also evolute specimens), <i>Orbulina suturalis</i>	
CA1	142.9	small-size	<i>H. carteri</i> and <i>S. heteromorphus</i> abundant, very few <i>H. walbersdorffensis</i>	MNN5b	very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed	<i>Globigerinoides trilobus</i> , <i>MMi5a</i> <i>Globigerinoides sicanus</i> , <i>Paragloborotalia siakensis</i> (sin.)(R), <i>Globorotalia</i> spp., <i>Præorbulina glomerosa</i> circularis (also evolute specimens), <i>Orbulina suturalis</i>	<i>Præorbulina</i> / <i>Orbulina</i> gr rare
CF7.2	141	good	<i>H. carteri</i> and <i>S. heteromorphus</i> abundant, very few <i>H. walbersdorffensis</i> ; <i>C. premacintyreii</i> , <i>G. rotula</i> common	MNN5b	almost exclusively made up of undiagenated sediment grains. Very diluted planktonic foraminiferal content. Small-sized specimens	<i>Globigerinoides trilobus</i> , <i>Paragloborotalia siakensis</i> (sin.), <i>Globorotalia praescitula</i>	No markers
CX16	140.1	very good	<i>Helicospira carteri</i> (A), <i>H. ampliperta</i> (R), <i>H. waltrams</i> (R), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C)	MNN5a	no terrigenous fraction, very fossiliferous, residue made up of planktonic foraminifera, preservation good.	<i>Paragloborotalia siakensis</i> , <i>Globorotalia scitula</i> , <i>Globigerinoides trilobus</i> , <i>G. cf. sicanus</i> , <i>Præorbulina glomerosa</i> , <i>glomerosa glomerosa</i> , <i>P. glomerosa</i> circularis, <i>Orbulina suturalis</i>	

Table 1 (continued)

Sample Level (m)	Calcareous nanofossils	Preservation	Main taxa	Biozone	Planktonic foraminifera	marker species in bold		Notes	Benthic foraminifera	Ostracods
						Residue description	Main taxa			
CF6.2	140	good	H. carteri and S. heteromorphus abundant, few H. walbersdorffensis; C. premacintyreii, G. rotula common	MNN5b/c	very fossiliferous, made up of planktonic foraminifera. Preservation good even if sometimes deformed or fragmented	Globigerinoides trilobus (A), Globigerinoides cf. sicanius , Paragloborotalia siakensis (sin.), Globorotalia praescitula , Præorbulina glomerosa glomerosa , P. glomerosa circularis , Orbulina suturalis	MM15a			
CX14	139.7	good	Helicosphaera carteri (C) A), Sphenolithus heteromorphus (C/A), S. moriformis (C), H. walbersdorffensis (C), H. euphratis (R)	MNN5c	very fossiliferous, no terrigenous fraction. Planktonic foraminifera represent almost the all residue, preservation moderate.	Deneglobigerina altispira gr., Globigerinoides trilobus , G. sicanius, Præorbulina glomerosa curva , P. glomerosa glomerosa , P. glomerosa circularis , Orbulina suturalis	MM15a			
CF5.2	139.5	BARREN								
CX13	139.3	good	Sphenolithus moriformis (C/A), S. heteromorphus (C), Helicosphaera carteri (A)	MNN5b	inorganic fraction abundant, made up of oxidized and pyritized sediment fragments; pyrite. Plant remains abundant. Planktonic foraminifera common, moderately preserved, no benthic foraminifera	Globigerina bulloides gr., Globigerinoides trilobus , Globorborotalia woodi , Globorotalia scitula , Turborotalita cf. T. quinqueloba , Deneglobigerina spp., G. cf. sicanius, Præorbulina glomerosa curva , P. glomerosa glomerosa , P. glomerosa circularis , Orbulina suturalis	MM15a			
CX12	139.3	good	Helicosphaera carteri (C) A), Sphenolithus heteromorphus (C), S. moriformis (C), H. intermedia (R), H. waltrans (R), H. obliqua (R)	MNN5a	very little residue; az. mica. Planktonic foraminifera in trace, preservation moderate.	Deneglobigerina altispira gr., Turborotalita cf. T. quinqueloba , Globigerinoides trilobus , Orbulina suturalis? (only 1 specimen, apertures not well visible)	MM15a?			

CA8	138.7	very poor	UNDEFINABLE		inorganic fraction abundant (lithic grains), planktonic foraminifera in trace	rare <i>Streptochilus/Bolivina variabilis</i> in fraction <125 µm	no markers	miliolids common; rare abundant and recrystallized Loxoconcha punctatella hyaline species (Gavelinopsis? sp., Rosalina sp.)
CX8	138.5	good	<i>Helicospaera carteri</i> (C) MNN5a A), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C), <i>H. waltrans</i> (R), <i>H. intermedia</i> (R), <i>H. ampliaperta</i> (R), <i>H. obliqua</i> (R), <i>H. mediterranea</i> (R/C)					
CX6	138.1	very poor	UNDEFINABLE	MNN4a?	sediment fragments		barren	
CF3.2	138	very poor	<i>S. moriformis</i> , <i>H. ampliaperta</i> , <i>D. variabilis</i> and <i>H. carteri</i> are present					
CX3	137.4	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (RR), <i>S. moriformis</i> (C), <i>H. mediterranea</i> (R), <i>H. ampliaperta</i> (R)	MNN4c	very little residue; sediment fragments, pyrite. Planktonic foraminifera rare, preservation good	<i>Globigerinoides trilobus</i> , <i>G. cf. sicamus</i> , <i>Denegobigerina altispira</i> gr., <i>Globorotalia praescitella</i>	No markers	
CX02	137.2				very little residue, mica (muscovite) very abundant, lithic grains rare		barren	
CX01	137				very little residue, mica (muscovite) very abundant, lithic grains rare, oxidized fragments rare, echinids remains, foraminifera in trace	small-sized globigerinids, <i>Turborotalita</i> cf. <i>T. quinqueloba</i>	Nearly barren, no markers	
CA9	136.5	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R), <i>H. ampliaperta</i> (C), <i>H. walbersdorffensis</i> (R)	MNN3b	very little washed residue, muscovite abundant, pyritized fragments, foraminifera in trace, radiolarians.	One deformed planktonic foraminifer: <i>Globigerinoides sicamus</i> ??. rare <i>Streptochilus/Bolivina variabilis</i> in fraction <125 µm. One <i>Morozovella</i> sp. (Paleogene)	nearly barren	rare benthic foraminifera: <i>Bolivina plicatella</i> , <i>Bulimina elongata</i> , miliolids.
CF2-1	136.5	very poor	UNDEFINABLE					
CF1.2	135.5	moderate	<i>S. moriformis</i> (C), <i>H. ampliaperta</i> (C), <i>H. carteri</i> (C), <i>H. euphratis</i> (R)	MNN4a				
CA10	133.7	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>H. intermedia</i> (R), <i>H.</i>	MNN3b	very little residue, aggregated sediment, muscovite. Ostracods,	<i>Denegobigerina</i> spp., <i>Globigerina</i> spp., rare <i>Streptochilus/Bolivina</i>	nearly barren, no markers	benthic foraminifera extremely rare and recrystallized:

Table 1 (continued)

