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

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**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 Campinit¸ a 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.

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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 Campinit¸a and Brebu sections, located in the Carpathian bend area in the East Carpathian Foredeep, where both intervals share similar features (Fig. 2., Fig. 3a). 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-Giurgest¸i (CG), Cepari (CP) and Campinit¸a (CA) sections. Additionally, biostratigraphic samples were taken at an approximately 25 cm resolution in the intervals just below the marine transgression...
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 Râmniciu Vâlce-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
the Doftana, Campinita 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 Ciresu 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 Campinita 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
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 Pers¸ ani 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 Campinit¸ a section. Two notable evaporitic intervals could be recognized; the Perchiu gypsum at the base of the Doftana Fm, and the Cires¸ u 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 Slăníc tuff level is clearly visible in the top of the main Brebu profile. The transgressive boundary between the Doftana Fm and Campiniţa 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 Campiniţa 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-Giurgeşti and Cepari

The Valea Dracului (DV), Ciceu-Giurgeşti (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
| Sample Level (m) | Preservation | Main taxa | Biozone | Residue description | Marker species in bold | Biozone | Notes |
|------------------|--------------|-----------|---------|---------------------|------------------------|---------|-------|
| 151.8            | very fossiliferous, made up of planktonic foraminifera. Preservation good | Sphenolithus moriformis (A), Helicosphaera carteri (A), H. mediterranea (C), H. eupratis (R), S. heteromorphus (R). | MNN5b | assemblage is dominated by small-sized specimens of globorotalids | No markers |
| 150.7            | very fossiliferous, made up of planktonic foraminifera. Preservation moderate (recrystallized and very often deformed) | Globigerinoides trilobus, Globorotalia praescitula | MNN5b | No markers |
| 149.4            | very fossiliferous, made up of planktonic foraminifera. Preservation good | H. carteri and S. heteromorphus abundant | MNN5b | assemblage of fraction >125μm is dominated by Orbulinids. Orbulina suturalis, O. suturalis/ univcrsa transition. | MMi5b |
| 149.2            | very fossiliferous, made up of planktonic foraminifera. Preservation good even if slightly oxidized, often deformed and fragmented | Sphenolithus moriformis (C/A), S. heteromorphus (C), Helicosphaera carteri (A) | MNN5b | No markers |
| 148.3            | very fossiliferous, made up of planktonic foraminifera. Preservation good if H. ampliaperta is reworked | H. carteri and S. heteromorphus abundant | MNN5b | No markers |
| 147.4            | very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed | H. carteri abundant, S. heteromorphus common; very few H. ampliaperta. Biozone MNN4b | MNN4b | No markers |
| 147.4            | very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed | Dentoglobigerina spp. (A), Globigerinoides trilobus (R), Globorotalia spp., Praeorbula glomerosa glomerosa, P. glomerosa circulares, Orbulina suturalis | MMi5a | Praeorbula/Orbulina group common |
| Index  | Depth (m) | Description |
|--------|-----------|-------------|
| CA3    | 145.4     | Good. *H. carteri* and *S. heteromorphus* abundant, *H. walbersdorffensis* present; *C. premacintyrei*, *G. rotula* common. |
| MNN5c  |           | Very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed and fragmented. *Globigerinoides trilobus*, *Globigerinoides sicanus*, *Globorotalia praescitula*, *Globorotalia* spp. No markers. |
| CF9    | 144.8     | Very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed and sometimes fragmented. *Globigerinoides trilobus*, *Globigerinoides sicanus*, *Paragloborotalia siakensis* (sin.)(R), *Globorotalia praescitula*, *Globorotalia* spp., *Praeorbulina glomerosa circularis* (also evolute specimens), *Orbulina suturalis* very rare and deformed. |
| CF8    | 143.5     | Very fossiliferous, made up of planktonic foraminifera. Preservation moderate (slightly recrystallized and often deformed). *Globigerinoides trilobus*, *Globigerinoides sicanus*, *Paragloborotalia siakensis* (sin.), *Globorotalia praescitula*, *Globorotalia* spp., *Praeorbulina glomerosa circularis* (also evolute specimens), *Orbulina suturalis* gr rare. |
| CA1    | 142.9     | Small-size *H. carteri* and *S. heteromorphus* abundant, very few *H. walbersdorffensis*. |
| MNN5b  |           | Very fossiliferous, made up of planktonic foraminifera. Preservation good even if often deformed. *Globigerinoides trilobus*, *Globigerinoides sicanus*, *Paragloborotalia siakensis* (sin.)(R), *Globorotalia praescitula*, *Globorotalia* spp., *Praeorbulina glomerosa circularis* (also evolute specimens), *Orbulina suturalis*. |
| CF7.2  | 141       | Good. *H. carteri* and *S. heteromorphus* abundant, very few *H. walbersdorffensis*; *C. premacintyrei*, *G. rotula* common. |
| MNN5b  |           | Almost exclusively made up of undisaggregated sediment grains. Very diluted planktonic foraminiferal content. Small-sized specimens *Globigerinoides trilobus*, *Globigerinoides sicanus*, *Paragloborotalia siakensis* (sin.)(R), *Globorotalia praescitula*. No markers. |
| CX16   | 140.1     | Very good. *Helicosphaera carteri* (A), *H. ampligera* (R), *H. waltrans* (R), *Sphenolithus heteromorphus* (C), *S. moriformis* (C). |
| MNN5a  |           | No terrigenous fraction, very fossiliferous, residue made up of planktonic foraminifera, preservation good. *Paragloborotalia siakensis*, *Globorotalia scitula*, *Globigerinoides trilobus*, *G. cf. sicanus*, *Praeorbulina glomerosa glomerosa*, *P. glomerosa circularis*, *Orbulina suturalis*. MM5a. |

