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CRETACEOUS / TERTIARY BOUNDARY IN THE EAST CARPATHIANS, BASED ON NANNOFLORAL EVIDENCE

MIHAELA CARMEN MELINTE[1]

Abstract. The study of two sections from the East Carpathians (Pietrosita, Ialomita Valley and Lepsa, Putna Valley Basin) offered nannofloral evidence for the presence of a continuous sedimentation in the Cretaceous/Tertiary boundary interval. The first occurrence of the species *Micula prinsii* was identified, in both studied sections, in the topmost Maastrichtian. At the Cretaceous/Tertiary boundary the extinction of the most Cretaceous nannofossil taxa was remarked. The pattern of the decline of some taxa (*Chiastozygus* spp., *Cretarhabdus* spp., *Prediscosphaera* spp., *Watznaueria barnesae*) above the boundary could be regarded as a result of reworking. The early Danian nannofloras are dominated by the *Braarudosphaera* and *Thoracosphaera* taxa. The first occurrence of the Tertiary nannofossils (*Biantholithus sparsus*, *Neobiscutum romeinii*, *N. parvulum* and *Cruciplacolithus primus*) is situated in the first 20-50cm above the K/T boundary. Besides the *Braarudosphaera* and *Thoracosphaera* species, some other survivors, crossing the K/T Boundary, such as: *Markalius inversus*, *Biscutum constans*, *B. castrorum*, *Cyclagelosphaera reinhardtii*, C. *alta*, *Octolithus multiplus*, *Zygodiscus spiralis*, were identified in both analyzed sections.

Keywords: calcareous nannofossils, K/T Boundary, mass extinction, survivors, East Carpathians, Romania.

INTRODUCTION

The study of K/T boundary from different latitudes, based on calcareous nannofossils, was previously the subject of many works (Romein, 1979; Perch-Nielsen, 1979a; Perch-Nielsen, 1979b; Perch-Nielsen, 1985; Thierstein, 1980; van Heck & Prins, 1989; Gorostidi & Lamolda, 1991; Posphical & Huber, 1992; Posphical, 1995).

Together with the foraminifera mass extinction, observed at the K/T boundary (Keller, 1988), the disappearance of the most Cretaceous nannofossil taxa is one of the major bioevents, taking place in the marine planktonic world, within this interval (Keller and Perch-Nielsen, 1995)

This turnover could be strongly related to the long-term environmental changes (volcanism, sea-level fluctuation, climatic changes, as described by Stinnesbeck, 1996; Stinnesbeck & Keller, 1996).

The marine sediments, covering the Upper Cretaceous – Lower Tertiary interval, are widespread in the Carpathian area from Romania.

Palaeobiological evidence, accounting for the K/T Boundary in the East Carpathians, were observed based on foraminifera studies (Ion et al., 1985; Ion et al., 1994) and on dinoflagellate ones (Antonescu and Alexandrescu, 1982).

The present paper is the first attempt in identifying the K/T Boundary in the Carpathian area from Romania, based on calcareous nannofossils.

For this purpose two sections were selected: the Lepsa Section (Putna Valley Basin) and the Pietrosita Section (Ialomita Valley).

GEOLOGICAL CONTEXT

The two studied sections are both located in the East Carpathians (Fig. 1).

The investigated deposits of the Lepsa Section, located in the Vrancea Halfwindow, belong, from a tectonical point of view, to the Marginal Fold Nappe (*sensu* Sandulescu, 1984).

Lithologically, the investigated sequence of the Lepsa Formation is represented by calcareous turbidites.