Sample	Level (m)	Calcareous nanofossils		Biozone	Planktonic foraminifera		marker species in bold		Biozone	Notes	Benthic foraminifera	Ostracods
		Preservation	Main taxa		Residue description	Main taxa	Main taxa					
CA11	130.9	good	<i>euphratis</i> (R), <i>H. mediterranea</i> (R), <i>H. ampliaperta</i> (R), <i>H. obliqua</i> (R)	MNN3b	radiolarians, plant remains, Foraminifera in trace	radiolarians, plant remains, Foraminifera in trace	<i>variabilis</i> in fraction <125 µm			nearly barren, no markers	<i>Astronion?</i> sp., <i>Cibicides lobatulus</i> .	
CA12	118.9	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R), <i>H. ampliaperta</i> (R), <i>H. walbersdorffensis</i> (R)	MNN3b	inorganic fraction made up of only mica (muscovite), abundant plant remains	inorganic fraction made up of only mica (muscovite), abundant plant remains	rare <i>Streptochilus/Bolivina variabilis</i> in fraction <125 µm			barren	few benthic foraminifera: <i>Bolivina spathulata</i> , <i>Bulimina elongata</i> , <i>B. striata</i> , <i>Cassidulina carinata</i> , <i>Cibicides</i> sp., <i>discorbis</i> , <i>Hanzawaia boueana</i> , <i>Oridorsalis umbonatus</i> , <i>Rosalina bradyi</i>	
CA13	117.9	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R), <i>H. ampliaperta</i> (R), <i>H. walbersdorffensis</i> (R)	MNN3b	residue made up of mica, quartz, lithic grains, terrigenous fragments. Very diluted foraminiferal (planktonic and benthic) content. Radiolarians??	residue made up of mica, quartz, lithic grains, terrigenous fragments. Very diluted foraminiferal (planktonic and benthic) content. Radiolarians??	abundant, lithic grains, rare oxidized fragments, planktonic foraminifera very rare and poorly preserved, possible reworking	<i>globigerinids</i>		no markers	fragmented benthic foraminifera: fragments of nodosarids, <i>Ammonia</i> , agglutinated taxa	
CA18	102.9	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R), <i>H. ampliaperta</i> (C), <i>H. walbersdorffensis</i> (R)	MNN3b	very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments	very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments	<i>Paraglobobulimina siakensis</i> , <i>Globigerinoides trilobus</i> , <i>G. cf. sicanius</i>	MM14c?		This datum and thus the subzonal attribution is very weak		
CA19	101.7	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>S. heteromorphus</i> (C), <i>H. euphratis</i> (R/C), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (R), <i>H. intermedia</i> (R), <i>H. scissura</i> (R), <i>H. obliqua</i>	MNN5a	very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments	very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments	<i>Pracorbulina glomerosa</i> 1 spec. !			nearly barren		
CA20	100.2	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>S. heteromorphus</i> (C), <i>H. euphratis</i> (R/C), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (R), <i>H. intermedia</i> (R), <i>H. scissura</i> (R), <i>H. obliqua</i>	MNN5a	very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments	very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments	Just 1 planktonic foraminifer: <i>Globigerinoides sicanius</i> (3 apertures)			nearly barren		

CA21	98.7	good	(R), <i>H. recta</i> (R), <i>H. waltrans</i> (R) <i>Helicospaera carteri</i> (C) MNN4a A), <i>Sphenolithus moriformis</i> (A), <i>H. euphratis</i> (C), <i>H. ampliaperta</i> (C), <i>H. intermedia</i> (R), <i>S. heteromorphus</i> (C), <i>H. obliqua</i> (R), <i>H. mediterranea</i> (R/C) <i>Helicospaera carteri</i> , <i>H. euphratis</i> , <i>H. scissura</i> , <i>H. waltrans</i> , <i>Sphenolithus heteromorphus</i> , <i>S. moriformis</i>	very little residue, mica very abundant, lithic grains terrigenous fragments, small-sized foraminifera in trace	nearly barren, no markers	
CA22	97.5	poor	MNN5a <i>Helicospaera carteri</i> , <i>H. euphratis</i> , <i>H. scissura</i> , <i>H. waltrans</i> , <i>Sphenolithus moriformis</i>	very little washed residue (>63µm)	barren	
CA23	96.5			very little residue, lithic grains, qz, mica	barren	
CA24	95.4			very little residue, lithic grains, qz, mica, plant remains	barren	
CA25	93.9			residue made up of mica (mainly muscovite), qz, rare lithic grains, terrigenous fragments. Very diluted foraminiferal (planktonic and benthic) content. Radiolarians?	no markers	rare and fragmented benthic foraminifera: nodosarids, Ammonia, Elphidium, Bulimina, Uvigerina spp.; agglutinated taxa?
CA26	92.4			residue made up of qz, mica (mainly muscovite), lithic grains, Planktonic foraminifera in trace (some reworked)	nearly barren, no markers	rare calcareous benthic foraminifera (Ammonia sp., Bulimina sp., nodosarids)
CA27	90.9			very little residue, terrigenous and lithic grains, pyritized fragments, mica, qz	barren	
CA28	89.5			residue made up of mica (mainly muscovite), qz, rare lithic grains. Very diluted planktonic foraminiferal content	No markers	
CA29	88	good	<i>Helicospaera carteri</i> (C) MNN4c A), <i>Sphenolithus moriformis</i> (C/A), <i>S. heteromorphus</i> (R), <i>H. euphratis</i> (R/C), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (R), <i>H. scissura</i> (R), <i>H. obliqua</i> (R), <i>H. recta</i> (R), <i>H. walbersdorfenensis</i> (R)	very little residue, lithic grains, qz, rare pyritized fragments, rare plant remains. Planktonic foraminifera in trace reworked (Cretaceous?)	barren	

Table 1 (continued)

Sample	Level (m)	Calcareous nanofossils		Planktonic foraminifera		Benthic foraminifera		Ostracods
		Preservation	Main taxa	Biozone	Residue description	Main taxa	Biozone	
CA30	87				very little residue, terrigenous fragments, lithic grains, qz, muscovite, plant remains. Planktonic foraminifera in trace reworked (Cretaceous?)			
CA33	83.9				little residue, lithic grains, qz, muscovite, rare plant remains. Planktonic foraminifera absent			nearly barren
CA34	82.9				very little residue, lithic grains, mica (muscovite) (A), oxidized fragments, lignite and plant remains. Planktonic foraminifera absent.			barren
CA35	80.4				terrigenous grains, common transparent crystals (gypsum?). Planktonic foraminifera absent.			barren
CA36A	79.4	good	<i>Helicosphaera carteri</i> (C), <i>Sphaeralithus moriformis</i> (C/A), <i>S. heteromorphus</i> (R), <i>H. intermedia</i> (R/C), <i>H. euphratis</i> (R/C), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (C), <i>H. scissura</i> (R), <i>H. obliqua</i> (R)	MNN4a	very little residue, lithic grains, qz, rare plant remains			nearly barren
CA40B	71.1				muscovite and aggregated sediment			barren
CA44	62.6				little residue, lignite (A), oxidized and pyritized terrigenous grains, mica, quartz. Planktonic foraminifera in trace	<i>Globigerinoides trilobus</i> (4 specimens), <i>Globorotalia</i> sp. (1 specimen), <i>Globatuborotalia woodi</i> (1 specimen), <i>Pracorbuthia glomerosa glomerosa</i> (1 specimen)	MM14c?	Nearly barren: 1 specimen of <i>Pracorbuthia</i> . This datum and thus the subzonal attribution is very weak
CA45	60.3				very little residue, terrigenous grains, oxidized and pyritized fragments			barren

