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THE STRATIGRAPHY OF THE UPPER CRETACEOUS MARINE SEDIMENTS FROM THE NW HATEG AREA (SOUTH CARPATHIANS, ROMANIA)

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Abstract. This paper presents the results of a study carried out in the NW Hateg area and focussed on the stratigraphy of the Upper Cretaceous marine deposits. The fieldwork investigations allow us to separate three lithological units: the Quartzous Sandstone Formation, the Stei Formation and the Rachitova Formation. The age of the above described marine deposits was assigned based on calcareous nannofossil investigations, as follows: the Stei Formation covers the Middle Coniacian-Upper Santonian interval (CC14 up to CC18-19 Nannozones), while the Rachitova Formation sediments are Uppermost Santonian-Uppermost Campanian in age (CC18-CC19 up to CC22 Nannozones).

Keywords: Upper Cretaceous, Marine sediments, Stratigraphy, Nannofossils, Hateg.

INTRODUCTION

The stratigraphical study of the Upper Cretaceous deposits of Hateg (an area located in the western South Carpathians, Figure 1) started already at the beginning of the last century (Nopcsa, 1902). Following these early studies, most of the investigations carried out in Hateg were focussed on the lithology and paleontology of the continental Maastrichtian deposits, famous for their dinosaurs remains (Laufer, 1925; Grigorescu, 1983, 1990; Grigorescu *et al.*, 1985). Besides the continental deposits, Upper Cretaceous marine sediments, displaying a large facial variety, outcrop in the NW and SE Hateg area. The studies of the marine Upper Cretaceous deposits were more concentrated so far in the SE Hateg zone (Mamulea, 1953; Pop *et al.*, 1972; Pop & Szasz, 1973; Stilla, 1985; Pop *et al.*, 1990) and less in the NW one (Pop, 1990).

The aim of this paper is to present a detailed stratigraphy of the Upper Cretaceous marine sediments from the NW part of the Hateg area, based on lithological and micropaleontological investigations.

The studied area, extending from the Rachitova village, in the northern part, up to the Criva Valley, in the south, was studied in the field, lithological and tectonical points of view, allowing us to obtain a detailed map (Figure 2). Three sections, Rachitova, Stei and Criva, were detailed sampled and analyzed for their calcareous nannofossil content.

LITOSTRATIGRAPHY

The Upper Cretaceous sediments of NW Hateg area represent the post-tectonic cover of the Median Dacides (*sensu* Sandulescu, 1984), unconformable overlaying the Precambrian rocks of the crystalline basement, belonging to the Getic and Supragetic Nappes (Codarcea and Dimitrescu, 1967).

The oldest sediments, ***"the Quartzous Sandstone Formation"***, are represented by 150-200m of gray-yellowish quartzous sandstones, with local basal polymictic conglomerates and subordinately, by grey argillaceous siltstones. The lower part of this formation was assigned to the Upper Albian, based on microfloras identified by Antonescu in Pop *et al.*, 1990, while its upper part is Cenomanian in age, according to the macrofaunas reported by Maier & Lupu (1979).

The above described lithological unit is unconformably covered by 200-250m of hemipelagic sediments (Figure 3), made up by white and gray marls and calcarenites, which we named herein ***"the Stei Formation"***. It is to remark that, in the northern part of the investigated area, in the Rachitova Valley, a sequence composed of 50m of variegated (red and green) marls and calcarenites was

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observed at the base of the Stei Formation. The Rachitova Valley is the only section in the investigated area where the variegated marls could be separated as a lithological unit. More to the south, only thin lenses of "couches rouges" type were identified at the base of the Stei Formation.

The hemipelagic Stei Formation is conformably covered by a turbiditic sequence, described in this paper as "***the Rachitova Formation***", which is the youngest marine succession identified in the studied area. This formation has a thickness between 700 and 900 m and outcrops on large areas around the Rachitova village, as well as further south, in the Stei and Criva valleys.

Two distinct lithological features were observed in the Rachitova Formation.

The lower part is made up by 500-700m of sandy-shaly flysch, characterized by a rhythmical alternance of medium to fine grained, grey, calcareous sandstones, clays and marls. Localy, microconglomerates containing fragments of metamorfic rocks (crystalline schists of Getic type), as well as sedimentary ones (limestones of urgonian type and gray silts and sandstones) were observed.