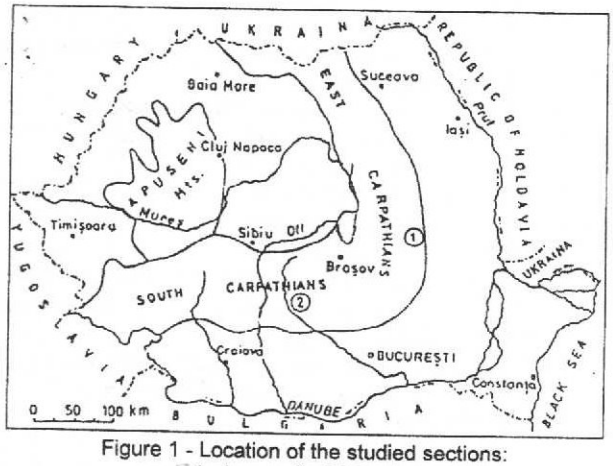

Figure 1 - Location of the studied sections:
1 - Lepşa; 2 - Pietroşiţa

The Lepsa Section was previously studied for its planktonic foraminiferal content. The Upper Maastrichtian interval is characterized by the *Abathomphalus mayaroensis* and *Plummerita kantkeninoides* Foraminiferal Zones, while in the Lowermost Paleocene (Lower Danian) *Globigerina (Parvularugoglobigerina) eugubina* and *Globotruncana (Eoglobigerina) bulloides* Foraminiferal Zones are reported (Ion, 1995)

The Pietrosita Section is located on the right bank of the Ialomita Valley, at a distance around 500m from the Pietrosita railway station.

The investigated deposits of this section (the Gura Beliei Formation) are represented by red marls, with rare whitish marly limestones.

Tectonically. this formation belongs to the post-tectonic cover of the Outer Dacides (*sensu* Sandulescu, 1984).

METHODS AND PROCEDURES

In all, 102 smear-slides, prepared from samples from the two studied sections, were analyzed. The smear-slides were prepared from a non-centrifugal suspension, in order to retain the original nannofossil assemblages.

