UPPERMOST CRETACEOUS CALCAREOUS NANNOFOSSILS IN RED PELAGIC SEDIMENTS (ROMANIAN CARPATHIANS)

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Abstract Calcareous nannofossil investigations were carried out on successions cropping out in an expanded section situated in the Romanian Carpathians bend area (nearby the Pucheni village, Dâmbovița River basin). Nannofossil biostratigraphy indicates a Santonian - late Maastrichtian age for the investigated deposits. The studied red and variegated sediments are correlated with similar deposits occurring in the bend region of the Romanian Carpathians.

Keywords: Santonian-Maastrichtian interval, Romanian Carpathian Bend, red marine beds, nannofossil biostratigraphy.

INTRODUCTION

Upper Cretaceous marine red beds are known to occur in many regions of the Mesozoic Tethyan Realm, starting to be sedimented from the latest Early Cretaceous interval to the end of the Cretaceous (Hu et al., 2012). In some European Tethyan regions, such as central Italy (Premoli-Silva et al., 1976; Arthur and Fischer, 1977) and Eastern Carpathians (Săndulescu et al., 1981), the red beds cross the Maastrichtian/Paleogene boundary and occur up to the Eocene.

Cretaceous marine red beds were identified by geologists since the 19th Century. Štur (1860) and Gümbel (1861) described this kind of lithology from the Western Carpathians (the Puchov beds) and the Eastern Alps (the Nierental beds). In Romania, Popovici-Hatzeg (1898) identified the “red marls” in the Carpathian bend region.

The term CORBs (Cretaceous Oceanic red beds), illustrating the marine Cretaceous red sediments, was firstly used by Wang et al. (2004, 2009) and Hu et al. (2005), and became widely applied in global correlation. CORBs are Cretaceous reddish to pinkish to brownish sedimentary rocks (generally limestone, marl, shale, and/or chert) deposited in pelagic and hemipelagic marine environments (Hu et al., 2005; Scott et al., 2009), but also in turbidite facies (Wagreich & Krenmayr, 2005; Wagreich et al., 2009) As mainly pelagic/hemipelagic deposits, CORBs usually contain rich planktonic assemblages, mostly foraminifers and calcareous nannofossils, allowing an accurate biostratigraphy.

In Romania, CORBs are known to occur in the Carpathian region, from the Albian up to the Maastrichtian (Melinte-Dobrinescu et al., 2009; Melinte-Dobrinescu & Roban, 2011, 2014). A particular occurrence of CORB is situated in the Romanian Carpathian bend region. The red marine beds of this region were the first CORBs reported in Romania (Popovici-Hatzeg, 1898), being described as ‘‘Senonian red marls’’ (Protescu, 1915), ‘‘Gura Beliei Beds’’ (Băncilă, 1958), ‘‘couches rouges’’ (Murgeanu et al., 1963), ‘‘Gura Beliei Marls’’ (Ştefănescu, 1971) and Gura Beliei Formation (Melinte & Jipa, 2005).

The red marls of the Gura Beliei Formation were considered to be ‘Senonian’ in age, based on the occurrence of the belemnite genus *Belemnitella* (Popovici-Hatzeg, 1898). Later, Tocorjescu (1963) and Neagu & Georgescu (1991) attributed a Campanian–Maastrichtian age, based on foraminifer biostratigraphy. A latest Campanian-earliest Paleocene age was reported by Melinte & Jipa (2005) for the Gura Beliei Formation, based on calcareous nannofossil investigations in the Ialomița Valley.

This work is focused on the biostratigraphical and depositional aspects of the red marine beds, cropping out in the Romanian Carpathian bend area. Palaeoenvironmental considerations of the Upper Cretaceous strata are also presented herein.

MATERIAL AND METHODS

The investigated deposits are exposed along a large natural outcrop (Latitude: N 45º11’18.2”; Longitude: E 25º15’57.3”), towards W of the Pucheni village, in the Dâmbovița County. The studied succession is 178 m in stratigraphic thickness (Fig. 1).

For calcareous nannofossil investigations, a detailed sampling at 25 cm was realized. Nannofossil analysis were carried out using an Olympus LM (light microscope), at 1200x magnification. Taxonomic identification follows Perch-Nielsen (1985) and Burnett (1998). For nannofossil biostratigraphy, the CC zones of Sissingh (1977), emended by Perch-Nielsen (1985) and the UC zones of Burnett (1998) were used.

RESULTS

Lithology

In the studied sections (Fig. 2 and Fig. 3), several successions were distinguished (older first):

(i) 87 m-thick variegated (red and white) marlstones and claystones (Fig. 3A); cm up to dm thick glauconite sandstones are also present, mainly towards the base of this succession, along with very thin, 4-5 cm tuff beds. The aforementioned lithology forms parts of the Plaiu Formation described by Ştefănescu (1971; 1995). The hemipelagic Plaiu lithological unit overlies the Dumbrăvioara unit, made by variegated (grey, green and black pelites, locally red) marlstones and siltstones.

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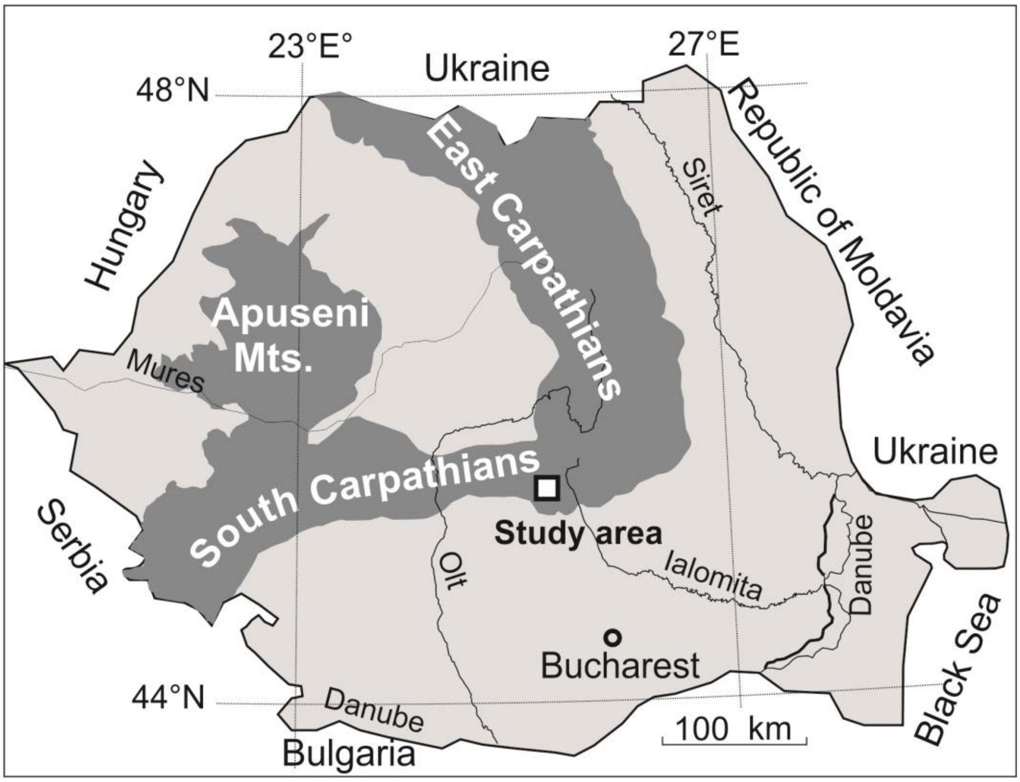

Fig. 1 Location of the studied section in the Romanian Carpathian bend region.