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| Sample | Level (m) | Preservation | Main taxa | Biozone | Residue description | Main taxa | Biozone | Notes |
|--------|-----------|--------------|-----------|---------|---------------------|-----------|---------|-------|
| CF6.2  | 140       | good         | H. carteri and S. heteromorphus abundant, f&w H. walbersdorfensis; C. premaciintyreii, G. rotula common | MNNSb/c  | very fossiliferous, made up of planktonic foraminifera. Preservation good even if sometimes deformed or fragmented | Globigerinoides trilobus (A), Globigerinoides cf. sicanus, Pfraglaborotalia sikanu (sin.), Globorotalia proesculata, Praeorbulina glomerosa glomerosa, P. glomerosa circulars, Orbulina suturalis | MMi5a    |       |
| CX14   | 139.7     | good         | Helicosphaera carteri (C/A), Spheroithus heteromorphus (C/A), S. moriformis (C), H. walbersorfensis (C), H. euphratis (R) | MNNSc    | very fossiliferous, no terrigenous fraction. Planktonic foraminifera represent almost the all residue, preservation moderate. | Dentoglobigerina altispina gr., Globigerinoides trilobus, G. sicanus, Praeorbulina glomerosa curva, P. glomerosa glomerosa, P. glomerosa circulars, Orbulina suturalis (apertures not always well visible) | MMi5a    |       |
| CF5.2  | 139.5     | BARREN       | Spheroithus moriformis (C/A), S. heteromorphus (C), Helicosphaera carteri (A) | MNNSb    | 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, Globoturborotalita woodi, Globorotalia scitula, Turborotalita cf. T. quinqueloba, Denthoglobigerina spp., G. cf. sicanus, Praeorbulina glomerosa curva, P. glomerosa glomerosa, P. glomerosa circulars, Orbulina suturalis | MMi5a    |       |
| CX13   | 139.3     | good         |                |         |                     | Dentoglobigerina altispina gr., Turborotalita cf. T. quinqueloba, Globigerinoides trilobus, Orbulina suturalis?? (only 1 specimen, apertures not well visible) | MMi5a??  |       |
| CX12   | 139.3     | good         | Helicosphaera carteri (C/A), Spheroithus heteromorphus (C), S. moriformis (C), H. intermedia (R), H. waltrans (R), H. obliqua (R) | MNNSa    | very little residue; qz, mica. Planktonic foraminifera in trace, preservation moderate. | Dentoglobigerina altispina gr., Turborotalita cf. T. quinqueloba, Globigerinoides trilobus, Orbulina suturalis?? (only 1 specimen, apertures not well visible) | MMi5a    |       |
| Sample | Depth | Fertility | Description |
|--------|-------|-----------|-------------|
| CA8    | 138.7 | Very poor | UNDEFINABLE inorganic fraction abundant (lithic grains), planktonic foraminifera in trace, rare Streptochilus/Bolivina variabilis in fraction <125 µm, no markers |
| CX8    | 138.5 | Good      | Helicosphaera carteri (C/A), Sphenolithus heteromorphus (C), S. moriformis (C), H. waltrans (R), H. intermedia (R), H. ampliaperta (R), H. obliqua (R), H. mediterranea (R/C) |
| C6     | 138.1 | Poor      | S. moriformis, H. ampliaperta, D. varabiliis and H. carteri are present |
| CF3.2  | Very poor | UNDEFINABLE sediment fragments | barren |
| CX3    | 137.4 | Poor      | Helicosphaera carteri (C), Sphenolithus heteromorphus (RR), S. moriformis (C), H. mediterranea (R), H. ampliaperta (R) |
| CX02   | 137.2 | Poor      | Very little residue, mica (muscovite) very abundant, lithic grains rare, pyrite, Planktonic foraminifera rare, preservation good, Globigerinoides trilobus, G. cf. sicanus, Dentoglobigerina altispia gr., Globorotalia praescitula |
| CX01   | 137    | Poor      | Very little residue, mica (muscovite) very abundant, lithic grains rare, pyrite, Globigerinoides spp., Globorotalia spp.; rare Streptochilus/Bolivina variabilis in fraction <125 µm, One Morozovella sp. (Paleogene) |
| CA9    | 136.5 | Good      | Helicosphaera carteri (C), Sphenolithus moriformis (C), H. euphratis (R), H. mediterranea (R), H. ampliaperta (C), H. walbersdorfiensis (R) |
| CA10   | 133.7 | Poor      | Helicosphaera carteri (C), Sphenolithus moriformis (C/A), H. intermedia (R), H. euphratis (R) |
| CF2-1  | 136.5 | Very poor | UNDEFINABLE S. moriformis (C), H. ampliaperta (C), H. carteri (C), H. euphratis (R) |
| CF1.2  | Moderate | UNDEFINABLE S. moriformis (C), H. ampliaperta (C), H. carteri (C), H. euphratis (R) |