[1] *Geological Institute of Romania, Caransebes 1, 78344 Bucharest*

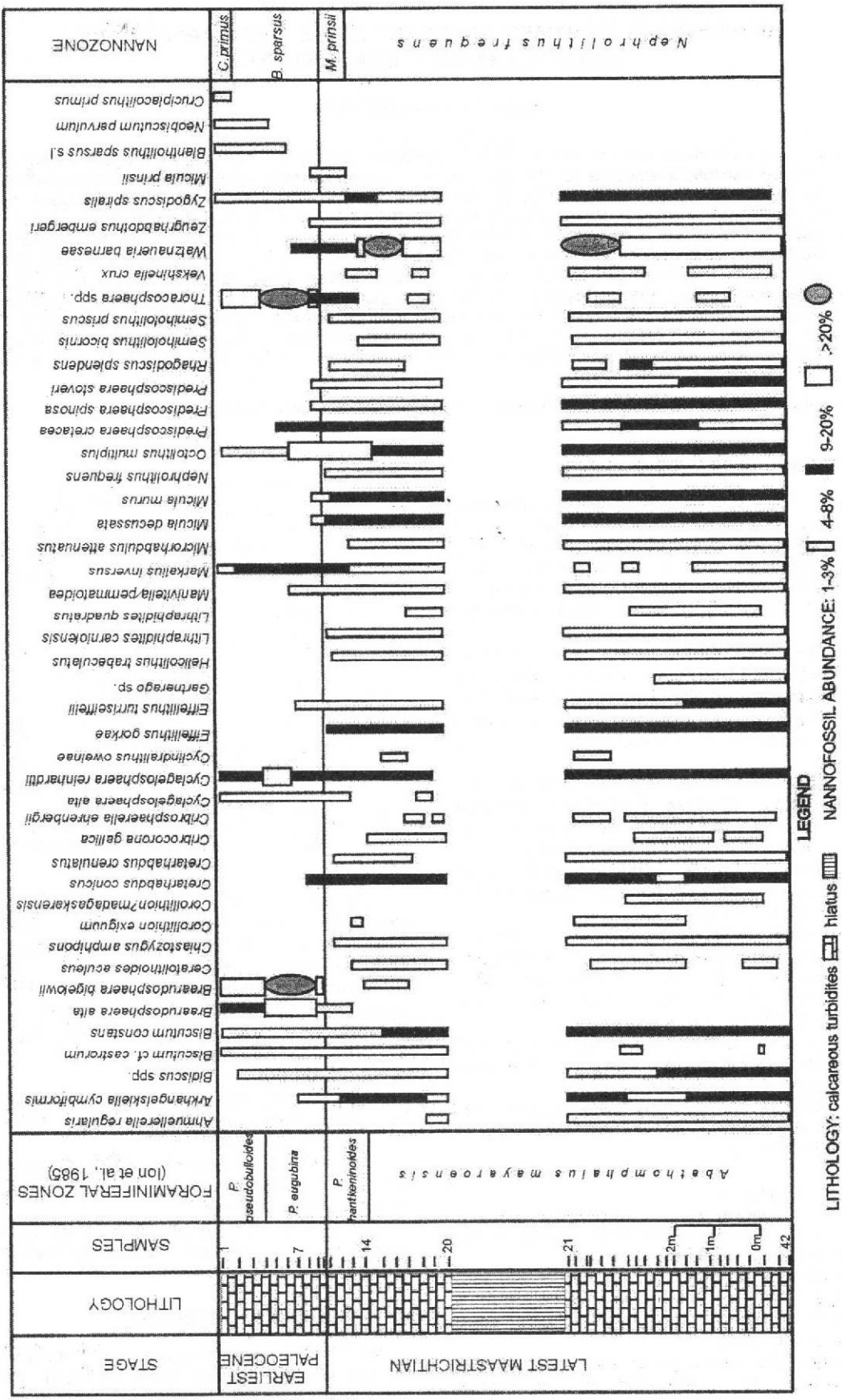

Figure 2 - Nannofossil distribution in the Lepşa section

Quantitative studies were performed using a light polarized microscope at 1600x magnification. A total of 250-300 specimens were counted on each smear-slide, in longitudinal traverse. The individual species percentage for each sample was calculated as percent from the total number of counted. Four different classes were used for estimating the species richness: taxa forming between 1-4% from the total assemblage; between 5-8%; between 9-20%; over 20%.

The preservation of the calcareous nannofossils in the studied sections is as follows: good for the Pietrosita section, little or no overgrowth and/or dissolution was observed; moderate to good in the Lepsa section, in which some overgrowth and/or dissolution were identified.

NANNOFOSSIL ASSEMBLAGES

In both studied sections abundant and diversified nannofossil assemblages were observed.

In the lower part of the Lepsa Section (*Abathomphalus mayaroenis* Foraminiferal Zone), common taxa, representing between 4-8% from the total nannofloral assemblages, as: *Micula decussata* VEKSHINA, 1959, *Micula murus* (MARTINI) BUKRY 1973, *Octolithus multiplus* (PERCH-NIELSEN) ROMEIN, 1979, *Prediscosphaera cretacea* (ARKHANGELSKY) GARTNER, 1968, *P. spinosa* (BRAMLETTE and MARTINI) GARTNER, 1968, *P. stoveri* (PERCH-NIELSEN) SHAFIK and STRADNER, 1971, *Eiffellithus gorkae* REINHARDT, 1965, *Zygodiscus spiralis* BRAMLETTE and MARTINI, 1964, *Cretarhabdus* spp. and *Cyclagelosphaera* spp. were observed (Fig. 2). *Watznaueria barnesae* (BLACK) PERCH-NIELSEN, 1968 is common to abundant, representing in some samples over 20% from the total nannofossil assemblages. *Arkhangelskiella cymbiformis* VEKSHINA, 1959 is common in the lower part of the studied sequence, then became rare. Other taxa, identified as rare (less than 3% from the total nannofloral assemblages) in the lower part of the Lepsa Section are: *Nephrolithus frequens* GORKA, 1957, *Ahmuellerella regularis* (GORKA) VERBEEK, 1977, *Ceratolithoides aculeus* (STRADNER) PRINS and SISSINGH *in* SISSINGH, 1977, *Lithraphidites qudratus* BRAMLETTE and MARTINI, 1964, *Semiholollithus bicornis* PERCH-NIELSEN, 1973 and *Semiholollithus priscus* PERCH-NIELSEN, 1973.

In the topmost Maastrichtian, within the *Plummerita kantkeninoides* Planktonic Foraminiferal Zone, *Micula prinsii* PERCH-NIELSEN, 1979 first occur.