(ii) The next interval (Fig. 3B) is represented by 68 m of red marlstones and claystones within thin-cm sandstones that represent the red marine beds of the Gura Beliei Formation. Commonly, pyrite concretions occur.

(iii) The upper part of the section exposes 23 m of grey-green succession of marlstones and claystones, interbedded with cm up to dm-thick sandstones (Fig. 3C). This rhythmic alternation represents a shaly turbidite facies. Hence, the red marine beds vanished at the top of the studied outcrop. This type of lithology was not encountered so far in the area where the uppermost Cretaceous red beds are known to occur as post-tectonic cover of the Moldavides and Outer Dacides. In all other sections exposing the Gura Beliei Formation in the Dâmbovița, Ialomița and Prahova river basins (Fig. 4 and Fig. 5), on a territory about 250 km^2, the CORBs are followed by the violaceous marlstones and claystones of the Şotrile Formation, i.e., its Lower Member (Ştefănescu, 1995; Melinte & Jipa, 2005). The later authors identified the Cretaceous/Paleogene boundary towards the top of the Gura Beliei unit, while the Lower Member of the Şotrile Formation is Paleocene up to Eocene. Based on these data, we propose herein, for the aforementioned succession, a new lithostratigraphical unit, namely the Pucheni Formation, with the stratotype in the studied section.

Biostratigraphy

The investigated succession contains rich and diversified nannofossil assemblages, proving that the deposition took place above CCD. This finding agrees with previous studies, which assume a palaeodepth of the Gura Beliei red beds to be around 200 m (Ştefănescu, 1995).

The preservation is generally good, as over 75 % of the total encountered specimens may be recognized at species level. Rarely, overgrowth and dissolution of nannofossils were observed. No reworked nannofossils from older deposits were observed, as the investigated sediments are mostly pelagites/hemipelagites.

The nannofossil assemblages are dominated by *Watznaueria barnesiae* and *Micula* spp. that jointly sum up 50–70% of the assemblages. In general, *W. barnesiae* is considered to be a reliable proxy for the diagenetic alteration of Cretaceous calcareous nannofossil assemblages, when its relative abundance exceeds 40% (Roth & Krumbach, 1986). In the investigated samples of Pucheni, the relative abundance of *W. barnesiae* is between 15 and 25%, indicating that there was not a significant diagenetic alteration of the nannofossil assemblages.

In the lower part of the studied succession, within the Plaiu Formation, the FO (first occurrence) of *Calculites obscurus* was recorded. This nannofossil event marks the boundary between CC16 and CC17 biozones, and took place within the UC12 zone, respectively (Fig. 2), placed in the Santonian stage (Burnett, 1998). The next nannofossil events are successive FOs of *Arkhangelskiella cymbiformis* (marking the base of UC13 biozone) and *Broinsonia parca parca* that indicates the base of CC18 and, respectively of UC14 biozones (Fig. 2). The Santonian-Campanian boundary is hence situated in the Plaiu Formation, within the CC17 and respectively UC13 nannofossil zones, as in other Alpine and Carpathian regions (Monechi & Thierstein, 1985; Wagreich et al., 2010).

Within the Campanian sediments of the Plaiu Formation, successive FOs of *Broinsonia parca constricta* and *Cera-*