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| Sample Level (m) | Preservation | Main taxa[^1] | Biozone | Residue description[^2] | Main taxa[^1] | Biozone | Notes |
|-----------------|--------------|---------------|---------|--------------------------|---------------|---------|-------|
| CA11 130.9      |              | euphratis (R), H. mediterranea (R), H. ampliaperta (R), H. obliqua (R) |          | radiolarians, plant remains. Foraminifera in trace | variabilis in fraction <125 µm |         |       |
|                 |              | inorganic fraction made up of abundant mica (mainly muscovite), common terrigenous fragments and quartz, foraminifera very rare |           | small-sized globigerinids, Turborotalita cf. T. quinqueloba; rare Streptochilus/Bolivina variabilis in fraction <125 µm |         | nearly barren, no markers |
| CA12 118.9      |              |              |         |         |       |         |       |
|                 |              | inorganic fraction made up of only mica (muscovite), abundant plant remains very little residue, muscovite very abundant, quartz, terrigenous fragments, some plant remains. Foraminifera in trace, plant remains, radiolarians and spiculas |           |     |       |         |       |
| CA13 117.9      | good        | Helicocphaera Carteri (C), Sphenolithus moriformis (C), H. intermedia (R), H. euphratis (R), H. mediterranea (R), H. ampliaperta (R), H. walbersdorfeni (R) | MNN3b    | nearly barren, no markers |         |         |       |
|                 |              |              |         |       |       |         |       |
| CA18 102.9      |              |              |         |         |       |         |       |
|                 |              |              |         |         | globeigerinids |         | no markers |
| CA19 101.7      | good        | Helicocphaera Carteri (C), Sphenolithus moriformis (C/A), H. intermedia (R), H. euphratis (R), H. mediterranea (R), H. ampliaperta (C), H. walbersdorfeni (R) | MNN3b    | very little residue, terrigenous fragments abundant, lithic grains, rare pyritized fragments, very diluted foraminiferal (planktonic and benthic) content. Radiolarians?? | Paragloborotalia siakensis, Globigerinoides triobulus, G. cf. sconus (apertures not visible), Praeorbulina glomerosa glomerosa 1 spec. 1 | MM4c? | This datum and thus the subzonal attribution is very weak |
| CA20 100.2      | good        | Helicocphaera Carteri (C), Sphenolithus moriformis (C/A), S. heteromorphus (C), H. euphratis (R/C), H. mediterranea (R/C), H. ampliaperta (R), H. intermedia (R), H. scissura (R), H. obliqua | MNN5a    | very little residue, muscovite abundant, lithic grains, quartz, rare pyritized fragments |         |         | nearly barren |

[^1]: Marker species in bold.
[^2]: Ostracods
| CA21 | 98.7 | good |
|------|------|------|
| Helicophaga Carteri (C/A), Sphenolithus moriformis (A), Helicosphaera euphratis (C), H. ampliaperta (C), H. intermedius (R), S. heteromorphus (C), H. obliqua (R), H. mediterranea (R/C) | MNN4a | very little residue, mica | nearly barren, no markers |

| CA22 | 97.5 | poor |
|------|------|------|
| Helicophaga Carteri, H. euphratis, H. scissura, H. walbersdorfensis, Sphenolithus heteromorphus, S. moriformis | MNN5a | very little washed residue (>63 mm) | barren |

| CA23 | 96.5 | barren |
|------|------|------|
| very little residue, lithic grains, qz, mica | barren |

| CA24 | 95.4 | barren |
|------|------|------|
| very little residue, lithic grains, qz, mica, plant remains | barren |

| CA25 | 93.9 | barren |
|------|------|------|
| residue made up of mica, Globigerinoids, Globigerina praebulloides, Globigerinoides trilobus, Globigerina praebulloides, Globigerinella sp. | nearly barren, no markers |

| CA26 | 92.4 | rare and fragmented benthic foraminifera: fragments of nodosarids, Ammonia, Elphidium, Bulimina, Uvigerina spp.; aggregates of taxa? |
|------|------|------|
| Globigerinoides trilobus, Globigerina praebulloides, Globigerinella sp. | nearly barren, no markers |

| CA27 | 90.9 | barren |
|------|------|------|
| very little residue, terrigenous and lithic grains, pyritized fragments, mica, qz | barren |

| CA28 | 89.5 | barren |
|------|------|------|
| residue made up of mica, Globigerina praebulloides, Globigerinella sp. | No markers |

| CA29 | 88 | good |
|------|----|------|
| Helicophaga Carteri (C/A), Sphenolithus moriformis (C/A), S. heteromorphus (R), Helicosphaera euphratis (R/C), H. mediterranea (R/C), H. ampliaperta (R), H. scissura (R), H. obliqua (R), H. recta (R), H. walbersdorfensis (R) | MNN4c | very little residue, lithic grains, qz, rare pyritized fragments, rare plant remains. Planktonic foraminiferal content | barren |