Sample	Ciceu-Giurgești Section	Calcareous nannofossils		Planktonic foraminifera		Benthic foraminifera		Ostracods
		Preservation	Main Taxa	Biozone	Residue description	Main Taxa	Biozone	
CA46B	55.3	good	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>S. heteromorphus</i> (R), <i>H. intermedia</i> (R/C), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (C), <i>H. obliqua</i> (R)	MNN4a	very little residue, qz, terrigenous fragments, lithic grains, mica, planktonic foraminifera in trace.	<i>Globigerinoides trilobus</i> (2 specimens), <i>Praeorbulina</i> sp. very badly preserved (1 specimen)	nearly barren	rare fragments of (mainly agglutinated) benthic foraminifera
CA47	51.8	good	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>S. heteromorphus</i> (R), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (C), <i>H. obliqua</i> (R)	MNN4a				
CA55	37.3	good	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C/A), <i>S. dishelemaos</i> (R), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (C), <i>H. recta</i> (R)	MNN3b	very little residue, terrigenous fragments, lithic grains, muscovite abundant, and less elongated rare plant remains, very rare planktonic foraminifera (poorly preserved).	<i>Globigerinoides trilobus</i> , <i>G. scamus</i> (elongated grains, muscovite abundant, and less elongated rare plant remains, very rare morphotypes, maybe 1 with 3 apertures) <i>Paragloborotalia</i> cf. <i>siakensis</i>	nearly barren	rare fragments of benthic foraminifera
CA60	29.6	poor	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R/C), <i>H. ampliaperta</i> (R/C)	MNN3b	very little residue, quartz, lithic grains, muscovite, rare plant remains, planktonic foraminifera in trace	<i>Globigerinoides trilobus</i> (1 specimen), <i>Dentoglobigerina</i> sp.	nearly barren	rare fragments of benthic foraminifera
CA71	8.7	poor	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus moriformis</i> (C), <i>H. euphratis</i> (R), <i>H. mediterranea</i> (R), <i>H. perel-nielsensiae</i> (R), <i>H. scissura</i> (R), <i>H. ampliaperta</i> (R), <i>H. recta</i> (R)	MNN3b	very little residue, rare muscovite		barren	
CC24	-80	good	<i>Helicosphaera carteri</i> (A), <i>S. moriformis</i> (A), <i>H. walbersdorffensis</i> (R)	MNN5c	quartz (A), lithic grains, sediment fragments. Foraminifera in trace (benthic > planktonic)		nearly barren, no markers	rare fragments of benthic foraminifera

(continued on next page)

Table 1 (continued)

Circu-Giurgești Section		Calcareous nannofossils		Planktonic foraminifera		marker species in bold		Benthic foraminifera		Ostracods
Sample	Level (m)	Preservation	Main Taxa	Biozone	Residue description	Main taxa	Biozone	Notes		
CG23	72.8				sediment fragments, quartz, rare biotite, lithic grains, plant remains.			nearly barren, no markers		
CG22	67.8	good	<i>Helicospaera carteri</i> (C) A), <i>Sphenolithus heteromorphus</i> (RR), S. <i>moriformis</i> (GA), H. <i>mediterranea</i> (R)	MNN5b	sediment fragments, quartz, rare biotite, lithic grains, plant remains.			nearly barren, no markers		
CG18	57.9	very poor	UNDEFINABLE		inorganic fraction abundant (sediment fragments). Echinid remains, ostracods. Foraminifera common, moderately/poorly preserved, almost exclusively benthic.	<i>Globigerinoides trilobus</i> (1 specimen), <i>Globigerina praebulloides</i> (1 specimen)		no markers	relatively rich. Ammonia tepida, Bolivina elongata, Bulimina elongata, Cibicides dutemplei, C. ungerianus, Discanomalina coronata, discorbids/ glabratellids, Elphidium spp., Fursenkoina acuta, Globobulimina sp., Nonion sp., Rosalina bradyi, large Uvigerina spp. (U. cf. acuminata, U. continuosa, U. semiornata). Few but large agglutinated taxa, a.o. textulariids. Large, reworked miliolids.	<i>Citharidea acuminata</i>
CG17	55.4	good	<i>Helicospaera carteri</i> (C) A), <i>Sphenolithus heteromorphus</i> (C), S. <i>moriformis</i> (GA), H. <i>vedderi</i> (R)	MNN5b	Planktonic foraminifera in trace					
CG16	52.4	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C/R), S. <i>moriformis</i> (C/R), H. <i>vedderi</i> (R)	MNN5b						
CG14	47.5	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), S. <i>moriformis</i> (C), H. <i>walbersdorffensis</i> (C), H. <i>intermedia</i> (R), H. <i>mediterranea</i> (R), H. <i>vedderi</i> (R), <i>Discosaster musteus</i> (C)	MNN5c	inorganic fraction prevalent (lithic grains, sediment fragments, quartz, glauconite). Planktonic foraminifera rare, moderately/poorly preserved. Benthic foraminifera more abundant.	<i>Globigerina praebulloides</i> , <i>Globigerinoides trilobus</i> , <i>Orbulina suturalis</i> (some specimens are more evolved toward <i>O. univversa</i>)	MM15a		relatively rich. Bolivina spathulata, Bulimina elongata, Cibicides dutemplei, C. ungerianus group (C. cf. pachyderma, C. ungerianus, C. cf. ungerianus), discorbids, Elphidium sp., Globocassidulina	

CG13	44.5	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C/R), <i>H. walbersdorffensis</i> (C), <i>H. euphratis</i> (R)	MNN5c	sediment fragments dominant, quartz, lithic grains, mica. Foraminifera in trace: few benthic, few planktonic foraminifera		nearly barren, no markers	subglobosa, nodosariids, Pullenia bulloides, Spaeroidina bulloides, large Uvigerina spp. (U. continuosa, U. semiornata, U. venusta). Few but large agglutinated taxa, a.o. Spiroplectinella carinata.
CG12	36.4	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C/R), <i>S. moriformis</i> (C), <i>H. walbersdorffensis</i> (C), <i>H. vedleri</i> (R)	MNN5c	inorganic fraction subordinate to organic one. Foraminifera abundant, moderately preserved but very often deformed.	MM15a		Very few benthic foraminifera (Uvigerina, Bulimina)
CG11	33	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C/A), <i>H. intermedia</i> (R)	MNN5b	inorganic fraction prevalent (sediment fragments, quartz, rare pyritized fragments). Planktonic foraminifera rare, moderately/poorly preserved (often deformed).	MM15a	Præorbulina and Orbulina poorly preserved (often deformed and apertures not well visible).	
CG10	29	poor	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C), <i>H. intermedia</i> (R), <i>H. mediterranea</i> (R)	MNN5b	sediment fragments dominant, quartz, rare pyritized fragments, plant remains. Foraminifera in trace		nearly barren, no markers	
CG8	22.1	good	<i>Helicospaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>H. intermedia</i> (R), <i>H. mediterranea</i> (R)	MNN5b	inorganic fraction dominant (sediment fragments, quartz, rare pyritized fragments). Planktonic foraminifera common, moderately/poorly preserved (often deformed).	MM14d		Rare, fragmented benthic foraminifera

(continued on next page)

DV18	28	poorly	<i>S. moriformis</i> and <i>H. carteri</i> are present	MNN4c?			
DV19d	26.5	poor	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C), <i>H. ampliperta</i> (R), <i>H. waltrans</i> (R), <i>H. mediterranea</i> (R), <i>H. intermedia</i> (R), <i>H. scissura</i> (R)	MNN5a	quartz and lithic fragments abundant		barren
DV19c	26.3	BARREN	UNDEFINABLE		quartz and lithic fragments		barren
DV19b	26.1	very poor	<i>Helicosphaera carteri</i> (C),				barren
DV19a	25.7	good	<i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C), <i>H. mediterranea</i> (R), <i>H. ampliperta</i> (R)	MNN5a			benthic foraminifera very rare. <i>A. millolid</i> , <i>Textularia</i> sp. (each 1 specimen)
DV17	21.8	BARREN		MM14c?	little residue, quartz, lithic grains, oxidized fragments, no benthic foraminifera, planktonic foraminifera in trace	just 2 specimens: <i>Dentaglobigerina</i> sp., <i>Pracorbolina glomerosa</i> (evolutioned specimens toward circulatis)	nearly barren; based on only a single occurrence
DV16	20.3	BARREN			quartz abundant, lithic grains abundant, not well sorted		barren
DV14	17	BARREN			quartz abundant, lithic residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxydized and pyritized fragments, plant remains	<i>Globigerinoides trilobus</i>	nearly barren, no markers
DV13	14.3	BARREN			residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxydized and pyritized fragments, plant remains		barren
DV12	12.9	BARREN			residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxydized and pyritized fragments, plant remains		barren
DV11	11.6	BARREN			residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxydized and pyritized fragments, plant remains		barren
DV03	5.6	BARREN			residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxydized and pyritized fragments		barren