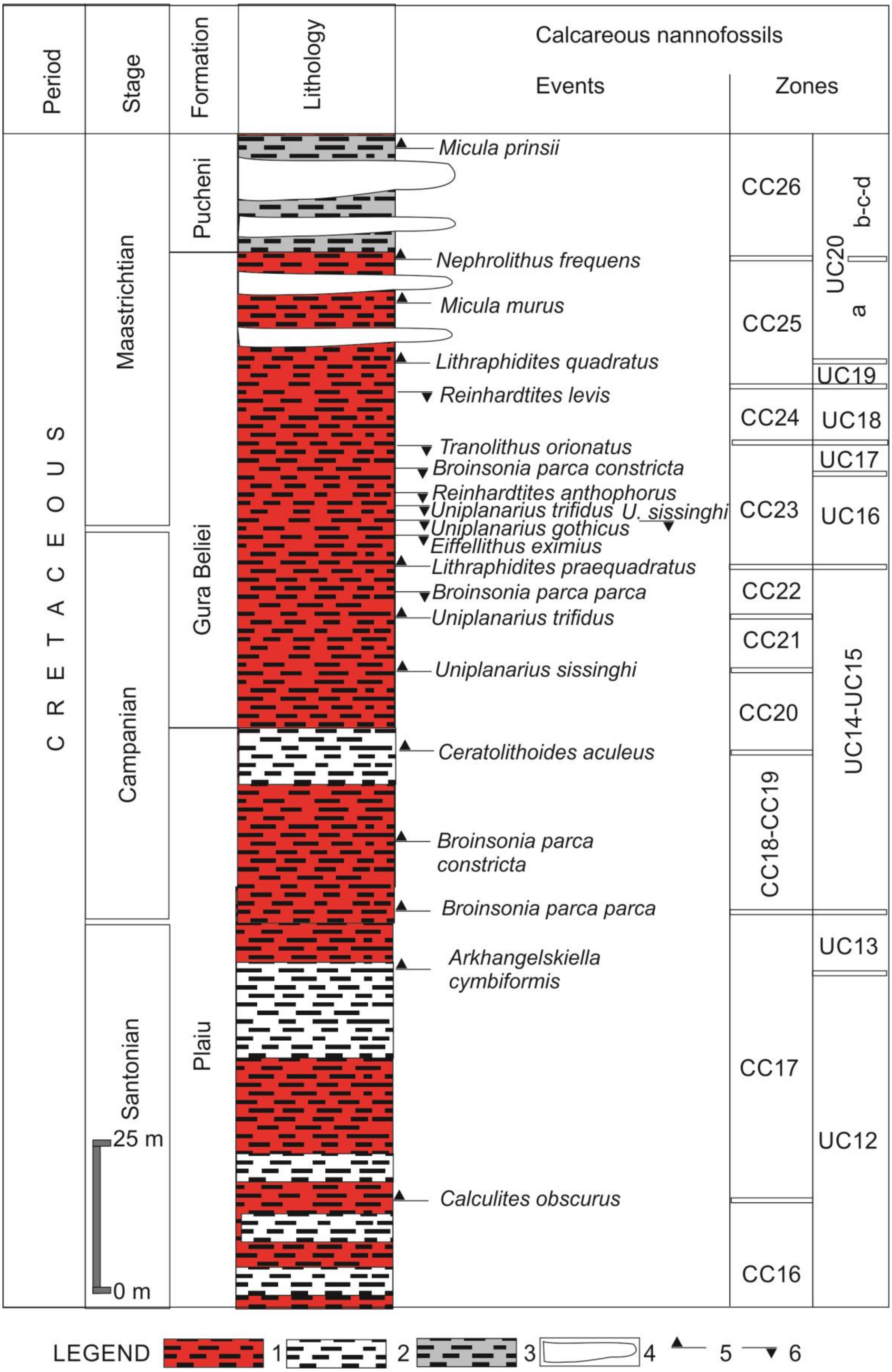

Fig. 2 Lithology and biostratigraphy of the investigated upper Cretaceous sediments in the Pucheni section. Legend: 1 - red marlstones and claystones; 2 - white marlstones and claystones; 3 - grey marlstones and claystones; 4 - sandstones; 5 - FO (first occurrence of a nannofossil); 6 – LO (last occurrence of a nannofossil). CC nannofossil zones of Sissingh (1977), emended by Perch-Nielsen (1985); UC zones of Burnett (1998).

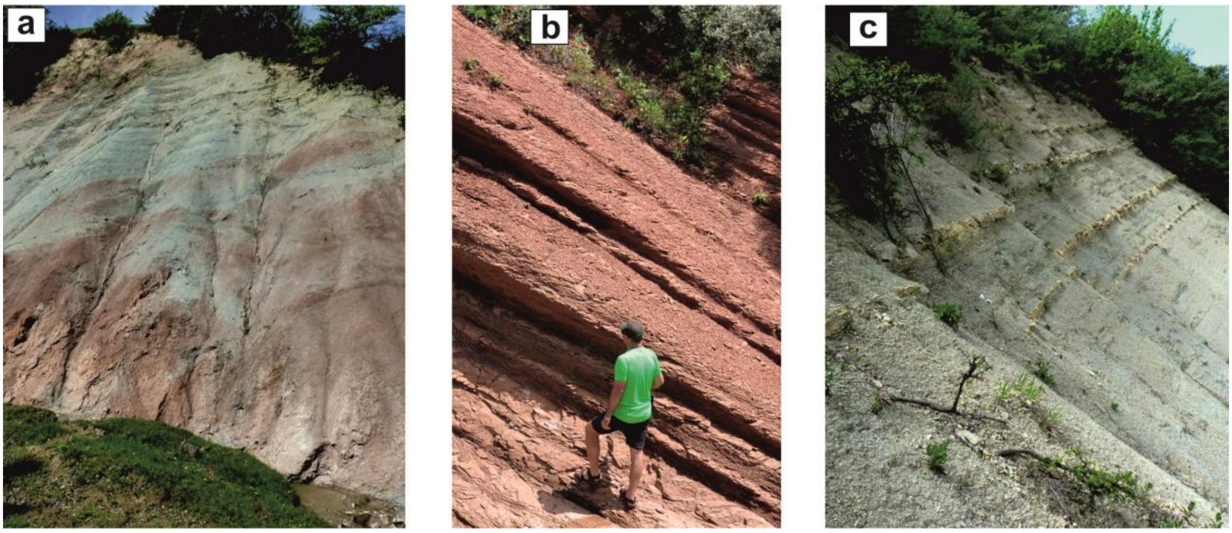

Fig. 3 Photographs of the exposed sediments in the Pucheni section. **a** variegated marlstones and claystones of the Plaiu Formation; **b** red marlstones and claystones of the Gura Beliei Formation; **c** the shaly turbidites of the Pucheni Formation (top of the studied section).

tolithoides aculeus were observed, indicative for the boundary between the biozones CC18/CC19 and CC19/CC20 and respectively UC14-UC15 biozones. The FO of *C. aculeus* (=base of CC20) is the youngest nannofossil event recorded in the variegated marlstones and claystones of the Plaiu unit.

The next lithological unit, the Gura Beliei Formation, extends in the late Campanian-late Maastrichtian interval, covering the CC20 up to CC25 biozones and, respectively UC14-UC15 up to UC20a. Within this interval, a high speciation and high extinction rate in terms of nannofossil was encountered, i.e., 13 bioevents, as follows (Fig. 2): FO of *Uniplanarius sissinghi*, FO of *Uniplanarius trifidus*, LO of *Broinsonia parca constricta*, FO of *Lithraphidites praequadratus*, followed by successive LOs of *Eiffellithus eximius*, *Uniplanarius gothicus*, *Uniplanarius trifidus*, *Reinhardtites anthophorus*, *Broinsonia parca constricta*, *Tranolithus orionatus* and *Reinhardtites levis*. Towards the top of the Gura Beliei unit, the FO of *Lithraphidites quadratus*, succeeded by the FO of *Micula murus*, were identified.

The Campanian-Maastrichtian boundary is placed, at Tercis-les-Bains (Landes, France), which is the global stratotype (GSSP) of the Maastrichtian stage, in terms of nannofossils, between the LO of *Eiffellithus eximius* and LO of *Uniplanarius* (=*Quadrum*) *sissinghi* (Gardin et al., 2001). In agreement with these data, the Campanian/Maastrichtian boundary is situated in the investigated section approximately in the middle part of the Gura Beliei Formation, between the LO of *Eiffellithus eximius* and LO of *Uniplanarius sissinghi*. The later bioevent is coeval with the LO of *Uniplanarius gothicus* (Fig. 2).

The FO of *Nephrolithus frequens* (= the base of CC26 and respectively UC20b) is located towards the top of the Gura Beliei Formation. The youngest nannofossil event observed in the studied section, i.e., the FO of *Micula prinsii*, is located already in the overlaying Pucheni Formation. This bioevent is placed at the top of the Maastrichtian (Perch-Nielsen, 1985; Burnett, 1998; Lamolda et al., 2005).

DISCUSSION

Palaeoenvironmental changes

The Santonian part of the investigated section is characterized by a high abundance of *Micula* spp. (Fig. 6), nannofossils considered as warm-water taxa (Wind, 1979; Pospichal and Wise, 1990; Thibault & Gardin, 2006). Thus, the Tethyan character prevails in the Santonian studied interval. Starting from the Santonian/Campanian boundary interval, *Ahmuellerella octoradiata*, *Gartnerago* spp., *Kamptnerius magnificus* and *Arkhangelskiella cymbiformis*, which are considered as high-latitude taxa, with greater affinity to cool surface waters (Svábenická, 1995; Lees, 2002; Thibault et al., 2016) commonly occur in the encountered assemblages. The mixed Tethyan and Boreal character of the nannofossil assemblages of those times may be related to short sea-level highstand in late Santonian times, followed by a distinct lowstand at the Santonian-Campanian boundary (Haq, 2014; Thibault et al., 2016).