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| Sample Level (m) | Preservation | Main taxa | Biozone | Residue description | Main taxa | Biozone | Notes |
|-----------------|--------------|-----------|---------|---------------------|-----------|---------|-------|
| CA30 87         | very little residue, terrigenous fragments, lithic grains, qz, muscovite, plant remains. Planktonic foraminifera in trace reworked (Cretaceous?) | Planktonic foraminifera | nearly barren | rare fragments of agglutinated benthic foraminifera |
| CA33 83.9       | little residue, lithic grains, qz, muscovite, rare plant remains. Planktonic foraminifera absent | | barren | |
| CA34 82.9       | very little residue, lithic grains, mica (muscovite) (A), oxydized fragments, lignite and plant remains. Planktonic foraminifera absent | Planktonic foraminifera | barren | |
| CA35 80.4       | terrigenous grains, common transparent crystals (gypsum?). Planktonic foraminifera absent. | Globigerinoides trilobus (4 specimens), Globorotalia sp. (1 specimen), Globorotalita woodi (1 specimen), Praeorbulina \( \textit{glomerosa glomerosa} \) (1 specimen) | nearly barren | rare fragments of agglutinated benthic foraminifera |
| CA36A 79.4      | good \( \textit{Helicosphaera carteri} \) (C), \( \textit{Sphenolithus mastiformis} \) (C/A), \( \textit{S. heteromorphus} \) (R), \( \textit{H. intermedia} \) (R/C), \( \textit{H. euphratis} \) (R/C), \( \textit{H. mediterranea} \) (R/C), \( \textit{H. ampliaperta} \) (C), \( \textit{H. scissura} \) (R), \( \textit{H. obliqua} \) (R) | MNN4a | barren | |
| CA40B 71.1      | muscovite and aggregated sediment | | barren | |
| CA44 62.6       | little residue, lignite (A), oxydized and pyritized terrigenous grains, mica, quartz. Planktonic foraminifera in trace | Globigerinoideidae trilobus | Nearly barren: 1 specimen of benthic foraminifera | |
| CA45 60.3       | very little residue, terrigenous grains, oxydized and pyritized fragments | | barren | |
| Sample | Level (m) | Preservation | Calcareous nannofossils | Planktonic foraminifera | Benthic foraminifera | Ostracods |
|--------|-----------|--------------|-------------------------|-------------------------|----------------------|-----------|
| CA46B  | 55.3      | good         | *Helicosphaera carteri* (C), Sphenolithus* moriformis* (C/A), *S. heteromorphus* (R), *H. intermedia* (R/C), *H. euphratis* (R), *H. mediterranea* (R/C), *H. ampliaperta* (C), *H. obliqua* (R) | MNN4a very little residue, qz, terrigenous fragments, lithic grains, mica, planktonic foraminifera in trace. *Globigerinoides trilobus* (2 specimens). *Praeorbulina* sp. very badly preserved (1 specimen) | nearly barren | rare fragments of (mainly agglutinated) benthic foraminifera |
| CA47   | 51.8      | good         | *Helicosphaera carteri* (C), Sphenolithus* moriformis* (C/A), *S. heteromorphus* (R), *H. intermedia* (R), *H. euphratis* (R), *H. mediterranea* (R/C), *H. ampliaperta* (C), *H. obliqua* (R) | MNN4a | | |
| CA55   | 37.3      | good         | *Helicosphaera carteri* (C), Sphenolithus* moriformis* (C/A), *S. disbelemnos* (R), *H. intermedia* (R), *H. euphratis* (R), *H. mediterranea* (R/C), *H. ampliaperta* (RC) | MNN3b very little residue, terrigenous fragments, lithic grains, muscovite abundant, rare plant remains, very rare planktonic foraminifera (poorly preserved). *Globigerinoides trilobus*, *G. sconus* (elongated and less elongated morphotypes, maybe 1 with 3 apertures) *Paragloborotalia* cf. spinulosis | | |
| CA60   | 29.6      | poor         | *Helicosphaera carteri* (C), Sphenolithus* moriformis* (C), *H. intermedia* (R), *H. euphratis* (R), *H. mediterranea* (R), *H. ampliaperta* (R) | MNN3b very little residue, quartz, lithic grains, muscovite, rare plant remains, planktonic foraminifera in trace. *Globigerinoides trilobus* (1 specimen), *Dentoglobigerina* sp. | nearly barren | rare fragments of benthic foraminifera |
| CA71   | 8.7       | poor         | *Helicosphaera carteri* (C), Sphenolithus* moriformis* (C), *H. euphratis* (R), *H. mediterranea* (R), *H. perch-nielseniae* (R), *H. scissura* (R), *H. ampliaperta* (R), *H. recta* (R) | MNN3b very little residue, rare muscovite | barren | |