Sample Level (m)	Cepari Section		Planktonic foraminifera		Benthic foraminifera		Ostracods		
	Calcareous nannofossils	Preservation	Main Taxa	Biozone	Residue description (> 125 µm)	Main taxa		Biozone	Notes
CP10	18.7	good	<i>Helicospira carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C), <i>H. intermedia</i> (R), <i>H. euphratis</i> (R)	MNN5a	inorganic fraction common, planktonic foraminifera abundant but very poorly preserved (very often deformed)	<i>Præorbulina glomerosa</i> , <i>Præorbulina glomerosa circularis</i> , <i>G. cf. saturalis</i> , <i>Paragloborotalia siakensis</i> rare	MM14d	<i>Præorbulina</i> very poorly preserved (recrystallized and deformed)	
CP9	16.7	?		MNN5a	inorganic fraction rare,	<i>Globigerinoides trilobus</i> , <i>G. cf. sicanius</i> ,	MM14c	<i>Præorbulina</i> very poorly preserved (recrystallized and deformed)	
CP7B	14.7	good	<i>Helicospira carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C), <i>S. moriformis</i> (C), <i>H. vedderi</i> (R)	MNN5a	planktonic foraminifera very abundant but very often deformed	<i>Præorbulina glomerosa curva</i> , <i>Præorbulina glomerosa glomerosa</i> , <i>Paragloborotalia siakensis</i> rare			
CP6	11.7	?		MNN5b	terrigenous fraction abundant (quartz, lithic grains, rare mica),	<i>Globigerinoides trilobus</i> , <i>G. cf. sicanius</i> ,			
CP5	9.2	poor		MNN5b?	planktonic foraminifera common	<i>Paragloborotalia cf. siakensis</i> trace			
CP4	7.7	?		MNN5b	poorly preserved (often deformed)				
CP3B	3.4	BARREN			dirty, terrigenous material				no markers
CP3A	3.4	BARREN			pyritized terrigenous fraction, pyritized burrows abundant, echinids remains, planktonic foraminifera in trace	<i>Globigerina bulloides</i> , <i>Globigerinoides trilobus</i>			barren
CP2	1.4	BARREN							no markers

benthic foraminifera relatively abundant. *Ammonia beccarii* and *A. tepida*, *Bulimina elongata*, many *Cassidulina carinata*, few *Cibicides* (a.o. *C. lobatulus*), *Discanomalina coronata*, *Elphidium* spp., *Fursenkoina acuta*, *Gavelinopsis lobatula*, *Globobulimina* spp., *Porosonion granosum*. Few large agglutinated taxa: *Spiroplectinella deperdita*, *Textularia* spp. Large reworked miliolids.

Cytheridea acuminata, *Loxocochoa kochi*, *Pterygocythereis calcarata*

CPI	0.1	BREBU SECTION	Calcareous nannofossils		Biozone	Planktonic foraminifera	marker species in bold		Biozone	Notes
			Preservation	Main taxa			Main taxa	Main taxa		
Sample	Level (m)					Residue description (> 125 microm)				
BX13	2.4	good	Helicosphaera carteri (C), Spiroolithus heteromorphus (C), S. moriformis (C), H. intermedia (R), H. euphratis(R)	MNN5b	very fossiliferous, no terrigenous fraction, only rare pyritized fragments and burrows. Preservation of planktonic foraminifera moderate (recrystallized and sometimes deformed)	Globigerinoides trilobus, Dentoglobigerina spp., Praeorbulina abundant but the apertures are not always visible, P. cf. glomerosa curva, P. glomerosa glomerosa, P. glomerosa circularis, Orbulina suturalis	MMI5a	A few specimens seem to be transitional to O. universa.		
BX10	2	good	Helicosphaera carteri (A), Spiroolithus heteromorphus (C), S. moriformis (C), H. ampliaperta (R), H. waltrans, H. intermedia (R)	MNN5a	very little washed residue; inorganic fraction rare (sediment fragments, pyritized fragments, quartz, mica). Planktonic foraminifera abundant, preservation moderate/poor (recrystallized, deformed)	Globigerinoides trilobus, G. cf. sicam, Globorotalia praescitula, Globoturborotalita woodi, Paragloborotalia siakensis, D. altispira gr., Turborotalia cf. quinqueloba, Praeorbulina glomerosa circularis, Orbulina suturalis	MMI5a			
BX8	1.6	poor	Helicosphaera carteri (C), Spiroolithus heteromorphus (C), S. moriformis (C), H. euphratis (R), H. mediterranea (R)	MNN5a	very little residue made up of sediment fragments, quartz, plant remains. Planktonic foraminifera rare, preservation good.	Globigerina praebulloides, Globorotalia praescitula, G. trilobus, Dentoglobigerina altispira gr., Paragloborotalia siakensis, Globoturborotalita woodi, G. sicam, Praeorbulina cf. glomerosa glomerosa, Praeorbulina glomerosa circularis, Orbulina suturalis	MMI5a			
BX6	1.25	BARREN			little residue, terrigenous fraction very abundant (sediment fragments, quartz, mica), very abundant plant remains, planktonic foraminifera rare, preservation moderate	Globigerinoides trilobus, Dentoglobigerina altispira gr., Globigerina praebulloides, Globorotalia praescitula, Turborotalia cf. T. quinqueloba, Paragloborotalia siakensis, Praeorbulina spp. (the apertures are not always visible), Orbulina suturalis	MMI5a			
BX5	1	UNDEFINABLE			elongated crystals (A), oxidized sediments fragments (A), plant remains.			barren		
BX4	0.75	BARREN								
BX3	0.5	poor	Helicosphaera carteri (C), S. moriformis (A), H. ampliaperta (R), H. euphratis (R/C), H. mediterranea (R/C), H. intermedia (R/C)	MNN4c						

(continued on next page)

Table 1 (continued)

Brebou section		Calcareous nannofossils		P planktonic foraminifera		marker species in bold		
Sample	Level (m)	Preservation	Main taxa	Biozone	Residue description (> 125 micron)	Main taxa	Biozone	Notes
BX2	0.25	poor	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C/R), <i>S. moriformis</i> (C), <i>Heuphratis</i> (R), <i>H. mediterranea</i> (R)	MNN4b	sediment fragments, elongated crystals, mica (muscovite), oxidized and pyritized fragments, plant remains.			barren
BX1	0	poor	<i>Helicosphaera carteri</i> (C), <i>Sphenolithus heteromorphus</i> (C/R), <i>S. moriformis</i> (C), <i>Heuphratis</i> (R), <i>H. mediterranea</i> (R)	MNN4b	very little residue made up of pyritized fragments, pyrite, sediment fragments, plant remains. Foraminifera in trace, preservation moderate/poor (recrystallized and deformed)	<i>Globigerinoides trilobus</i> , G. cf. <i>sicamus</i> , <i>Praeorbulina glomerosa glomerosa</i> , <i>Praeorbulina glomerosa circularis?</i>	MM4c (d?)	nearly barren