From the upper Campanian, i.e. above the FO of *Ceratolithoides aculeus*, a high abundance of the Tethyan species, i.e., *Micula* spp., along with common presence of *Ceratolithoides* and *Uniplanarius* taxa, was recorded. Previous investigations focused on the uppermost Cretaceous successions from both Tethyan and Boreal realms, based on isotope fluctuations (Odin & Lamaurelle, 2001; Jarvis et al., 2002; Thibault et al., 2012) indicate that the late Campanian interval is characterized by increased $\delta^{13}C$ isotope values and high surface water temperature.

This palaeoclimate modification is showed both by the nannofossil assemblages recorded herein and in the lithology. The Tethyan character of the assemblages dominated throughout. The occurrence of prevailing red marlstones and claystones in the Romanian Carpathian bend region from the upper Campanian is probably linked to the persistence of an arid climate, allowing the accumulation of red soils on emerged coastal plains in some areas; transgressions of those times implied redeposition of se-

Fig. 4 Positions of sections in the Romanian Carpathian bend region, i.e., between the Dâmboviţa, Ialomiţa and Prahova river basins, where red beds of the Gura Beliei Formation occur (www.googlemaps).

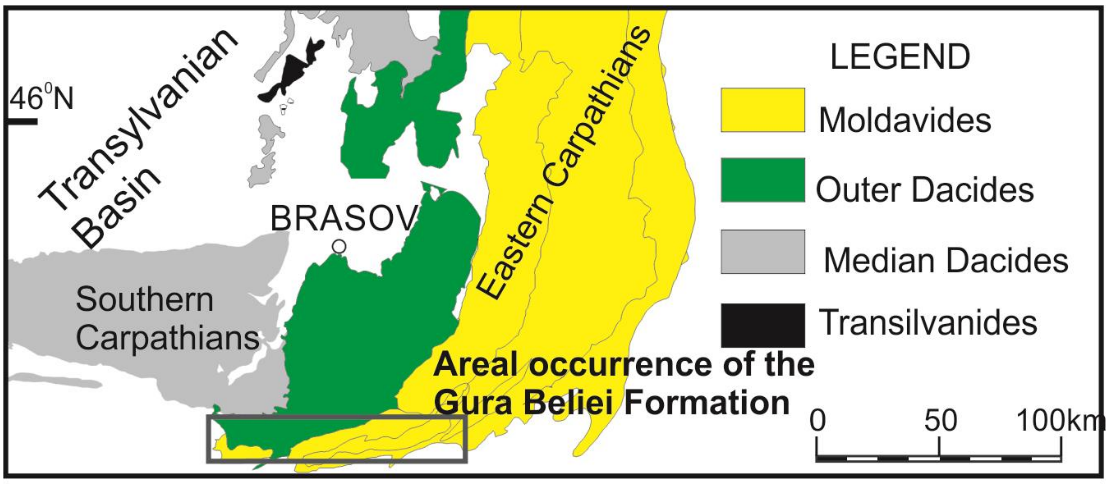

Fig. 5 The areal occurrence of CORBs belonging to the Gura Beliei Formation, as post-tectonic cover of the Outer Dacides and Moldavides nappes. Geological map modified after Săndulescu et al. (1981) and Săndulescu (1984).

diments rich in Fe-hydroxides in the marine environment, generating the red beds of Gura Beliei type.

Possibly, the global cooling that is assumed to characterize the early Maastrichtian interval (Barrera and Savin, 1999; Jarvis et al., 2006) is responsible for the disappearance of several Tethyan nannofossils, such as *Uniplanarius gothicus*, *U. sissinghi* and *U. trifidus* towards the base of the Maastrichtian; the later two species show a very short range, within the late Campanian - early Maastrichtian interval. We assume that these species, appearing during the warm late Campanian, did not adapt to the palaeoclimate shift settled at the base of the Maastrichtian.

As elsewhere (Burnett, 1998), a high extinction rate was observed in the lower Maastrichtian deposits of the studied Romanian section, probably linked to a short recovery of the surface water temperature. Therefore, lower Maastrichtian assemblages are dominated by taxa mostly confined to low to middle paleolatitudes, such as the species of the *Micula*, *Cylindralithus*, *Ceratolithoides*, *Semihololithus* and *Lithraphidites* genera (Perch-Nielsen, 1985; Lamolda et al., 2005; Thibault and Gardin, 2010).

At the end of the Maastrichtian, several species more related to high paleolatitudes (Lees, 2002; Mutterlose et al., 2005; Thibault et al., 2012), such as *Ahmuellerella octoradiata*, *Arkhangelskiella maastrichtiana*, *A. cymbiformis*, *Biscutum constans*, *Kamptnerius magnificus*, *Nephrolithus frequens* and *Prediscosphaera stoveri* show an increased frequency in the uppermost part of the studied section, evidencing a mixed character of the nannofossil assemblages, including Tethyan and Boreal taxa.

A recent reevaluation of the Cretaceous sea-level variations (Haq, 2014) indicates that below the Cretaceous-Paleogene boundary a transgression took place, just after the upper Maastrichtian lowstand (sequence boundary) KMa5 (66.8 Ma). We may assume that the occurrence of the uppermost Maastrichtian mixed Boreal and Tethyan nannofossil assemblages in the Pucheni section is linked to this global eustatic event, leading to pulses of cold surface-water at low to middle palaeolatitudes.

Correlation

The red beds of the Gura Beliei Formation represent the post-tectonic cover of the Eastern Carpathians structures, such as the Ceahlău and Bobu nappes of the Outer Dacides, as well as the Teleajen and Macla nappes of the Inner Moldavides. This unit crops out in a limited area (Figs. 4 and 5), on around 350 km^2, at the southern end of