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(continued on next page)
| 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 Helicosphaera Carteri (C/A), Sphenolithus heteromorphus (RR), S. moriformis (C/A), H. mediterranea (R) | MNN5b nearly barren, no markers |
| CG18   | 57.9      | very poor UNDEFINABLE |
| CG17   | 55.4      | good Helicosphaera Carteri (C/A), Sphenolithus heteromorphus (C), S. moriformis (C/A), H. vedderi (R) | MNN5b inorganic fraction abundant (sediment fragments). Echinid remains, ostracods. Foraminifera common, moderately/poorly preserved, almost exclusively benthic. Planktonic foraminifera in trace |
| CG16   | 52.4      | poor Helicosphaera Carteri (C), Sphenolithus heteromorphus (CR), S. moriformis (C/R), H. vedderi (R) | MNN5b |
| CG14   | 47.5      | poor Helicosphaera Carteri (C), Sphenolithus heteromorphus (C), S. moriformis (C/R), H. walbersofensis (C), H. intermedia (R), H. mediterranea (R), H. vedderi (R), Discoaster musculus (C) | MNN5c inorganic fraction prevalent (lithic grains, sediment fragments, quartz, glauconite). Planktonic foraminifera rare, moderately/poorly preserved. Benthic foraminifera more abundant. |
|        |           |              | Globigerinoides trilobus (1 specimen), Globigerina praebulloides (1 specimen) | MM5a relatively rich. Bolivina spathulata, Bulimina elongata, Cibicides dutempleri, C. ungerianus, Discosphaerina coronata, discorbids/glabratellids, Elphidium spp., Fursenkoina acuta, Globobulimina sp., Nonion sp., Rosalina bradyi, large Uvigerina spp. (U. cf. acuminata, U. continuosa, U. semiorientata). Few but large agglutinated taxa, a.o. textularids. Large, reworked miliolids. |

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subglobosa, nodosariids, Pullenia bulloides, Spaeroidina bulloides, large Uvigerina spp. (U. continuosa, U. seminornata, U. venusta). Few but large agglutinated taxa, a.o. Spiroplectinella carinata.

CG13 44.5 poor  
*Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (C/R), *H. walbersdorffensis* (C), *H. ephraimis* (R)  
MNN5c sediment fragments dominant, quartz, lithic grains, mica. Foraminifera in trace: few benthic, few planktonic foraminifera inorganic fraction subordinate to organic one. Foraminifera abundant, moderately preserved but very often deformed.  
Nearly barren, no markers  
Very few benthic foraminifera (*Uvigerina*, *Bulimina*)

CG12 36.4 poor  
*Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C/R), *S. moriformis* (C), *H. walbersdorffensis* (C), *H. vederi* (R)  
MNN5c inorganic fraction prevalent (sediment fragments, quartz, rare pyritized fragments). Planktonic foraminifera rare, moderately/poorly preserved (often deformed), sediment fragments dominant, quartz, rare pyritized fragments, plant remains. Foraminifera in trace: Globigerinoides trilobus (A), *Praeorbulina gromerosa circularis*, *Orbulina suturalis* (1 specimen).  
MMi5a  
Globigerinoides trilobus (A), *Praeorbulina gromerosa circularis*, *Orbulina suturalis* (often deformed)  
MMi5a  
Praeorbulina and Orbulina poorly preserved (often deformed and apertures not well visible).

CG11 33 good  
*Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (G/A), *H. intermedia* (R)  
MNN5b inorganic fraction dominant (sediment fragments, quartz, rare pyritized fragments). Foraminifera in trace: Globigerinoides trilobus, *G. cf. sicamus*.  
MMi4d  
Globigerinoides trilobus, *G. cf. sicamus*, *Praeorbulina gromerosa circularis* (some specimens evolved toward *O. suturalis*)  
MMi4d

CG10 29 poor  
*Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (G/A), *H. intermedia* (R), *H. mediterranea* (R)  
MNN5b inorganic fraction dominant (sediment fragments, quartz, rare pyritized fragments). Foraminifera in trace: Globigerinoides trilobus, *G. cf. sicamus*.  
Nearly barren, no markers

CG8 22.1 good  
*Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (C), *H. intermedia* (R), *H. mediterranea* (R)  
MNN5b inorganic fraction dominant (sediment fragments, quartz, rare pyritized fragments). Foraminifera in trace: Globigerinoides trilobus, *G. cf. sicamus*, *Praeorbulina gromerosa circularis* (some specimens evolved toward *O. suturalis*)  
MMi4d  
Rare, fragmented benthic foraminifera