The upper part of the Rachitova Formation is made up by a shaly flysch, composed by grey-greenish marls and clays, with rare thin fine sandstones, as well as calcarenites interbedded. The thickness of the shaly flysch is 300m in Rachitova Valley, around 150m in the Stei Valley, while further south, in the Criva Valley, it is completely covered by the continental deposits of the Densus Ciula Formation (Figure 3).

BIOSTRATIGRAPHY

Calcareous nannofossils

A total of 47 samples, collected from the Rachitova, Stei and Criva valleys, were investigated for their calcareous nannofossil content.

Preparation of smear-slides for light microscope study followed the technique described in Lamolda *et al.* (1994). The nannofossil analyzes were performed by using an optical Zeiss microscope, with 3200x magnification.

Bibliographical references for the recognized taxa are given in Perch-Nielsen (1985) and Bown (1998).

Both qualitative and quantitative studies of calcareous nannofossils were realized. For each smear-slide at least 300 specimens were counted in randomly distributed longitudinal transverses.

The relative frequency of the nannofossils was considered as follows:

R- rare: 1 specimen > 50 Fields of view;
F- few: 1 specimen at 11 – 50 F.O.V.;
C - common: 1 specimen at 5-10 F.O.V.;
A - abundant: 1 specimen at 1-4 F.O.V

A total of 57 calcareous nannofossil taxa were identified in the studied samples. The distribution of the identified taxa and their relative frequency is given in Figure 4.

The preservation of the observed nannofloral assemblages is moderate to good. A better preservation of the calcareous nannoplankton taxa was remarked in the hemipelagic sediments of the Stei Formation, while the nannofossils from the turbiditic sediments of the Rachitova Formation showed slight to moderate overgrowth and partial dissolution of some taxa, but the specific identification is not hindered.

The calcareous nannofossil assemblages are dominated by *Watznaueria barnesae* (BLACK *in* BLACK & BARNES) PERCH-NIELSEN, 1968, which represents 15-22% from the total nannofloras. Common taxa are also the species of *Cretarhabdus*, *Calculites*, *Eiffellithus*, *Eprolithus*, *Lucianorhabdus*, *Micula*, *Nannoconus* and *Prediscosphaera* genera.

Concerning the character of the nannofloras identified in the Upper Cretaceous sediments of the NW Hateg area, this is cosmopolitan and tethyan. The presence, within the Upper Campanian, of common *Ceratolithoides aculeus* (STRADNER) PRINS & SISSINGH *in* SISSINGH, 1977, *Uniplanarius sissinghi* PERCH-NILESEN, 1986 and *U. trifidus* (STRADNER *in* STRADNER & PAPP) HATTNER & WISE, 1980, species related to the south-middle latitudes (Svabenicka, 1995; Wagreich, 1992), argue for the tethyan character of the nannofloras encountered.

Nannofossil Zones

The nannofossil zones identified in the Upper Cretaceous sediments of the NW Hateg area are those from the Sissingh's Zonation (1977), recalibrated by Burnett (1996, 1998), Lamolda *et al.* (1999), Melinte (1997) and Melinte & Odin (2001).

Based on the calcareous nannofossil studies several biozones, covering the Middle Coniacian-Uppermost Campanian were recognized, as follows (Figure 5):

- CC14 (*Micula staurophora* Zone) was identified from the base of the Stei Formation, in the variegated marls. The nannofloras characterizing this zone contain, as significant taxa: *Micula staurophora* (GARDET) STRADNER, 1963, *M. concava* (STRADNER in

MARTINI & STRADNER) BUKRY, 1969, *Eiffellithus eximius* (STOVER) PERCH-NIELSEN, 1968, *E. turriseiffelii* (DEFLANDRE *in* DEFLANDRE & FERT) REINHARDT, 1965, *Nannoconus truittii* BRÖNIMANN, 1955, *N. multicadus* DEFLANDRE & DEFLANDRE-RIGAUD, 1959, *N. elongatus* BRÖNIMANN, 1955, *Quadrum gartneri* PRINS & PERCH-NIELSEN *in* MANIVIT *et al.*, 1977, *Eprolithus floralis* (STRADNER) STOVER, 1966 and *Lithastrinus septenarius* FORCHHEIMER, 1972.

The age of this biozone is considered to be Middle Coniacian, taking into account the studies of Melinte (1999), who calibrated this nannozone with the *Peroniceras tridorsatum* Ammonite Zone in Romania.