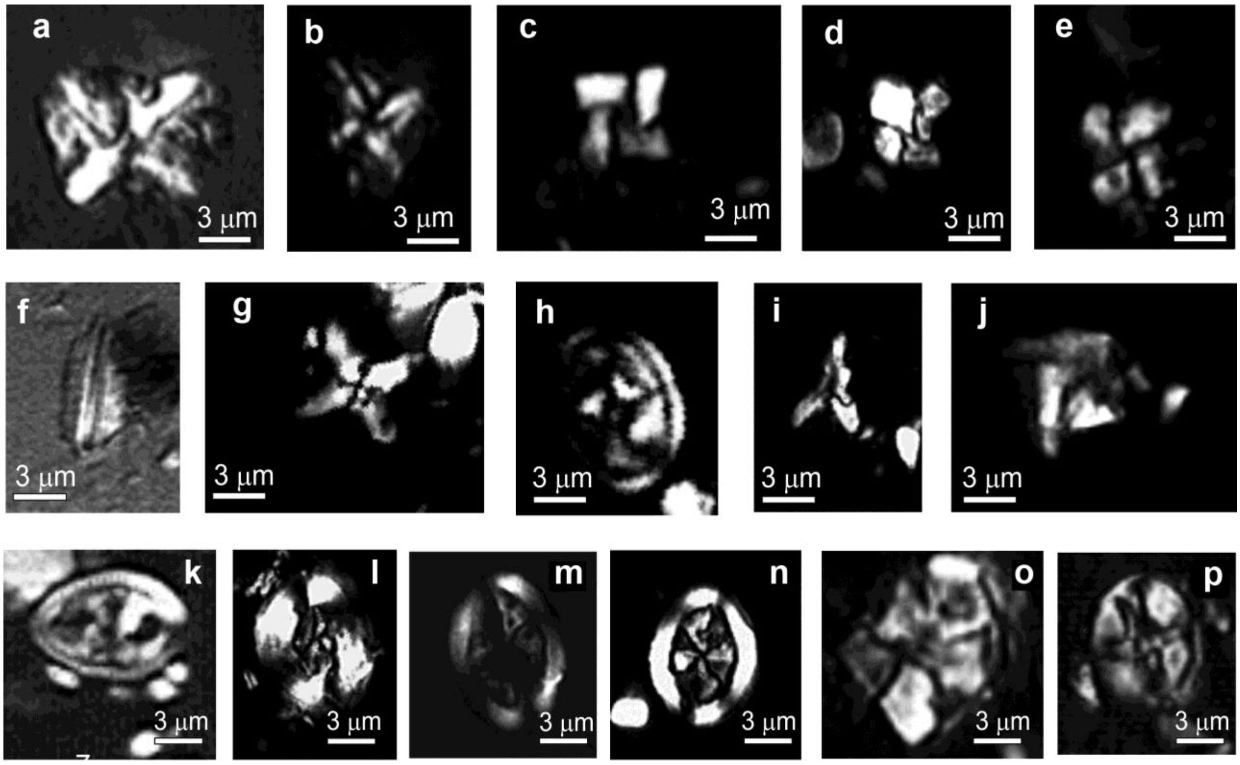

Fig. 6 Upper Cretaceous calcareous nannofossils from the Pucheni section. All microphotographs at LM (light microscope), crossed-nicols; scale bar in microns. **a** *Micula decussata* Vekshina, 1959; Santonian, Plaiu Formation; **b** *Micula concava* (Stradner *in* Martini & Stradner, 1960) Verbeek, 1976; Santonian, Plaiu Formation; **c** *Micula murus* (Martini, 1961) Bukry, 1973; Maastrichtian, Gura Beliei Formation; **d**, **e** *Micula prinsii* Perch-Nielsen, 1979; upper Maastrichtian, Pucheni Formation; **f** *Lithraphidites quadratus* Bramlette & Martini, 1964; upper Maastrichtian, Gura Beliei Formation; **g** *Uniplanarius sissinghi* (Perch-Nielsen, 1986) Farhan 1987; upper Campanian, Gura Beliei Formation; **h** *Reinhardtites levis* Prins & Sissingh in Sissingh, 1977; lower Maastrichtian, Gura Beliei Formation; **i** *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977; upper Campanian, Plaiu Formation; **j** *Micula swastica* Stradner & Steinmetz, 1984; upper Maastrichtian, Pucheni Formation; **k** *Tranolithus orionatus* (Reinhardt, 1966a) Reinhardt, 1966b; lower Maastrichtian, Gura Beliei Formation; **l** *Broinsonia parca parca* (Stradner, 1963) Bukry, 1969; lower Campanian, Plaiu Formation; **m** *Arkhangelskiella cymbiformis* Vekshina, 1959; lower Campanian, Plaiu Formation; **n** *Gartnerago segmentatum* (Stover, 1966) Thierstein, 1974; upper Maastrichtian, Pucheni Formation; **o** *Uniplanarius gothicus* (Deflandre, 1959) Hattner & Wise, in Wind & Wise 1983; upper Campanian, Gura Beliei Formation; **p** *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968; upper Campanian, Gura Beliei Formation.

the Eastern Carpathians, a region also known as the Romanian Carpathian bend area.

The studied Santonian-Maastrichtian interval is mainly characterized by pelagic to hemipelagic sedimentation. Towards the upper part of the Gura Beliei Formation, within the upper Maastrichtian, cm-thick sandstones are intercalated, being observed in sections from the basins of Prahova and Ialomiţa (Melinte and Jipa, 2005). In those areas, according to the above mentioned authors, the Cretaceous/Paleogene boundary is placed at the top of the Gura Beliei Formation (Fig. 7). In Prahova and Ialomiţa valleys, the red marls of the Gura Beliei unit are followed by Paleocene-Eocene turbidites deposits of the Şotrile Formation, starting with successions of mainly violaceous pelites and very thin sandstones, grading up to sandy turbidites. Trace fossils, such as *Belorhaphe* and *Paleodictyon gomezi* have been described from this unit (Brustur, 1993). Hence, the upper Maastrichtian pelagic to hemipelagic sedimentation was replaced by shaly turbidites at the end of the Maastrichtian, grading up to sandy turbidites in the upper Paleocene up to the Eocene.

As concerning the variegated (white and locally red) marlstones and claystones of the Plaiu Formation, the most complete succession of this unit is probably exposed in the western part of its spatial occurrence (Fig. 5 and Fig. 7). In the Izlaz Valley section (near Laicăi, in the Dâmboviţa basin), the integrated biostratigraphy based on foraminifers and nannofossils indicates a late Santonian to late Campanian age (Cetean et al., 2011). In the Pucheni section, the Plaiu Formation extends from the Santonian up to the base of the late Campanian, as the FO of *Ceratolithoides aculeus* took place at the top of the unit (Figs. 2 and 7). In the eastern part of the areal occurrence of this unit, i.e. the Ialomiţa and Prahova basins, the base of Plaiu Formation is situated in the early Campanian (Melinte & Jipa, 2005).