From the base of the Danian (*Parvularugo-globigerina eugubina* Foraminiferal Zone), the blooms of *Thoracosphaera* spp. and *Braarudosphaera* spp were identified.

The calcareous nannofossil assemblages, identified from the base of the Danian contain also some Cretaceous species, such as: *Arkhangelskiella cymbiformis*, *Cretarhabdus crenulatus* BRAMLETTE and MARTINI, 1964, *Prediscosphaera* spp., *Watznaueria barnesae*, *Eiffellithus turriseiffelii* (DEFLANDRE and FERT) REINHARDT, 1965.

The above mentioned nannofossil species are not survivors; their presence is related to reworking, due to the turbiditic sedimentation of the studied succession.

The appearance of the Tertiary nannofossils - the first occurrence of *Biantholithus sparsus* BRAMLETTE and MARTINI, 1964 - took place within the *Globigerina (Parvularugoglobigerina) eugubina* Foraminiferal Zone

The next nannofossil event observed is the first occurrence of *Neobiscutum parvulum* (ROMEIN) VAROL, 1989, followed by the first occurrence of *Cruciplacolithus primus* PERCH-NIELSEN, 1977. Both bioevents are placed in the *Globotruncana (Eoglobigerina) bulloides* Foraminiferal Zone.

Concerning the survivor species, crossing the K/T boundary in the Lepsa Section, these could be primarily considered *Thoracosphaera operculata* BRAMLETTE and MARTINI, 1964 and *Braarudosphaera bigelowii* (GRAN and BRAARUD) DEFLANDRE, 1947. These two species are abundant, forming each of them 22-25% from the total nannofloral assemblage.

Another species surviving to the K/T boundary is *Braarudosphaera alta* ROMEIN, 1979. The first occurrence of this species was identified, in the studied succession, in the Uppermost Maastrichtian, within the *Plummerita hantkeninoides* Foraminiferal Zone.

Concerning the distribution of this species, an increasing frequency (10% from the total nannofloral assemblage) could be noticed in the *Thoracosphaera* bloom interval, within the *Globigerina (Parvularugo-globigerina) eugubina* Planktonic Foraminiferal Zone. From the upper part of the above mentioned foraminiferal zone and also within the *Globotruncana (Eoglobigerina) bulloides* one, the abundance of *Braarudosphaera alta* decreased, up to 5-6% from the total nannofloral assemblage.

Cyclagelosphaera alta PERCH-NIELSEN, 1979 and *Cyclagelosphaera reinhardtii* (PERCH-NIELSEN) ROMEIN, 1977 are both crossing the K/T boundary. While *Cyclagelosphaera alta* was always identified as rare, *Cyclagelosphaera reinhardtii* is common (7-8% from the total early Danian nannofloral assemblages), with an increasing frequency (10-12%) at the top of *Globigerina (Parvularugoglobigerina) eugubina* Planktonic Foraminiferal Zone.

Markalius inversus (DEFLANDRE) BRAMLETTE AND MARTINI, 1964 is another survivor. It is common, from the uppermost Maastrichtian (upper part of *Plummerita hantkeninoides* Foraminiferal Zone) up to the Lower Danian (*Eoglobigerina bulloides* Planktonic Foraminiferal Zone).

Another species, with a range extending also in the Danian, is *Octolithus multiplus* (PERCH-NIELSEN) ROMEIN, 1979. This taxon was common to abundant in the K/T boundary interval (15-18% from the total nannofloral assemblages), then became rare. Within the upper part of the *Globigerina (Parvularugoglobigerina) eugubina* Planktonic Foraminiferal Zone and in the *Globotruncana (Eoglobigerina) bulloides* Planktonic Foraminiferal Zone *Octolithus multiplus* represents no more than 2-3% from the nannofossil assemblages.

Biscutum cf. *castrorum*, *Biscutum constans* (GORKA) BLACK *in* BLACK and BARNES, 1959 and *Bidiscus* spp. (with the most common species *Bidiscus rotatorius* BUKRY, 1969) are also survivors in the studied section. All these taxa are rare within the Danian, representing less than 3% from the total nannofloral assemblages.