- CC15 (*Reinhardtites anthophorus* Zone), was identified from the lower part of the Stei Formation, below the litjhological boundary between the variegated Marls and the grey marls and calcarenites. The base of the biozone was recognized based on the FO of *Reinhardtites anthophorus* (DEFLANDRE) PERCH-NIELSEN, 1968. As common species are: *Eiffellithus eximius*, *E. turriseiffelii*, *Eprolithus floralis*, *Micula staurophora*, *M. concava*, *Nannoconus truittii*, *N. multicadus*, *N. elongatus*, *Quadrum gartneri* and *Prediscosphaera* spp.

As concerning the age of this biozone, previous studies (Sissingh, 1977 and Perch-Nielsen, 1985) assigned it to the Lower Santonian. Recent integrated biostratigraphical studies (Burnett, 1998; Merlinte, 1999) pointed out that *Reinhardtites anthophorus* first occurred around the Middle/Upper Coniacian boundary, both in the Tethys and in the Boreal Realms. Taking into account these data, it can be stated that the CC15 Nannozone covers the Middle-Upper Coniacian Interval.

- CC16 (*Lucianorhabdus cayeuxii* Zone) was identified based on the FO of the index species, obsrved in the Stei Formation, from the lower part of the gray marls, interbedded with calcarenites. This nannozone characterized the Coniacian/Santonian Boundary Interval in the marine sediments of the Tethys Realm (Lamolda *et al.*, 1999; Melinte & Lamolda, 2001). The nannofossil assemblages characterizing this zone in the studied sections are dominated by the taxa of the genera *Lucianorhabdus* (*L. cayeuxii* DEFLANDRE. 1959 and *L. quadrifidus* FORCHHEIMER, 1972) and *Calculites*, as well as by common to abundant *Watznaueria barnesae*, *Prediscosphaera* spp., *Eiffellithus* spp., *Nannoconus* spp., *Micula staurophora* and *Micula concava*.

- CC17 (*Calculites obscurus* Zone). The base of this zone, pointed out based on the common occurrence of the index species, was identified from the upper part of the Stei Formation. Other significant bioevents identified in this biozone are: the FO of *Orastrum campanensis* (CEPEK) WIND & WISE *in* WISE & WIND, 1977, slightly above the base, followed by the FO of *Prediscosphaera arkhangelskii.* (REINHARDT) PERCH-NIELSEN. 1984. The nannofloral assemblages of this zone are dominated by *Watznaueria barnesae*, as well as by the species of the genera *Lucianorhabdus*, *Eiffellithus*, *Prediscosphaera*, *Micula*, *Nannoconus* and *Calculites.* Rare *Eprolithus floralis*, *Lithastrinus grillii* and *L. septenarius* were also observed. The age of this biozone was assigned to Santonian *pro parte*.

- CC18-CC19 Zones (*Aspidolithus* ex gr. *parcus-Calculites ovalis* Nannozones). The base of the CC18 Biozone, identified based on the FO of *Aspidolithus parcus constrictus,* is placed in the upper part of the Stei Formation. The base of the CC19 Biozone (characterized in the Sissingh's Scheme by the LO of the nannofossil *Marthasterites furcatus*) could not be identified, due to the frequent reworkings. M. furcatus was identified higher than it it normally reported, including in the CC20 Nannozone (Campanian) A significant bioevent remarked within the interval covered by the CC18-CC19 Nannozones is the FO of *Ceratolithoides verbeekii.*

- CC20 (*Ceratolithoides aculeus* Zone) was observed starting from lower part of the Rachitova Formation (the sandy flysch), based on the FO of the index species. Concerning the age, it is widely accepted that this nannozone covers the Lower/Upper Campanian boundary interval.

- CC21 (*Uniplanarius sissinghi* Zone). The biozone, was identified, as in the definition of Sissingh, 1977, between the FO of *Uniplanarius* (= *Quadrum*) *sissinghi* and *Uniplanarius* (= *Quadrum*) *trifidus.* This nannozone zone extends in the Upper Campanian (pro parte), within the upper part of the sandy-shaly flysch pf the Rachitova Formation. A significant event observed in the investigated deposits belonging to this nannozone is the LO of the nannoconids.

- CC22 (*Uniplanarius trifidus* Zone). The base of this zone is marked by the FO of the index species, observed from the upper part of the Rachitova Formation (the shally flysch). Concerning the age of the lower part of CC22 Nannozone, this is considered to be Upper Campanian, as it was identified by Melinte & Odin (2001) in the Global Point Stratotype Section of the Campanian/Maastrichtian Boundary from Tercis-les-Bains (France).