The base of the Gura Beliei Formation overlying the Plaiu Formation ranges into the late Campanian, above the occurrence of *Ceratolithoides aculeus* (Melinte & Jipa, 2005 and this paper), while in other sections (i.e., the westernmost occurrence in Laicăi-Coteneşti area) the base was found younger (late Campanian, above FO of *Uniplanarius trifidus*, Cetean et al., 2011). The integrated biostratigraphy of the Gura Beliei upper part (Neagu, 2016) indicates that this unit extends within the Campanian - Maastrichtian interval, based on the co-occurrence

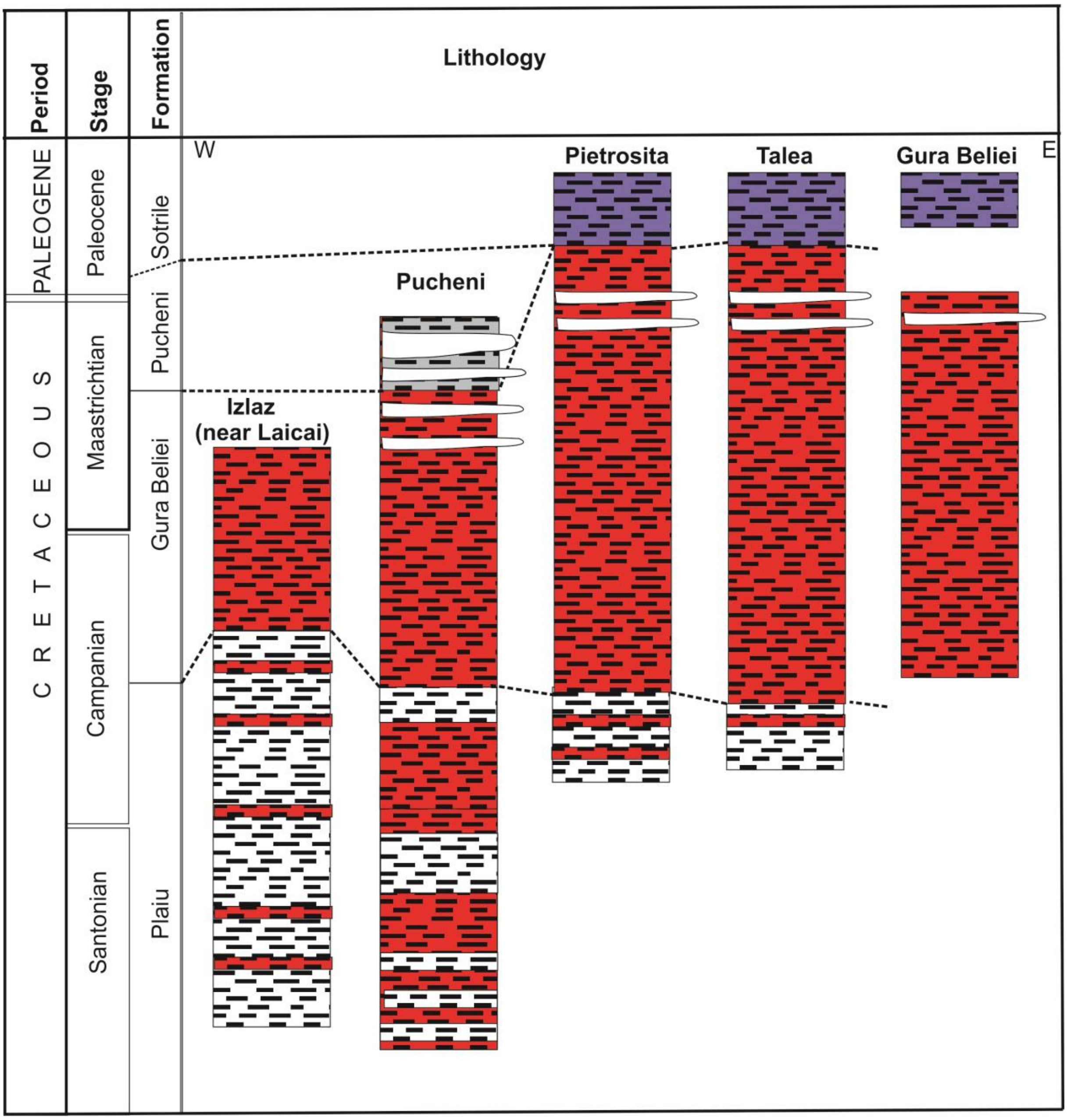

Fig. 7 Litho- and biostratigraphic correlation of the uppermost Cretaceous variegated sediments exposed in the Romanian Carpathians belt. For lithological legend see Fig. 2; the age assignment in the section Izlaz after Cetean et al. (2011), section Pucheni presented in this paper and sections Pietroșița, Talea and Gura Beliei from Melinte & Jipa (2005).

of macrofaunas such as *Belemnitella carpathica* and *Inoceramus salisburgensis*, and foraminifer biozones Globotruncana elevata (early Campanian), Globotruncana ventricosa (late Campanian), Globotruncanita calcarata (latest Campanian with *Belemnitella carpathica*), Globotruncanella havanensis (early Maastrichtian), Gansserina gansseri (earliest Maastrichtian) and Abatomphalus mayaroensis (latest Maastrichtian). According to Neagu (2016), in the section exposed on the Ialomiţa Valley at Pietroşiţa, the red clays of the Gura Beliei Formation are characterized by the occurrence of the planktonic foraminifer zone with small *Globigerina* indicating the base of the Paleocene (early Danian age). A similar age was found based on nannofossils (Melinte & Jipa, 2005), in the Pietroşiţa section and eastern part of Gura Beliei exposures (i.e., Talea and Gura Beliei in Prahova Valley), where the Cretaceous-Paleogene boundary is situated at the top of the Gura Beliei. The boundary was identified based on successive blooms of *Thoracosphaera* spp. and *Braarudosphaera bigelowii* (lowermost Paleocene events – Lamolda et al., 2016) and isotopic fluctuations (Bojar et al., 2009). In the Pucheni section, Gura Beliei Formation ends in the upper Maastrichtian (top of CC25 and respectively UC20a, in terms of nannofossil biostratigraphy), while the uppermost Maastrichtian is characterized by the sedimentation of the grey-whitish shaly turbidites of the Pucheni Formation.

CONCLUSIONS

Calcareous nannofossils investigations of the Upper Cretaceous sediments cropping in the Romanian Carpathian bend allow an accurate age assignment of several units, as follows:

- The Plaiu Formation, a pelagic to hemiplegic unit made by white marlstones and claystones locally interbedded with red ones, extends within the Santonian to lower/upper Campanian boundary interval.
- The Gura Beliei Formation, a pelagic to hemipelagic unit made by red marlstones and claystones (CORB facies), covers the upper Campanian-upper Mastrichtian depositional interval.
- The Pucheni Formation, made by shaly turbidites, extends in the topmost Maastrichtian.

The regional correlation points out that the base and the top of the red beds belonging to the Gura Beliei Formation are diachronous. Therefore, the base is placed in the lower Campanian or within the upper part of this stage, while the top is located in the upper Maastrichtian or in the early Paleogene (towards the base of the Danian stage). As the red beds are supposed to be accumulated in a marine basin, where terrigenous influx of nearby coastal areas periodically penetrated, the diachronicity may be related to the global eustatic sea-level changes, leading to periodic denudation of red soils. The global eustatic sea-level changes may be enhanced by the regional ones in correlation with the tectonic activity of the Romanian Carpathian region, where, in the latest Cretaceous, significant movements (i.e., Laramian ones) occurred.