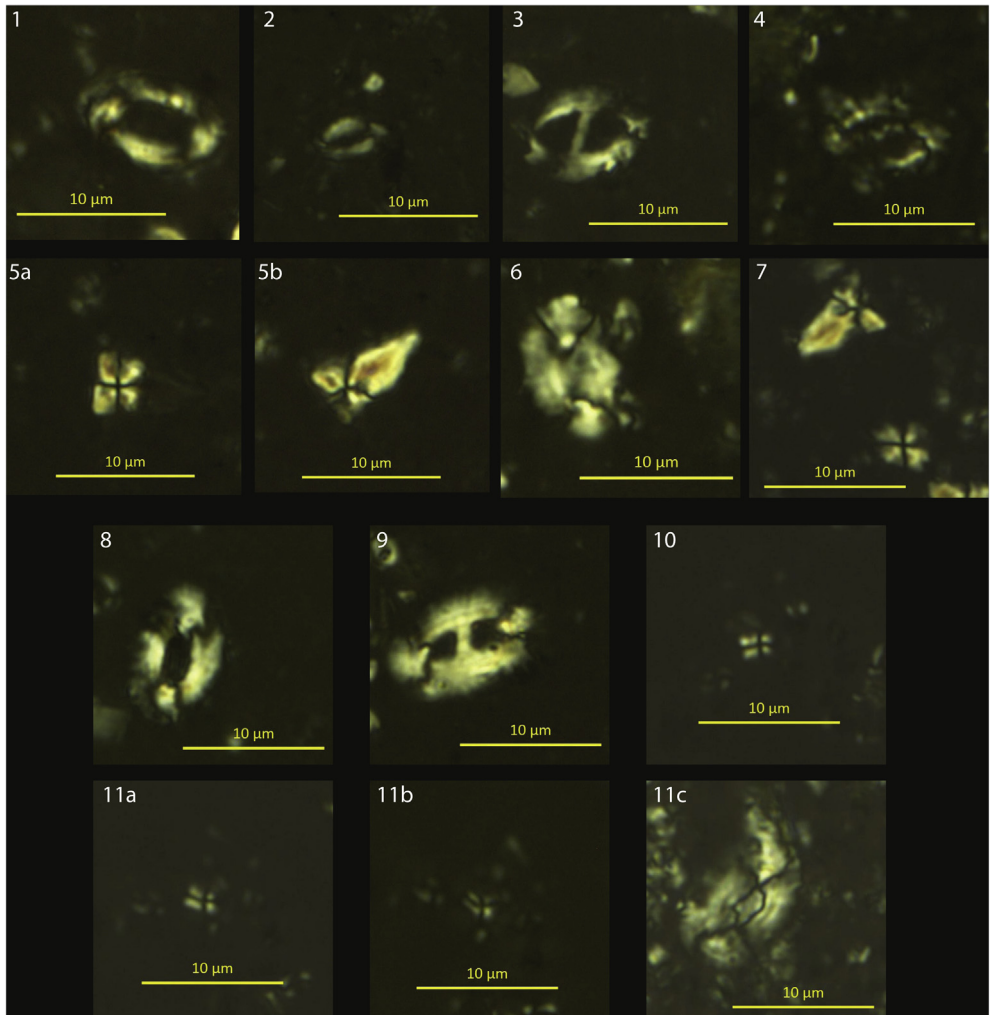


Fig. 4. Calcareous nannofossils. (1) *Helicosphaera ampliaperita* (sample CA10); (2) *H. walbersdorfensis* (sample CG13); (3) *H. waltrans* (sample CA20); (4) *H. euphratis* (sample CX14); (5a, b) *Sphenolithus heteromorphus* (sample CG1) at 0° and 45°; (6) *S. heteromorphus* and *S. moriformis* (sample BX13); (7) *H. carteri* (sample BX13); (8) *H. intermedia* (sample CA9); (9) *H. ampliaperita* (sample CA19); (10) *H. mediterranea* (sample CA20); (11a, b, c) *S. disbelemnos* (sample CA55) at 0°, 20° and 40°.

NN4 nannofossil biozone (Burdigalian) for the whole exposed Hida Fm, and the NN5a biozone (Langhian; after [10]) for the Dej Fm [11–13].

The 46 m long **Valea Dracului** (DV) section (alternative names: Dej, Râpa Dracului) (47.147342°N, 23.859869°E) is exposed on the flanks of a river canyon and covers the upper Hida and Dej Formations (Fig. 1). The upper Hida Fm (0–24 m) displays gray brown clays with cm-scale sand and coaly lenses. These are occasionally perturbed by yellow fine to medium sand beds that pinch out laterally (Fig. 3d). At 20 m, thick coarse to medium sand beds with basal clay with rip up clasts and coal chips appear. The facies reflect a distal fan delta environment with some gravity flow associated deposits.

The Dej Fm begins with a wedging conglomerate lens (0–5 m thick) cutting laterally into a finer-grained succession with middle Miocene planktonic foraminifera. The basal part starts with orange fine sand grading first into slightly mottled brown-orange silt and later into gray brown silty clay. A horizontal layer of cm-scale iron nodules is present at the silt to clay transition. The brown clay is

succeeded by distinct colored units: dark green bedded clay to sand, an orange clay level (1 cm), purple clay laminated with tuffites, gray marl with cm-lenses of tuffaceous sand, and green-white bedded tuffs (Fig. 1). This interval (24.3–28.7 m); DX in Fig. 2 is covered by massive volcanoclastics, towering high above the Dracului valley. The lowermost part is a tuffaceous sand with characteristic green elongated Dej tuff clasts with an erosive base, the middle part (~6 m) is coarse sand with large scale cross beds, and the top is a bedded alternation of silts and greenish tuff layers (Fig. 3d and e). The Dej Fm was deposited on the shelf margin or in deeper marine settings. The prominent coarse tuffites/sands with basal rip-up clasts were interpreted as a submarine meandering channel reflecting high input of volcanic activity. This channel eroded into the underlying shelf deposits.

The 73 m thick **Ciceu-Giurgesti** section (CG; 47.241532°N, 24.032811°E) is exposed along a low-standing river gully [14]. Published a log and planktonic foraminiferal bio-events for the lower part of the Ciceu-Giurgesti section covering the early-middle Miocene boundary. During the fieldwork campaign in 2015, however, the lowermost part of the section presented by [23] was covered by sediment and vegetation, and could not be studied. Therefore, the here presented section starts just above the First Occurrence (FO) of *Praeorbulina glomerosa*, and thus covers the Dej Fm only. Here, the Dej Fm is also known as the Ciceu-Giurgești Fm, but this term is not used to avoid confusion with the other Transylvanian sections. The lowermost part of the profile (0–11 m) contains clays, silts and a thin conglomerate layer and is mostly unexposed (see [14] for details). Upwards a 5 m thick package of poorly sorted medium-coarse sand with elongated coarse greenish rip-up clasts and pebbles (<10 cm) stands out. The rip-up clasts are rich in tuffaceous material and occur in all sizes, the largest are 75 cm in length. The sand body is covered by an interval of silty clays and sands with (often) reworked green tuffs, and an ~7 m interval dominated by volcanoclastic sands and cross-laminated layered tuffs. A tuff at ~20 m stratigraphic height was dated at 14.38 ± 0.06 Ma [14]. The stratigraphy continues with dark gray clays intercalated with green tuff levels and an 1.5 m silty bed with algae mats and dark clay lenses. In the top of the CG section (>50 m) fine and medium grained sands with organic rich interbeds and some tuff intercalations stand out.

The 38 m thick **Cepari** section (CP; 47.242542°N, 24.425911°E) is well-exposed in a former quarry. Some authors infer a discontinuity at the base of the Langhian transgression in this region (~7 km NW of Cepari) based on lithostratigraphy and microfaunal analysis [15]. In most places, the transgression begins with a conglomerate level followed by characteristic Langhian microfauna. The basal part (0–4.5 m) of Cepari section contains gray brown silty clay with occasional yellow sands, and may be part of the Hida Fm. It is overlain by two discontinuous beds of dark gray and gray clay, that are laterally cut by a maximally 3 m thick coarse-to-medium poorly sorted sand with sand intraclasts. The beginning of the Dej Fm is marked by the first 4 m thick tuff bed. Silty clays with tuffs including a second thick (3 m) tuff package are positioned on top. The section ends with tuffaceous yellow gray clays intercalating with some fine sands, and one thick volcanoclastic sand.