Another surviving species, identified in the studied Danian samples always as rare, is *Zygodiscus spiralis*.

A similar distribution pattern of the nannofloras within the Cretaceous/Tertiary boundary interval was observed in the Pietrosita Section (Fig. 3).

The base of the studied sequence is characterized by nannofloral assemblages containing rare *Nephrolithus frequens*, *Ahmullerella regularis*, *Arkhangelskiella cymbiformis*, *Eiffellithus* spp.,

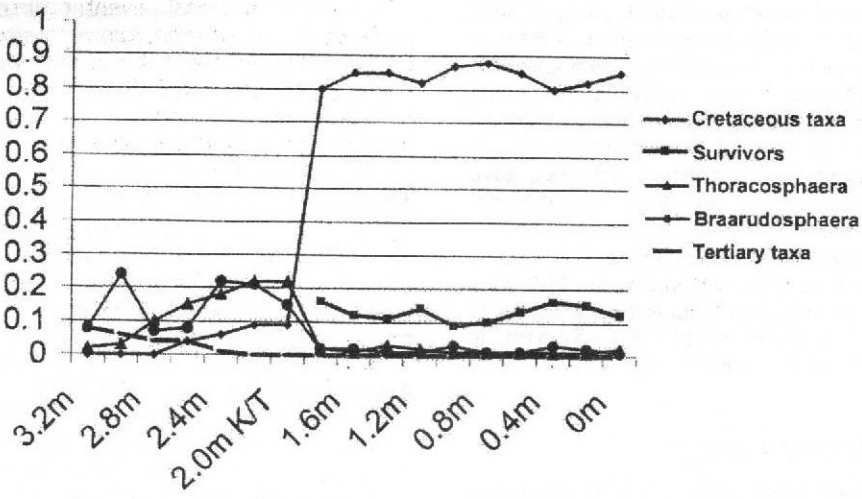

Figure 4 - Nannofloral abundance in the Pietroşiţa section

Ceratolithoides aculeus, *Lithraphidites quadratus* and common *Chiastozygus* spp., *Cretarhabdus crenulatus*, *Micula decussata*, *Prediscosphaera cretacea*, *P. stoveri*. *Watznaueria barnesae* represents 9-20% from the total nannofloral assemblages.

The first occurrence of *Micula prinsii* was identified 2.2m below the *Thoracosphaera* spp.

It is noteworthy that, in the studied succession, the *Thoracosphaera* bloom (over 20% from the total nannofloral assemblage) is not synchronous with the *Braarudosphaera* one, as they were identified in the Lepsa section. In the Pietrosita section the bloom of *Braarudosphaera* shortly follows that of *Thoracosphaera* (in 15cm).

In the stratigraphic succession follows an interval (10cm) of decreasing frequency of *Braarudosphaera* (between 10-15% from the total nannofloral assemblage), then another bloom.

Within the first *Braarudosphaera* bloom interval, the first occurrence of *Biantholithus sparsus* was observed, while in the second bloom interval of *Braarudosphaera*, the first consistent occurrence of *Neobiscutum parvulum* was identified, together with the first occurrence of *Cruciplacolithus primus*.

The surviving species *Cyclagelosphaera alta* and *C. reinhardtii* are quite common (up to 5-6% from the total nannofloral assemblages).

Octolithus multiplus, *Biscutum* spp and *Zygodiscus spiralis*, other nannofloral survivors, are also common (between 4-8% from the total nannofloral assemblages), while *Markalius inversus* is common only shortly after the K/T boundary, then it became rare.

Concerning the Tertiary species observed in the Pietrosita Section, they are the same as those identified in the Lepsa Section. Noteworthy is also the first occurrence of *Neobiscutum romeinii* (PERCH-NIELSEN) VAROL, 1989.

A chart of the abundance, in percentage, of *Braarudopshaera* spp, *Thoracosphaera* spp., Cretaceous taxa, Tertiary and survivor ones from the Pietrosita Section is given in Figure 4.

BIOSTRATIGRAPHY

The calcareous nannofossil study of two sections from the East Carpathians allows the identification of the nannofloral zones, characterizing the Upper Maastrichtian – Lower Paleocene interval.