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REFERENCES

Arthur, M.A. & Fischer, A.G., 1977. Upper Cretaceous–Paleocene magnetic stratigraphy at Gubbio, Italy I. Lithostratigraphy and sedimentology. Geological Society of America Bulletin 88(3): 367–389.

Barrera, E. & Savin, S. M., 1999. Evolution of late Campanian–Maastrichtian marine climates and oceans. In: Barrera, E. & Johnson, C.C. (eds.) Evolution of the Cretaceous ocean-climate system. GSA Special Paper, 332, 245–282.

Băncilă, I., 1958. Geologia Carpaţilor Orientali. Editura Ştiinţifică, Bucureşti, 368 pp.

Bojar, A.-V., Melinte-Dobrinescu, M.C., Bojar, H.-P., 2009. A continuous Cretaceous-Paleocene red beds section in the Romanian Carpathians. In: Hu, X., Wang, C., Scott, R.W., Wagreich, M. & Jansa, L. (eds.) Cretaceous Oceanic Red Beds: Stratigraphy, Composition, Origins and Paleoceanographic/Paleoclimatic Significance. SEPM Special Publication (Tulsa, OK), 91: 121-135.

Brustur, T., 1993. Observations on some echinoid traces from the Getic and Şotrile Eocene between the Vâlsan and Dâmbovita Valleys. Bul. Soc. Geol. Rom., 4(14): 23-28.

Burnett, J.A., 1998. Upper Cretaceous. In: Bown, P.R. (ed.) Calcareous nannofossils Biostratigraphy. Chapman & Hall Ltd/Kluwer Academic Press, London: 132–199.

Cetean, C., Bălc, R., Kaminski, M. & Filipescu, S., 2011. Integrated biostratigraphy and palaeoenvironments of an upper Santonian-upper Campanian succession from the southern part of the Eastern Carpathians, Romania. Cretaceous Research, 32: 575–590.

Gümbel, C.W., 1861. Geognostische Beschreibung des bayerischen Alpengebirges und seines Vorlandes. Gotha (J. Perthes), 950 pp.

Haq, B.U., 2014. Cretaceous Eustasy Revisited. Global and Planetary Change 113: 44-58.

Hu, X.M., Jansa, L., Wang, C.S., Sarti, M., Bak, K., Wagreich, M., Michalik, J. & Sotak, J., 2005. Upper Cretaceous oceanic red beds (CORBs) in the Tethys: occurrences, lithofacies, age, and environments. Cretaceous Research 26(1): 3–20.

Hu, X., Scott, R., Cai, Y, Wang, C. & Melinte-Dobrinescu, M.C., 2012. Cretaceous Oceanic Red Beds (CORBs): different time scales, different origin models. Earth Science Reviews, 115: 217–248.

Jarvis, I., Mabrouk, A., Moody, R.T.J. & de Cabrera, S., 2002. Late Cretaceous (Campanian) carbon isotope events, sea-level change and correlation of the Tethyan and Boreal Realms. Palaeogeography, Palaeoclimatolology, Palaeoecology, 188: 215–248.

Jarvis, I., Gale, A.S., Jenkyns, H.C. & Pearce, M.A., 2006. Secular variation in Late Cretaceous carbon isotopes: a new d13C carbonate reference curve for the Cenomanian-Campanian (99.6-70.6 Ma). Geological Magazine 143: 561–608.

Gardin, S., Odin, G.S., Bonnemaison, M., Melinte, M., Monechi, S. & von Salis, K., 2001. Results of the cooperative study on the calcareous nannofossils across the Campanian-Maastrichtian boundary at Tercis les Bains (Landes, France). In: Odin, G.S. (ed.) The Campanian/Maastrichtian stage boundary. Characterization at Tercis les Bains (France) and correlation with Europe and other continents. Developments in Palaeontology and Stratigraphy, 19: pp. 293–309.

Lamolda, M.A., Melinte, M.C. & Kaiho, K., 2005. Nannofloral extinction and survivorship across the K/T boundary at Caravaca, southeastern Spain. Palaeogeography, Palaeoclimatology, Palaeoecology, 224: 27-52.

Lamolda, M., Melinte-Dobrinescu, M., Kaiho, K., 2016. Calcareous nannoplankton assemblage changes linked to paleoenvironmental deterioration and recovery across the Cretaceous-Paleogene boundary in the Betic Cordillera (Agost, Spain). Palaeogeography, Palaeoclimatology, Palaeoecology, 441, 438-452.

Lees, J. A., 2002. Calcareous nannofossils biogeography illustrates palaeoclimate change in the Late Cretaceous Indian Ocean. Cretaceous Research, 23: 537–634.

Melinte, M.C. & Jipa, D., 2005. Campanian–Maastrichtian red beds in the Romanian Carpathians: biostratigraphical and genetical significance. Cretaceous Research, 26: 49–56.

Melinte-Dobrinescu, M.C., Jipa, D., Brustur, T. & Szobotka, S., 2009. Eastern Carpathian Cretaceous oceanic red beds: lithofacies, biostratigraphy and paleoenvironment. In: Hu, X., Wang, C., Scott, R.W., Wagreich, M. & Jansa, L. (eds.) Cretaceous Oceanic Red Beds: Stratigraphy, Composition, Origins and Paleoceanographic/Paleoclimatic Significance. SEPM Special Publication (Tulsa, OK), 91: 111–119.

Melinte-Dobrinescu, M.C. & Roban, R.D., 2011. Cretaceous oxic–anoxic changes in the Romanian Carpathians. Sedimentary Geology, 235: 79–90.

Melinte-Dobrinescu, M.C. & Roban, R.-D, 2014. Guide Filed Trip 1. Cretaceous cyclic sedimentation in the Eastern Carpathians. 2nd Workshop of IGCP-UNESCO Project 609 and EARTHTIME EU sequence Stratigraphy Workshop: Eustasy and sequence stratigraphy in a Cretaceous Greenhouse, 32 pp. ISBN 978-973-0-17356-7.

Monechi, S. & Thierstein H.R., 1985. Late Cretaceous-Eocene nannofossil and magnetostratigraphic correlations near Gubbio, Italy. Marine Micropaleontology, 9: 419–440.

Murgeanu, G., Patrulius, D., Contescu, L., Jipa, D., Mihăilescu, N. & Panin, N., 1963. The stratigraphy and sedimentology of the Cretaceous from the inner part of the bend area of Carpathians. Volume of the Carpatho-Balkan Geological Association, Fifth Congress, Bucharest, Guidebook Series of the Institute of Geology and Geophysics, Bucharest 3(2): 1–58.

Mutterlose, J., Bornemann, A. & Herrle, J.O., 2005. Mesozoic calcareous nannofossils—State of the art, Palaeontol. Z., 79: 113–133.