2.3. Biostratigraphic data

2.3.1. Calcareous nannoplankton

In the Campinița (CA) section, calcareous nannofossils are common in nearly all of the analyzed samples and show a good to sometimes poor degree of preservation. The stratigraphically lower and intermediate samples (CA71 to CA09: 8.7–136.5 m) are dominated by middle to late Burdigalian assemblages from the MNN3b Zone to the MNN4a Subzone (Table 1, Fig. 7), with the exception of CA29, CA21 and CA20. The Burdigalian attribution is based on the recognition of *Sphenolithus heteromorphus* (Fig. 4) First Common Occurrence (it marks the base of the MNN4a Subzone), and on the continuous presence of *Helicosphaera ampliaperta* (Fig. 4) (its Last Common Occurrence defines the base of MNN4b Subzone). The analysis of samples CX3–CX16 (137.4–140.1 m) allows recognizing the early-middle Langhian MNN4c–MNN5a bio-chronostratigraphic interval. This attribution is based on the recognition of the *Sphenolithus heteromorphus* paracme interval in the lowermost sample (it defines the base of MNN4c Subzone), and by high abundances of the species in the following samples (the *S. heteromorphus* Paracme End defines the base of the MNN5a Zone). The calcareous nannofossil assemblages from samples CF16-1 (150.7 m) and CF12-1 (149.2 m), as well as samples CA01–CA07 (142.9–149.4 m), allowed depicting the middle to late Langhian MNN5b Subzone based on the recognition of poor

percentages of *Helicosphaera walbersdorfensis* (Fig. 4) (its First Common Occurrence defines the base of the MNN5c Subzone) and the absence of *H. waltrans* (Fig. 4) (its Last Common Occurrence marks the base of MNN5b Subzone) (Figs. 4 and 7).

In the Brebu section, preservation is generally poor and calcareous nannofossil assemblages are often poorly preserved in the analyzed samples. However, in each sample the most relevant biostratigraphic markers were individuated, allowing to ascribe the deposits from the base to the top to the early Langhian MNN4b Subzone (BX1 and BX2 at 0 and 0.25 m), to the middle Langhian MNN5a Subzone (BX3 to BX10: 0.5–2 m), and to the late Langhian MNN5b Subzone (BX13, 2.4 m) (Table 1, Fig. 7).

The preservation of the calcareous nannofossil assemblages in the Dracului Valley (DV) section is very poor in the low-intermediate portion of the sampled interval, between samples DV01 and DV17 (base of section to 21.8 m). Conversely, starting from sample DV19a (25.7 m), a good degree of preservation allows ascribing the deposits to the middle to late Langhian MNN5a (samples DV19a–DV21; 25.7–30.7 m) – MNN5b (sample DV22; 33 m) subzones. Sediments from Ciceu-Giurgești Section are in general well-preserved. The bio-chronostratigraphic analysis allowed ascribing the samples between the early Langhian MNN5b Subzone (samples CG01–CG11; 6.5–33 m) and the late Langhian to early Serravallian MNN5c Subzone (samples CG12–CG24; 36.4–80 m). In the Cepari section, the preservation degree is very poor in the lowermost samples (CP01–CP3B; 0.1–3.4 m), and good in the upper part of the section (samples CP7b–CP10; 14.7–18.7 m). The bio-chronostratigraphic analysis allowed framing the deposition in the middle Langhian MNN5a Subzone (Fig. 7).

2.3.2. Planktonic foraminifera

Planktonic foraminifera from the lower part of the Campinița section (up to sample CA08 at about 139 m, Doftana Fm) are generally absent or very diluted (Table 1). In a few stratigraphic levels (CA30 and CA29 at about 87 m) ill-preserved double-keeled planktonic specimens are evidence of reworking of Cretaceous sediments. Miocene planktonic foraminiferal assemblages are represented by rare and scattered occurrences of *Dentoglobigerina* spp., *Globigerina praebulloides*, *Globigerinella* spp., *Globigerinoides trilobus* and *Paragloborotalia siakensis*. In only two samples (CA44 at about 62 m and CA19 at about 102 m) a single occurrence of *Praeorbulina glomerosa glomerosa* has been found suggesting the attribution to Subzone MMi4c (Fig. 7). However, the biostratigraphic interpretation is weak because of the extreme rarity of planktonic foraminifera. In a few samples (CA12, CA11, CA10 and CA9B, ~118–134 m) occurrences of *Streptochilus* spp./*Bolivina* spp. have been recorded in the >63 < 125 μm fraction of the washed residue (Table 1, Fig. 6).

Samples from the uppermost part of the section (from 139 m up to the top, Campinița Fm) generally yield abundant planktonic foraminifera mainly represented by globigerinids (in some levels), *Globigerinoides trilobus*, *Globigerinoides* cf. *G. sicanus*, *Paragloborotalia siakensis*, *Globorotalia praescitula*, *Globorotalia* spp., *Praeorbulina glomerosa glomerosa*, *P. glomerosa circularis* and *Orbulina suturalis* (Fig. 5). The occurrence of *O. suturalis* allows the attribution of the interval including samples CX13 to CA5 (139.3–147.4 m) to Subzone MMi5a. In sample CA07 (at about 150 m) the occurrence of *Orbulina universa* indicates Subzone MMi5b (Fig. 7).

In the Brebu section, most of the samples are barren in fossils or contain very rare planktonic foraminifera. Only the uppermost samples (BX10 and BX13) yield abundant and moderately preserved planktonic foraminifera. The most recurrent taxa are *Dentoglobigerina altispira* gr., *Globigerina praebulloides*, *Globigerinoides sicanus*, *Globigerinoides trilobus*, *Globorotalia praescitula*, *Globoturbotalita woodi*, *Paragloborotalia siakensis*, *Praeorbulina glomerosa* s.l. and *Orbulina suturalis*. Rare specimens of *Praeorbulina glomerosa glomerosa* and *P. cf. glomerosa circularis* occur in the lowermost sample (BX1) suggesting Subzone MMi4c/d?, while *Orbulina suturalis* has been found in the sample interval between BX06 and BX13 allowing the attribution of this interval to Subzone MMi5a. In the latter sample few specimens of *O. suturalis* show more evolved characters close to *O. universa*, whose first occurrence identifies the base of Subzone MMi5b (Table 1, Fig. 7).

Samples from the lower part of the Valea Dracului section, up to 25 m, are generally barren or nearly barren in foraminifera. In sample DV 17 (at ~22.8 m) a single specimen of *Praeorbulina glomerosa glomerosa* has been found suggesting Subzone MMi4c? Note, however, that the reliability of this biostratigraphic attribution is weak since planktonic foraminifera are extremely rare in this sample.

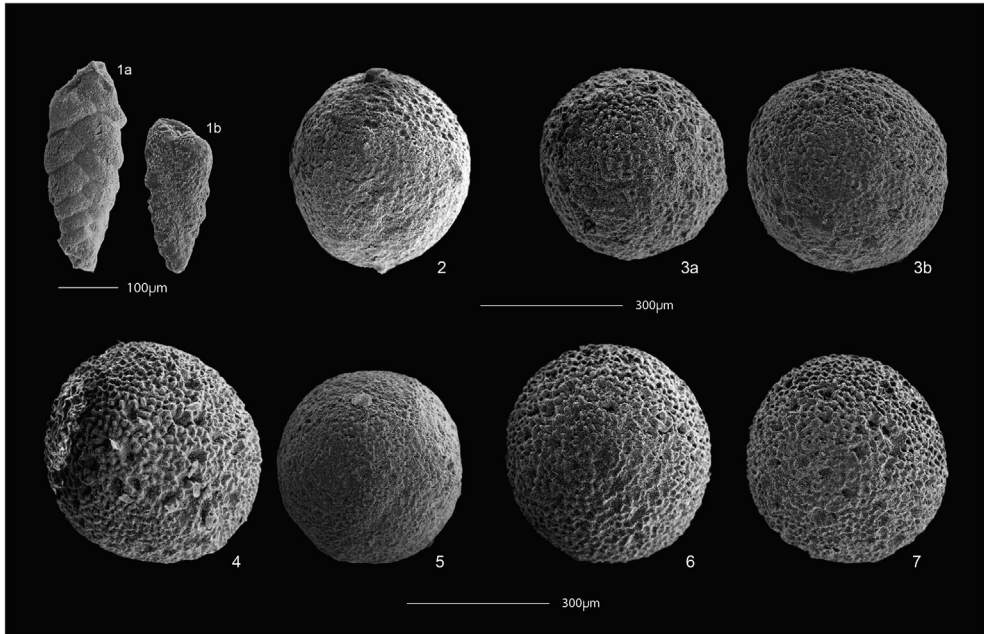


Fig. 5. Planktonic foraminifera. (1a, b) *Streptochilus* sp./*Bolivinina* spp. (sample CA10); (2) *Praeorbulina glomerosa glomerosa* (sample CF6); (3a, b) *P. glomerosa circularis* (sample CF6); (4) *O. suturalis* (sample CA7); (5) *O. suturalis* (sample CF6); (6) *Orbulina* intermed. *suturalis-universa* (sample CA7); (7) *O. universa* (sample CA7).