The nannofloras of the CC22 Biozone from the NW Hateg area contains, besides common cosmopolitan taxa belonging to the genera *Calculites*, *Cretarhabdus*, *Chiastozygus*, *Eiffellithus*, *Microrhabdulus*, *Prediscosphaera*, *Tranolithus*, *Zeugrhabdothus* and *Watznaueria*, frequent tethyan taxa, as: *Uniplanarius trifidus*, *U. sissinghi*, *Ceratolithoides aculeus* and *C. arcuatus*.

CONCLUSIONS

The Upper Cretaceous marine sediments, from the NW Hateg area were detalied studied litho- and biostratigraphical points of view.

The lithostraphical studies pointed out the deposition of three lithological units, which are in stratigraphical order: the Quartzous Sandstone Formation, the Stei Formation and the Rachitova Formation. The youngest two formations, Stei and Rachitova were detailed sampled and studied for their calcareous nannofossil content.

Based on the calcareous nannofossil assemblages, the age of the Stei and the Rachitova Formations was assigned as follows:

- The Stei Formation belongs to the Middle Coniacian - Upper Santonian interval (the CC14-CC18 Nannozones respectively).
- The Rachitova Formation is uppermost Santonian - Upper Campanian in age (the upper part of the CC18 - the lower part of the CC22 Nannozones).

These results indicate that a marine sedimentation took place in the NW Hateg area, during the Upper Cretaceous, the youngest Cretaceous marine deposits from the studied area being Upper Campanian in age.

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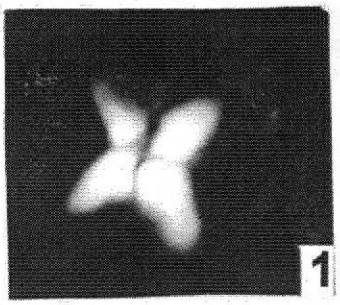
PLATE I

Light microscope, x 3200
Figures 1, 3-7,9-11 and 13-15 in crossed nicols; Figs. 2, 8 and 12 in polarized light.