(continued on next page)
| Sample | Level (m) | Preservation | Main Taxa | Biozone | Residue description | Main taxa | Biozone | Notes |
|--------|-----------|--------------|-----------|---------|---------------------|-----------|---------|-------|
| CG5    | 17.1      | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. moriformis (C), H. intermedia (R), H. mediterranea (R) | MNN5b | Dentoglobigerina abundant, Praeorbulina glomerosa, Orbulina suturalis (some specimens are evolved toward O. universa) | MMi5a | O. suturalis: a few specimens seem very close to O. universa but preservation is not optimal. Probably very close to MMi5b. |
| CG2    | 8.8       | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. moriformis (C), H. obliqua (R), H. mediterranea (R), H. euphratis (R) | MNN5b | Dentoglobigerina abundant, Globigerinoides trilobus (A), Dentoglobigerina spp., G. sicanus, Praeorbulina cf. glomerosa glomerosa? | MMi4c? | Preservation of Praeorbulina specimens is very poor (recrystallized and deformed). Uncertain interpretation. |
| CG1    | 6.5       | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. moriformis (C), H. intermedia (R), H. mediterranea (R) | MNN5a | Globigerinoides trilobus (A), Dentoglobigerina spp., G. sicanus, Praeorbulina cf. glomerosa glomerosa? | MMi4d | MMi4d |

**Table 1 (continued)**

| Sample | Level (m) | Preservation | Main Taxa | Biozone | Residue description | Main taxa | Biozone | Notes |
|--------|-----------|--------------|-----------|---------|---------------------|-----------|---------|-------|
| DV/22  | 33        | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. moriformis (C) | MNN5b | | | |
| DV/21  | 30.7      | good         | Helicosphaera carteri (A), Sphenolithus heteromorphus (C), S. moriformis (C), H. waltrans (R), H. mediterranea (R), H. intermedia (R) | MNN5a | | | |
| DV/20  | 30        | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. moriformis (C), H. waltrans (R), H. mediterranea (R), Discoaster variabilis (C) | MNN5a | | | |
| DV/20  | 29.5      | good         | | | | | |

**Valea Dracului section**

| Sample | Level (m) | Preservation | Main Taxa | Residue description | Main taxa | Biozone | Notes |
|--------|-----------|--------------|-----------|---------------------|-----------|---------|-------|
| DV/22  | 33        | good         | | | Dentoglobigerina abundant, Praeorbulina glomerosa, Orbulina suturalis (some specimens are evolved toward O. universa) | MMi5a | O. suturalis: a few specimens seem very close to O. universa but preservation is not optimal. Probably very close to MMi5b. |
| DV/21  | 30.7      | good         | | | Dentoglobigerina abundant, Globigerinoides trilobus, G. cf. sicanus, Praeorbulina glomerosa glomerosa, Praeorbulina glomerosa circularis (some specimens are evolved toward Orbulina suturalis) | MMi4d | MMi4d |
| DV/20  | 30        | good         | | | Globigerinoides trilobus/ sicanus, Praeorbulina glomerosa curvus, Praeorbulina glomerosa circularis (some specimens are evolved toward Orbulina suturalis) | MMi4d | |
| DV/19  | 29.5      | good         | | | Dentoglobigerina spp., Globigerinoides trilobus, Globorotalia praecoxula, Praeorbulina spp. (deformed) | No markers | rare benthic foraminifera, reworked? Cibicides lobatulus (1 specimen), C. cf. ungerianus? Fragments of agglutinated species (Textularia sp.) |
| DV18  | 28  | poorly | *S. moriformis* and *H. carteri* are present | MNN4c? |
|-------|-----|--------|---------------------------------------------|--------|
| DV19d | 26.5| poor   | *Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (C), *H. ampliaperta* (R), *H. mediterranea* (R), *H. intermedia* (R), *H. scissura* (R) | MNN5a  |
| DV19c | 26.3| BARREN | quartz and lithic fragments abundant        | barren |
| DV19b | 26.1| very poor | UNDEFINABLE *Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (C), *H. mediterranea* (R), *H. intermedia* (R), *H. scissura* (R) | MNN5a  |
| DV19a | 25.7| good   | quartz and lithic fragments                 | barren |
|       |     |        |                                              |        |
| DV17  | 21.8| BARREN | little residue, quartz, lithic             | MM14c? |
|       |     |        | grains, oxidized fragments, no benthic foraminifera, planktonic foraminifera in trace | nearly barren; based on only a single occurrence |
| DV16  | 20.3| BARREN | quartz abundant, lithic                      | barren |
|       |     |        | grains abundant, not well sorted            |        |
| DV14  | 17  | BARREN | quartz abundant, lithic                      | barren |
|       |     |        | grains abundant, well sorted                |        |
| DV13  | 14.3| BARREN | residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxidized and pyritized fragments, plant remains | barren |
| DV12  | 12.9| BARREN | residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxidized and pyritized fragments, plant remains | barren |
| DV11  | 11.6| BARREN | residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxidized and pyritized fragments, plant remains | barren |
| DV03  | 5.6 | BARREN | residue made up of sediment fragments, quartz, mica (muscovite and biotite), rare oxidized and pyritized fragments | barren |