Samples from the upper part of the section, from 25 m to the top, contain more abundant planktonic foraminiferal assemblages, mainly represented by *Dentoglobigerina altispira* gr., *Globigerinoides sicanus*, *Globigerinoides trilobus*, *Praeorbulina glomerosa* s.l. and *Orbulina suturalis*. Specifically, the occurrence of *Praeorbulina glomerosa circularis* in samples DV20 and DV21, and the occurrence of *O. suturalis* in sample DV22, indicates Subzones MMi4d and MMi5a, respectively (Table 1, Fig. 7).

Planktonic foraminiferal assemblages in the Ciceu-Giurgeşti section are moderately to poorly preserved and are mainly represented by *Dentoglobigerina* spp., *Globigerina praebulloides*, *Globigerinella* spp. *Globigerinoides sicanus*, *Globigerinoides trilobus*, *Globorotalia scitula*, *Praeorbulina glomerosa* s.l. and *Orbulina suturalis*. The lowermost part of the section (sample CG01) is tentatively assigned to Subzone MMi4c? On the basis of an uncertain single occurrence of *Praeorbulina glomerosa glomerosa*, while the occurrence of *Praeorbulina glomerosa circularis* in sample CG08 is indicative of the Subzone MMi4d (Fig. 7). The middle part of the section (samples CG11, CG12 and CG14: 33–47.5 m) can be assigned to Subzone MMi5a because of the presence of *Orbulina suturalis*. Note, however, that preservation of specimens of the *Praeorbulina/Orbulina* group is poor complicating the classification to a specific biozone. The absence of biostratigraphic marker species hampers a precise biostratigraphic interpretation of the upper part of the section (above 47.5 m: Table 1).

Finally, the lower part of the Cepari section (up to about 5 m) is characterized by very rare to common poorly preserved planktonic foraminifera, mainly represented by *Globigerina praebulloides*, *Globigerinoides* cf. *G. sicanus*, *Globigerinoides trilobus* and *Paragloborotalia siakensis*. The absence of marker species does not allow a precise biozonal assignment of this interval. Upward, planktonic foraminiferal assemblages are characterized by the occurrence of *Praeorbulina* and *Orbulina* spp., but their poor preservation generally hampers the classification at specific level. However, sample CP7B (14.7 m) is characterized by the presence of *Praeorbulina glomerosa curva* and *P. glomerosa glomerosa* indicating Subzone MMi4c, and sample CP10 (18.7 m) contains *P. glomerosa glomerosa*, *P. glomerosa circularis* and few specimens close to *Orbulina* (*O. cf. suturalis*) indicating Subzone MMi4d/MMi5a(?) (Table 1, Figs. 5 and 7).

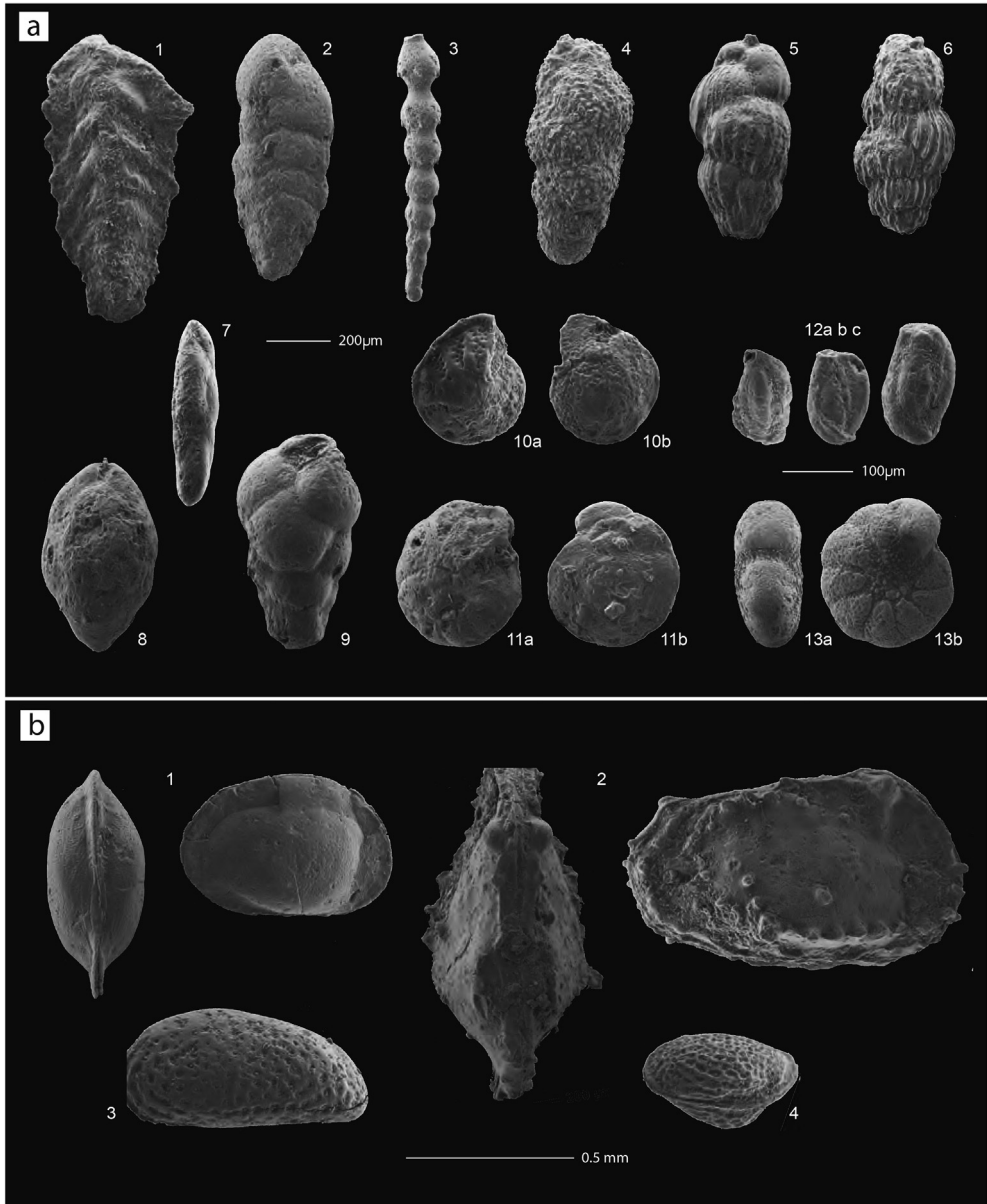


Fig. 6. a. Ostracods. (1) *Loxoconcha punctatella* (sample CA8); (2) *Pterygocythereis calcarata* (sample CP2); (3) *Cytheridea acuminata* (sample CP2); (4) *Loxoconcha kochi* (sample CP2). **b. Benthic foraminifera.** (1) *Spiroplectinella carinata* (sample CG14); (2) *S. deperdita* (sample CP2); (3) *Stilostomella* sp. (sample CP2); (4) *Uvigerina* cf. *U. acuminata* (sample CG14); (5) *Uvigerina semiornata* (sample CG14); (6) *Uvigerina* cf. *U. venusta* (sample CG14); (7) *Fursenkoina acuta* (sample CP2); (8) *Globbulimina* sp. (sample CP2); (9) *Bulimina elongata* (sample CG14); (10) *Cibicides* cf. *C. ungerianus* (sample CG14); (11) *Cibicides dutemplei* (sample CG17); (12) miliolid spp. (sample CA8); (13) *Porosonion granosum* (sample CP2).