Figures 1, 2. *Uniplanarius sissinghii* Perch-Nielsen 1986; sample R37, Upper Campanian, Rachitova Formation.
Figure 3. *Uniplanarius trifidus* (Stradner *in* Stradner and Papp, 1961) Hattner and Wise, 1980; sample R33, Upper Campanian, Rachitova Formation
Figure 4. *Eiffellithus turriseiffelii* (Deflandre *in* Deflandre 1nd Fert, 1954) Reinhardt, 1965; sample R23, Middle Coniacian, Stei Formation.
Figure 5. *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968; sample R18, Upper Santonian, Stei Formation.
Figure 6. *Helicolithus trabeculatus* (Górka, 1957) Verbeek, 1977; sample R28, Upper Coniacian, Stei Formation.
Figure 7. *Braarudosphaera bigelowii* (Gran and Braarud, 1935), Deflandre, 1947; sample R37, Upper Campanian, Rachitova Formation..
Figure 8. *Eprolithus floralis* (Stradner, 1962) Stover, 1966; sample R23, Middle Coniacian, Stei Formation.
Figure 9. *Quadrum gartneri* Prins and Perch-Nielsen *in* Manivit *et al.*, 1977, 1980; sample R8, Middle Santonian, Stei Formation.
Figure 10. *Nannoconus truitti* Brönnimann, 1955 and *Watznaueria barnesae* (Black, 1959) Perch-Nielsen, 1968; sample R6, Lower Campanian, Rachitova Formation.
Figure 11. *Micula staurophora* (Gardet, 1955) Stradner, 1963; sample R23, Middle Coniacian, Stei Formation.
Figure 12. *Nannoconus truittii* Brönnimann 1955; sample R10, Lower Santonian, Stei Formation.
Figure 13. *Lucianorhabdus cayeuxii* Deflandre, 1959; sample R28, Upper Coniacian, Stei Formation.
Figure 14. *Ceratolithoides aculeus* (Stradner, 1961) Prins and Sissingh *in* Sissingh, 1977; sample R33, Upper Campanian, Rachitova Formation
Figure 15. *Zeugrhabdotus embergeri* (Noël, 1958) Perch-Nielsen, 1984; sample R7, Lower Campanian, Rachitova Formation.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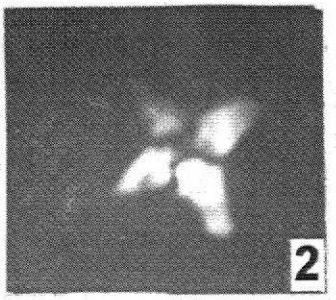
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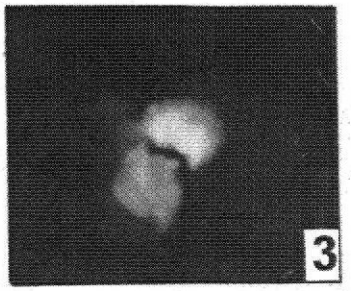
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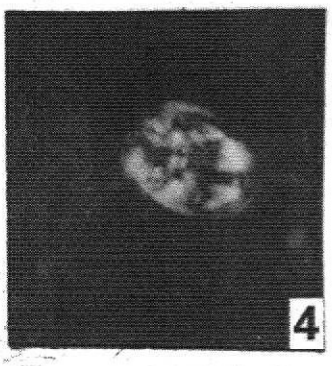
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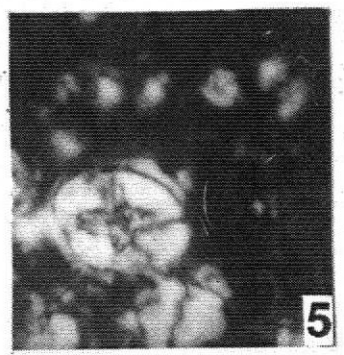
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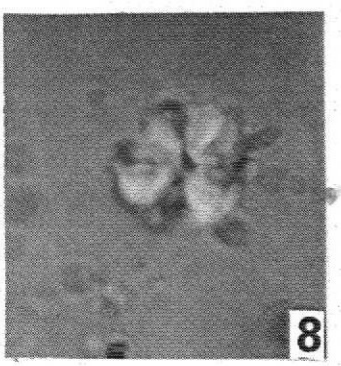
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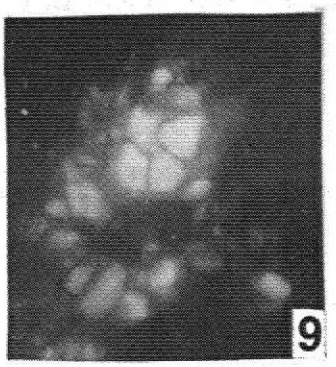
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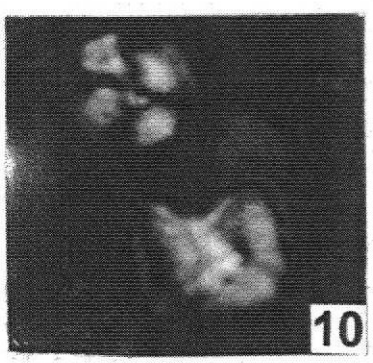
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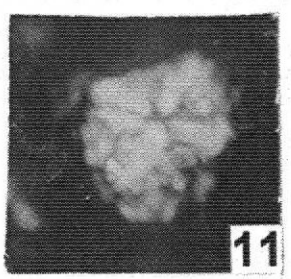
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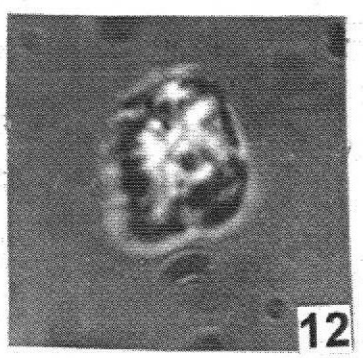
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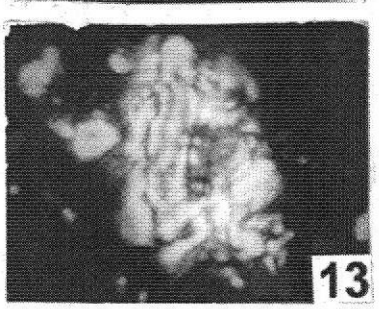
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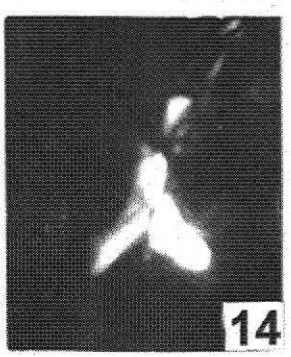
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