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| Sample  | Level (m) | Preservation | Main Taxa | Biozone | Residue description (>125 µm) | Main taxa | Biozone | Notes |
|---------|-----------|--------------|-----------|---------|------------------------------|-----------|---------|-------|
| CP10    | 18.7      | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. mortiformis (C), H. intermedius (R), H. euphratis (R) | MNN5a    | inorganic fraction common, planktonic foraminifera abundant but very poorly preserved (very often deformed) | Praeorbulina glomerosa glomerosa, Praeorbulina glomerosa circularis, O. cf. suturealis, Paragloborotalia siakensis rare | MM4d     | Praeorbulina very poorly preserved (recrystallized and deformed) |
| CP9     | 16.7      | ?            | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. mortiformis (C), H. vedderi (R) | MNN5a    | inorganic fraction rare, planktonic foraminifera very abundant but very often deformed | Praeorbulina glomerosa, Globigerinoides trilobus, G. cf. sicanus, Paragloborotalia cf. siakensis trace | MM4c     | Praeorbulina very poorly preserved (recrystallized and deformed) |
| CP7B    | 14.7      | good         | Helicosphaera carteri (C), Sphenolithus heteromorphus (C), S. mortiformis (C), H. vedderi (R) | MNN5a    | inorganic fraction rare, planktonic foraminifera very abundant but very often deformed | Praeorbulina glomerosa, Globigerinoides trilobus, G. cf. sicanus, Paragloborotalia cf. siakensis trace | MM4c     | Praeorbulina very poorly preserved (recrystallized and deformed) |
| CP6     | 11.7      | ?            |             | MNN5b    | terrigenous fraction abundant (quartz, lithic grains, rare mica), planktonic foraminifera common poorly preserved (often deformed) | Globigerinoides trilobus, G. cf. sicanus, Paragloborotalia cf. siakensis trace |         | no markers |
| CP5     | 9.2       | poor         |             | MNN5k    |             |                       |         |         |       |
| CP4     | 7.7       | ?            |             | MNN5b    |             |                       |         |         |       |
| CP3B    | 3.4       | BARREN       |             | MNN5b    | dirty, terrigenous material | Globigerinoides trilobus, G. cf. sicanus, Paragloborotalia cf. siakensis trace |         | no markers |
| CP3A    | 3.4       | BARREN       |             |         |             |                       |         | barren |       |
| CP2     | 1.4       | BARREN       |             |         | pyritized terrigenous fraction, pyritized burrows abundant, echinids remains, planktonic foraminifera in trace | Globigerinoides bulloides, Globigerinoides trilobus |         | no markers |

Benthic foraminifera: relatively abundant. Ammonia beccarii and A. tepida, Bulimina eckingata, many Cassidulina carinata, few cibicidids (a.o. C. lobatulus), Discosoridae coronata, Elphidium spp., Pusroyina acuta, Gavelinopsis lobatula, Globorotalia spp., Porosononion granosum. Few large agglutinated taxa: Spiroplectinella deperdita, Textularia spp. Large reworked miliolids.

Ostracods: Cytheridea acuminate, Loxoconcha kochi, Phetygocythereis calcarata.
| Sample | Level (m) | Preservation | Main taxa | Biozone | Residue description (>125 microm) | Main taxa | Biozone | Notes |
|--------|-----------|--------------|-----------|---------|----------------------------------|-----------|---------|-------|
| BX13   | 2.4       | good         | *Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (C), *H. intermedia* (R), *H. euphratis* (R) | MNNSb    | 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* | MM5a      | A few specimens seem to be transitional to *O. universa.* |
| BX10   | 2         | good         | *Helicosphaera carteri* (A), *Sphenolithus heteromorphus* (C), *S. moriformis* (C), *H. ampliaperta* (R), *H. waltrans, H. intermedia* (R) | MNNSa    | 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. sicanus, Globorotalia praescitula, Globoturborotalita woodi, Paragloborotalita sikanensis, D. altipira gr., Turborotalita cf. quinquela, Praeorbulina glomerosa glomerosa, Orbulina suturalis* | MM5a      | |
| BX8    | 1.6       | poor         | *Helicosphaera carteri* (C), *Sphenolithus heteromorphus* (C), *S. moriformis* (C), *H. euphratis* (R), *H. mediterranea* (R) | MNNSa    | very little residue made up of sediment fragments, quartz, plant remains. Planktonic foraminifera rare, preservation good. | *Globigerinoides praebulloides, Globorotalia praescitula, G. trilobus, Dentoglobigerina altipira gr., Paragloborotalita sikanensis, Globoturborotalita woodi, G. sicanus, Praeorbulina cf. glomerosa curva, Praeorbulina glomerosa glomerosa, Praeorbulina glomerosa circularis, Orbulina suturalis* | MM5a      | |
| 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 altipira gr., Globigerinoides praebulloides, Globorotalia praescitula, Turborotalita cf. T. quinquela, Paragloborotalita sikanensis, Praeorbulina sp. (the apertures are not always visible), Orbulina suturalis* | MM5a      | |
| BX5    | 1         | UNDEFINABLE  |           |         |                                 |           |         |       |
| BX4    | 0.75      | BARREN       | *Helicosphaera carteri* (C), *S. moriformis* (A), *H. ampliaperta* (R), *H. euphratis* (R/C), *H. mediterranea* (R/C), *H. intermedia* (R/C) | MNNS4c   | elongated crystals (A), oxydized sediments fragments (A), plant remains. |           |         |       |
| BX3    | 0.5       | poor         |           |         |                                 |           |         |       |