Nephrolithus frequens Zone (Sissingh, 1977)

This zone was identified in both studied sections, based on the nannofossil assemblages containing the index species *Nephrolithus frequens*, as well as common *Micula murus*, *Lithraphidites quadratus*, *Micula decussata*, *Arkhangelskiella cymbiformis*, *Cretarhabdus* spp., *Biscutum* spp., *Zygodiscus spiralis*, *Ahmuellerella regularis*, *Octolithus multiplus*, *Eiffellithus gorkae*, *E. turriseiffelii* and *Cyclagelosphaera* spp.

The *Nephrolithus frequens* Nannofossil Zone corresponds, in the Lepsa section, with the *Abathomphalus mayaroensis* and lower part of *Plummerita kantkeninoides* Foraminiferal Zones.

Micula prinsii Zone (Romein, 1979)

The base of this zone (the first occurrence of the index species) was identified in the Lepsa Section within the *Plummerita kantkeninoides* Foraminiferal Zone

The top of *Micula prinsii* zone corresponds with the extinction of the most Cretaceous nannofossil taxa, situated slighly before the bloom of the *Thoracosphaera* spp.

Biantholithus sparsus Zone (Perch-Nielsen), 1971, emend. Romein, 1979

This zone extends, in the present study, from the first bloom of *Thoracosphaera* spp. to the first occurrence of *Cruciplacolithus primus*.

The *Biantholithus sparsus* Nannofossil Zone was correlated, in the Lepsa Section, with the *Globigerina (Parvularugoglobigerina) eugubina* and the lower part *Globotruncana (Eoglobigerina) bulloides* Foraminiferal Zones.

It is noteworthy that *Biantholithus sparsus* Nannofossil Zone was divided by Perch-Nielsen (1981) into two subozones: *Neobiscutum romeinii* and *Neobiscutum parvulum*, based on the first occurrence of the index species.

It seems that the index species used for defining these subzones are mostly related to low latitudes. *Neobiscutum romeinii* and *Neobiscutum parvulum* are common in the Early Danian from Tunisia (Perch-Nielsen, 1981). They are also reported as common from NE Spain (Lamolda & Gorostidi, 1994) and SW France (Gorostidi & Lamolda, 1995).

In the studied section from the East Carpathians the above mentioned species were identfiied as rare.

Neobiscutum romeinii was observed only in the Pietrosita Section. *Neobiscutum parvulum* was identified in both studied sections, with its first occurrence situated in the Lepsa Section in the uppermost part of the *Globigerina (Parvularugoglobigerina) eugubina*

Cruciplacolithus primus Zone, Romein (1979)

The base of this zone, marked by the first occurrence of the index species, is situated, in the Lepsa Section, within the *Globotruncana (Eoglobigerina) bulloides* Planktonic Foraminiferal Zone.

CONCLUSIONS

The calcareous nannofossil study of two sections from the East Carpathians (Romania) offered evidence for a continuous sedimentation between the Cretaceous and the Tertiary.

The Upper Maastrichtian is characterized by the presence of *Nephrolithus frequens* and *Micula prinsii* Nannofloral Zones.

The base of the Tertiary is characterized by the *Thoracosphaera* and *Braarudosphaera* blooms.

Besides the *Braarudosphaera* and *Thoracosphaera* taxa, other survivors, crossing the K/T boundary, are the nannofossils: *Markalius inversus*, *Biscutum* spp., *Bidiscus* spp., *Cyclagelosphaera alta*, *Cyclagelosphaera reinhardtii*, *Octolithus multiplus* and *Zygodiscus spiralis*.

In the Lepsa Section, the presence of some Cretaceous taxa, such as: *Cretarhabdus* spp., *Prediscosphaera* spp., *Eiffellithus* spp., *Micula decussata*, *Micula prinsii* within the Early Danian, could be explained by reworking, due to the turbiditic sedimentation.

In both studied sections, slightly above the *Thoracosphaera* bloom, the first occurrence of the Tertiary nannofossil taxa: *Biscutum sparsus*, *Neobiscutum romeinii*, *N. parvulum* and *Cruciplacolithus primus* was identified.

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