2.3.3. Benthic foraminifera and ostracods

In the samples containing benthic foraminifera, the assemblages vary from extremely poor to relatively rich (Table 1). In the SE Carpathian Foredeep, in the Campinița (CA) section, the interval

displaced or reworked. Planktonic foraminifera are relatively common and minor pyrite and fish remains are present. Together with the virtual absence of benthic foraminifera this might point to bottom-water oxygen deficiency in shelf waters of normal marine salinity.

In the Ciceu-Giurgești (CG) section, two samples in the Dej Fm at 47.5 (CG14) and 55.4 m (CG17) contain comparatively rich and diverse benthic foraminiferal associations (Fig. 5). Most specimens are large, although some more fragile taxa are also present. The samples contain a mix of shallow-water (*Ammonia tepida*, *Discanomalina coronata*, *Elphidium* spp., *Rosalina bradyi*, discorbids) and deeper-water, mid (-outer) shelf taxa (*Cibicides dutemplei*, *C. ungerianus*, large *Uvigerina* spp.: *Uvigerina* cf. *U. acuminata*, *Uvigerina* cf. *U. venusta*, *U. semiornata*), indicating a mid-shelf environment for sample CG17. Sample CG14 may have been deposited in slightly deeper water (outer shelf depth) since it also contains *Globocassidulina subglobosa*, *Pullenia bulloides*, *Sphaeroidina bulloides* and nodosariids. The sediments were possibly deposited in slightly dysoxic environments, indicated by a relatively high percentage of species thriving under limited oxygenation and/or high organic load (*Bolivina spathulata*, *Bulimina aculeata*, *B. elongata*, *Fursenkoina acuta*, *Globobulimina* sp., *Uvigerina* cf. *U. acuminata*, *U. continuosa*, *U. semiornata*). Bimodal grain size sorting, especially in CG17 might indicate transport. This sample contains large, reworked miliolids and part of the shallow-water foraminifera and the (scarce) ostracods are pyritized, and may be reworked too.

Sample CP02, collected in the Ceparì (CP) section 3 m below the flooding surface contains relatively abundant, often large Miocene benthic foraminifera (Fig. 6). Bimodal grain size sorting suggests transport; taxa normally occurring on the shallow shelf (*Ammonia beccarii*, *A. tepida*, *Discanomalina coronata*, *Elphidium* spp.) may have been transported to mid-shelf depths (indicated by (scarce) *Cibicides* spp., *Cassidulina carinata*, *Gavelinopsis lobatula*, *Hanzawaia boueana*, *Spiroplectinella deperdita*). Large, pyritized miliolids are almost certainly reworked. Common *Bulimina elongata*, *Globobulimina* spp. and *Fursenkoina acuta*, together with pyrite might point to a high organic load and associated oxygen limitation, although burrows confirm the presence of some oxygen. Both smooth (*Loxococoncha punctatella*) and ornamented ostracods occur (*Cytheridea acuminata*, *Loxococoncha kochi*, *Pterygocythereis calcarata*; Fig. 6).

Acknowledgements

We thank Jan Spierings and Zelda Zeegers for their help with the fieldwork, Giovanna Gianelli for processing samples for foraminiferal analysis and Luca Barchi for SEM photographs. We are also very grateful for fruitful discussions with Rocco Gennari about tiny *Streptochilus* foraminifera. Marius Stoica is acknowledged for fruitful discussions and ostracod taxonomy. This project was financially supported by the Dutch Organization for Scientific Research (NWO) [VICI grant 865.10.011].

Transparency document

Transparency document associated with this article can be found in the online version at <https://doi.org/10.1016/j.dib.2019.103904>.

References

- [1] B.U. Haq, G.P. Lohmann, Pliocene–Pleistocene calcareous nannofossil distribution patterns in the western Mediterranean, *Mar. Micropaleontol.* 1 (1967) 119–194.
- [2] D. Rio, I. Raffi, G. Villa, Pliocene–Pleistocene Calcareous Nannofossil Distribution Patterns in the Western Mediterranean, 1990.
- [3] E. Fornaciari, D. Rio, Latest Oligocene to early middle Miocene quantitative calcareous nannofossil biostratigraphy in the Mediterranean region, *Micropaleontology* 42 (1996) 1–36.
- [4] A. Di Stefano, L.M. Foresi, F. Lirer, S.M. Iaccarino, E. Turco, F.O. Amore, R. Mazzei, S. Morabito, G. Salvatorini, H. Abdal Aziz, Calcareous plankton high resolution bio–magnetostratigraphy for the Langhian of the Mediterranean area, *Rev. Ital. Di Paleontol. e Stratigr.* 114 (2008) 51–76.
- [5] S.M. Iaccarino, A. Di Stefano, L.M. Foresi, E. Turco, N. Baldassini, A. Cascella, S. Da Prato, L. Ferraro, R. Gennari, F.J. Hilgen, F. Lirer, R. Maniscalco, R. Mazzei, F. Riforgiato, B. Russo, L. Sagnotti, G. Salvatorini, F. Speranza, M. Verducci, High-resolution integrated stratigraphy of the upper Burdigalian–lower Langhian in the Mediterranean: the Langhian historical stratotype and new candidate sections for defining its GSSP, *Stratigraphy* 8 (2011) 199–215.

- [6] D. Frunzescu, Stratigraphical and Sedimentological Study of Miocene Evaporites between Buzău Valley and Teleajen Valley, Bucharest University, 1998.
- [7] M. MăruŃeanu, Litho and biostratigraphy (calcareous nannoplankton) of the Miocene deposits from the Outer Moldavides, *Geol. Carpathica* 50 (1999) 313–324.
- [8] M. Crihan, Studiul lito-biostratigrafic al Miocenului mediu dintre Valea Prahovei Ńi Valea Teleajenului, la sud de Sinclinalul Slănic, „Babeş-Bolyai” University Cluj-Napoca, 1999.
- [9] M. Săndulescu, M. MăruŃeanu, G. Popescu, Lower-middle Miocene formations in the folded area of the East Carpathians, *rom. J. Stratigr.* 76 (1995) 1–32.
- [10] M. MăruŃeanu, M. Crihan, C. Chira, Badenian nannofossil zonation - the carpathian area, Romania, *Acta Paleontol. Rom.* 2 (1999) 261–267.
- [11] C. Beldean, S. Filipescu, R. Bălc, An early Miocene biserial foraminiferal event in the Transylvanian Basin (Romania), *Geol. Carpathica* 61 (2010) 227–234, <https://doi.org/10.2478/v10096-010-0013-4>.
- [12] C. Chira, Early Miocene calcareous nannofossils assemblages from Transylvania, *Acta Palaeontol. Rom.* 4 (2004) 81–88.
- [13] C. Chira, E. Szabo, C. Ianoliu, Badenian (middle miocene) calcareous nannofossils from PăgliŃa (cluj district): biostratigraphical importance, *Stud. Univ. Babeş-Bolyai Geol.* 45 (2000) 21–31.
- [14] A. de Leeuw, S. Filipescu, L. MaŃenco, W. Krijgsman, K. Kuiper, M. Stoica, Paleomagnetic and chronostratigraphic constraints on the middle to late Miocene evolution of the Transylvanian Basin (Romania): implications for central Paratethys stratigraphy and emplacement of the Tisza–Dacia plate, *Glob. Planet. Chang.* 103 (2013) 82–98, <https://doi.org/10.1016/j.gloplacha.2012.04.008>.
- [15] A. Rusu, G. Popescu, M. Melinte, Oligocene-Miocene transition and main geological events in Romania, *Rom. J. Stratigr.* 76 (1996) 56.
- [16] M. TiliŃă, Evolution of the Transylvanian Basin: Inferences from Seismic Interpretation and Numerical Modelling (PhD Thesis), Utrecht University, 2015.