(continued on next page)
| Brebu section | Sample | Level (m) | Preservesion | Main taxa | Biozone | Main taxa | Biomarkers | Biozone | Notes |
|---------------|--------|-----------|--------------|-----------|---------|-----------|------------|---------|-------|
| BX2           | 0.25   | poor      | **Helicophaera carteri (C), Sphenolithus heteromorphus (C/R), S. moriformis (C),** H. euphratis (R), H. mediterranea (R) | **MNN4b** sediment fragments, elongated crystals, mica (muscovite), oxidized and pyritized fragments, plant remains. | **Globigerinoides trilobus, G. cf. sicanus, Praeorbulina glomerosa glomerosa, Praeorbulina glomerosa circularis**? | barren |
| BX1           | 0      | poor      | **Helicophaera carteri (C), Sphenolithus heteromorphus (C/R), S. moriformis (C),** H. euphratis (R), H. mediterranea (R) | **MNN4b** very little residue made up of pyritized fragments, pyrite, sediment fragments, plant remains, foraminifera in trace, preservation moderate/poor (recrystallized and deformed) | G. Sant et al. / Data in brief 24 (2019) 103904 20 | barren |
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

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

Fig. 4. Calcareous nannofossils. (1) Helicosphaera ampliaperta (sample CA10); (2) H. walbersdorfiensis (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. ampliaperta (sample CA19); (10) H. mediterranea (sample CA20); (11a, b, c) S. disbelemnos (sample CA55) at 0°, 20° and 40°.
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-Giurgesti 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 Campinita (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 walbersdorfen*s (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 nanofossil 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 nanofossil 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-Giurgesti 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./Bolivin 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 sutruralis* (Fig. 5). The occurrence of *O. sutruralis* 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*, *Globoturborotalita woodi*, *Paragloborotalia siakensis*, *Praeorbulina glomerosa* s.l. and *Orbulina sutruralis*. Rare specimens of *Praeorbulina glomerosa glomerosa* and *P. cf. glomerosa circularis* occur in the lowermost sample (BX1) suggesting Subzone MMi4c/d?, while *Orbulina sutruralis* 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. sutruralis* 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.
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*, *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-Giurgești section are moderately to poorly preserved and are 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).

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 *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* sp., 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).
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

Fig. 6. a. Ostracods. (1) Loxoconcha punctatella (sample CA8); (2) Pterygothythereis 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) Farsenkoaina acuta (sample CP2); (8) Globobulimina 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).
below the open marine flooding (117.9–136.5 m; samples CA13, CA10 and CA9) is quartz-rich and the relatively rare hyaline taxa are poorly preserved. Grain size sorting suggests transport or winnowing. Plant remains in CA10 and CA13 indicate a near-coastal environment, possibly brackish and in the vicinity of a river plume. Most taxa in these samples are restricted to the inner-mid shelf; some taxa (miliolids, *Hanzawaia boueana*, *Rosalina globularis*) tolerate a certain degree of hypo- and hypersalinity. In sample CA09, preservation of fish remains suggests oxygen restriction (since phosphate is preserved under anoxic conditions), and a specimen of the planktonic foraminifer *Morozovella* sp. indicates reworking of Paleogene sediments. Sample CA08, located in the base of the flooding at 138.7 m, mainly contains diverse miliolids together with numerous, nearly monospecific smooth ostracods (*Loxoconcha punctatella*) pointing to an oxic, shallow-marine environment with deviating salinity (*Table 1; Fig. 5*).

In the Transylvanian Basin, the washed residue of the sample collected from the basal Dej Fm just above the flooding in the Valea Dracului (DV) section (DV19A; 25.7 m) is large, well-sorted and clean (mainly quartz, lithic fragments), suggesting a high-energy environment, possibly a beach. Absence of planktonic foraminifer and rare, recrystallized benthic foraminifera: miliolid, *Elphidium* sp. and *Textularia* sp. suggest shallow-marine waters. Higher up, the washed residue of sample DV19 (29.5 m) contains only two hyaline specimens (*Cibicides lobatulus* and a *C. cf. ungerianus*) which may be...
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-Giurgesti (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 shell 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 Cepari (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 (Loxoconcha punctatella) and ornamented ostracods occur (Cytheridea acuminata, Loxoconcha kochi, Pterygocythereis calcarata; Fig. 6).

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