Neagu, T. & Georgescu, D., 1991. Genus *Belemnitella* in the Campanian of Romania. Revue Roumaine de Géologie, 35: 57–74.

Neagu, T., 2016. Micropaleontological study if the Gura Beliei red marls Formation from the Pietroşiţa area (Turonian-Maastrichtian). Part III Campanian-Maastrichtian planktonic foraminifera. Acta Palaeontologica Romaniae 12 (2): 67–91.

Odin, G.S., Lamaurelle, M.A., 2001. The global Campanian-Maastrichtian stage boundary. Episodes, 24: 229–237.

Perch-Nielsen, K., 1985. Mesozoic calcareous nannofossils. In: Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K. (eds.) Plankton Stratigraphy. Cambridge University Press, Cambridge: 329–426.

Popovici-Hatzeg, V., 1898. Étude géologique des environs de Câmpulung et de Sinaia (Roumanie). Éditure Carré et Naud, Paris, 218 pp.

Pospichal, J.J. & Wise Jr., S.W., 1990. Calcareous nannofossils across the K–T boundary, ODP Hole 690C, Maud Rise, Weddell Sea, Proc. Ocean Drill. Program. Sci. Results, 113: 515–532.

Premoli Silva, I., Paggi, L. & Monechi, S., 1976. Cretaceous through Paleocene biostratigraphy of the pelagic sequence at Gubbio, Italy. Memorie di Scienze Geologiche, 15: 21–32.

Roth, P.H. & Krumbach, K.R., 1986. Middle Cretaceous calcareous nannofossil biogeography and preservation in the Atlantic and Indian oceans; implications for paleoceanography. Marine Micropaleontology 10: 235–266.

Scott, R., 2009. Chronostratigraphic database for Upper Cretaceous oceanic red beds (CORBs). In: Hu, X., Wang, C., Scott, R.W., Wagreich, M. & Jansa, L. (eds.), Cretaceous Oceanic Red beds: Stratigraphy, Composition, Origins, Paleogeographic, and and Paleoclimatic Significance. SEPM Special Publication (Tulsa, OK), 91: 31–53.

Săndulescu, M., 1984. Geotectonica României. Editura Tehnică Bucureşti, 336 pp.

Săndulescu, M., Ştefănescu, M., Butac, A., Pătruț̦ I. & Zaharescu, P., 1981. Genetical and structural relations between the Flysch and Molasse (the East Carpathians model). Volume of the Carpatho-Balkan Geological Association, 12th Congress, Bucharest, 1981. Guidebook Series of the Geological Institute of Romania, Bucharest 19, 94 pp.

Sissingh, W., 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. Geol. Mijnbouw, 56:37–65.

Ştefănescu, M., 1971. Structura geologică a regiunii dintre Valea Talea şi Valea Ialomiţei. Dări de Seamă, Institutul Geologic al României, 57(5): 191–219.

Ştefănescu, M., 1995. Stratigraphy and structure of Cretaceous and Paleogene flysch deposits between Prahova and Ialomița valleys. Romanian Journal of Tectonics and Regional Geology 76(1): 4–49.

Svábenická, L., 1995. The stratigraphical correlation of the Campanian low- and high-latitude calcareous nannofossils in Southern Moravia (Western Carpathians). Geologica Carpathica 46: 297–302.

Štur, D., 1860. Bericht über die geologische übersichts - Aufnahmed. Wassergebietes der Waag und Meutra. Geologische Reichsanstalt, Jahrbuch, 11: 17–149.

Tocorjescu, M., 1963. Étude micropaléontologique des dépôts crétacés supérieurs-paléogènes de Mitoi - region Lăicăi. Volume of the Carpatho-Balkan Geological Association, Fifth Congress, Bucharest, Guidebook Series of the Institute of Geology and Geophysics, Bucharest 3(2): 15–24.

Thibault, N. & Gardin, S., 2010. The calcareous nannofossil response to the end-Cretaceous warm event in the Tropical Pacific. Palaeogeography, Palaeoecology, Palaeoclimatology, 291: 239–252.

Thibault, N., Harlou, R., Schovsbo, N., Schiøler, P., Minoletti, F., Galbrun, B., Lauridsen, B.W., Sheldon, E., Stemmerik, L. & Surlyk, F., 2012. Upper Campanian-Maastrichtian nannofossil biostratigraphy and high-resolution carbon-isotope stratigraphy of the Danish Basin: Towards a standard δ13C curve for the Boreal Realm. Cretaceous Research 33: 72–90.

Thibault, N., Harlou, R., Niels, H., Schovsbo, N.H., Stemmerik, L. & Surlyk, F., 2016. Late Cretaceous (late Campanian–Maastrichtian) sea-surface temperature record of the Boreal Chalk Sea. Climate of the Past, 12: 1–10.

Wagreich, M. & Krenmayr, H.G., 2005. Upper Cretaceous oceanic red beds (CORB) in the Northern Calcareous Alps (Nierental Formation, Austria): slope topography and clastic input as primary controlling factors. Cretaceous Research, 26 (1): 57–64.

Wagreich, M., Neuhuber, S., Egger, H., Wendler, I., Scott, R.W., Malata, E. & Sanders, D., 2009. Cretaceous Oceanic Red Beds (CORBs) in the Austrian Eastern Alps: Passive Margin vs. Active- Margin Depositional Settings. In: Hu, X., Wang, C., Scott, R.W., Wagreich, M. Jansa, L. (eds.) Cretaceous oceanic red beds: stratigraphy, composition, origins and paleoceanographic and paleoclimatic significance. SEPM Special Publication (Tulsa, OK), 91: 73–88.

Wagreich, M., Summesberger, H. & Kroh, A., 2010. Late Santonian bioevents in the Schattau section, Gosau Group of Austria – implications for the Santonian–Campanian boundary stratigraphy. Cretaceous Research, 31: 181-191.

Wang, C., Huang, Y., Hu, X. & Li, X., 2004. Cretaceous oceanic redbeds: implications for paleoclimatology and paleoceanography. Acta Geologica Sinica-English Edition, 78 (3): 873–877.

Wang, C., Hu, X., Huang, Y., Scott, R. & Wagreich, M., 2009. Cretaceous oceanic red beds (CORB): a window on global oceanic/climatic change. In: Hu, X., Wang, C., Scott, R.W., Wagreich, M., Jansa, L. (eds.) Cretaceous Oceanic Red Beds: Stratigraphy, Composition, Origins and Paleoceanographic/Paleoclimatic Significance. SEPM Special Publication (Tulsa, OK), 91: 13–33.

Wind, F.H., 1979. Maestrichtian–Campanian nannofloral provinces of the southern Atlantic and Indian Oceans, in: Deep Drilling Results in the Atlantic Ocean: Continental Margins and Paleoenvironment. In: Talwani, M., Hay, W.W. & Ryan, W.B.F. (eds.) AGU, Maurice Ewing, Series 3: 123–137