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NEW UPPER CRETACEOUS DEPOSITS IN THE SOUTH-EASTERN TRASCĂU MOUNTAINS (APUSENI MTS., ROMANIA)

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Abstract. Upper Cretaceous syn-orogenic deposits from south and south-eastern Apuseni Mountains play a crucial role in deciphering the evolution of this orogen. Therefore, the proper identification and description of the Upper Cretaceous sediments within this region is of special importance. Located in the south-eastern part of Trascău Mountains (Apuseni Mts.), the area between Ighiel and Mănăstirii valleys was described as Lower Cretaceous in age, the sediments being assigned to Meteş and Feneş Formations. For the first time, calcareous nannofossils studies were perform in the area in order to check the age of these sediments. Based on the presence of *Micula staurophora* and *Quadrum gartneri*, an Upper Cretaceous unit was identified. The lithological characteristics of this unit, as rhythmic alternation of sandstone and clay/marls are very similar with those of Râmeți Formation, which outcrop north of the studied area. These points to the existence of a Râmeți-like, Upper Cretaceous band in the eastern part of Trascău Mountains, which can represent a south-eastern prolongation of Râmeți Formation.

Keywords: calcareous nannoplankton, turbidites, Upper Cretaceous, Râmeți Formation, Trascău Mountains, Apuseni.

1. INTRODUCTION

The calcareous nannoplankton is minute unicellular photosynthetic protists, members of the group Haptophyta. Their first appearance is registered in Upper Triasic, and their descendants can still be found today, in abundance, in the shallow waters of nowadays oceans.

The calcareous nannoplankton have a high biostratigraphical importance because (1) are very abundant in marine sediments, (2) have a large geographical distribution and (3) rapid changes in their evolution are registered in sediments and can be used for subtle division of the geological timescale (Siesser, 1993). For Cretaceous, the most used biozonation schemes are those of Sissingh (1977), Perch-Nielsen (1985), Bown et al. (1998) and Burnett (1998).

Belonging to the Alps-Carpathians-Dinarides chain, the Apuseni Mts. were formed during Upper Cretaceous, as a result of collision of Tisia and Dacia microplates, the suture between them being positioned in the south and southeastern part of the mountains. Therefore, the Upper Cretaceous syn-orogenic sediments from this part of the Apuseni Mts. hold important clues in understanding the creation and evolution of this orogen, and it is very important to be corectly located in the field and properly studied.

The area selected for study is located in south-eastern part of Trascău Mountains, west of Mureş Valley, between Ighiel and Mănăstirii Brooks (Fig. 1). It has been described as consisting only of Lower Cretaceous deposits, from both Meteş and Feneş Formations (e.g. Lupu et al., 1967; Ion, 1985). However, giving the possibility of existence in the area of Upper Cretaceous sediments (e.g. Antonescu, 1973, 1974), we performed a systematical research in order to clarify this hypothesis. Our study focused on calcareous nannoplankton, because of their high biostratigraphical resolution. Along with these, lithological and sedimentological observations were performed.

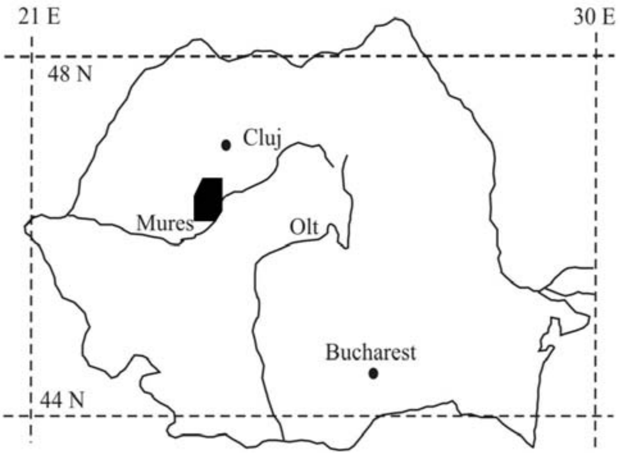


Figure 1. Location of the studied area (black polygon) on the map of Romania.

Previous studies focused on the mineralogical and petrographical characteristics of the sedimentary rocks from the studied area (Ilie, 1950; Bleahu & Dimian, 1963, 1967), and tried to determine the age based on micropalaeontological analyses: foraminifera (Bleahu et al., 1968; Bordea, 1971; Ion, 1985) and spores and pollens (Antonescu, 1973). Because some of the micropaleontological data were inconclusive, the ages were assigned based on superposition criteria (Ianovici et al., 1976). The present study is the first attempt to determine the age of the deposits in the studied area based on calcareous nannofossils content.

2. GEOLOGICAL SETTING

The Apuseni Mountains originate from the Preapulian Craton (Săndulescu, 1994) and from the Transylvanian Tethys (Săndulescu, 1984). From tectonical point of view, Apuseni Mts. consist of three large units, namely Bihor Unit (Autochtonous), Apusenides and Western Transylvanides. Three deformation periods affected the Apuseni Mts.: Austrian, Pregosau and Laramian (Bleahu et al., 1981). The Transylvanides were emplaced during the Austrian tectonic phase and reworked during the Laramian one. The Pregosau tectonic phase sheared only the Apusenides (Bleahu et al., 1981; Balintoni, 1997).

Transylvanides are obduction nappes (Săndulescu, 1984) with ophiolites and associated sedimentary suites, and, according with the main tectogenetic event which affected different parts of the unit, they are subdivided into Laramian and Austrian units (Balintoni, 1997). In the studied area, the Transylvanides are grouped within Feneş Nappe, which comprise two Lower Cretaceous units (Meteş and Feneş Formations) and two Upper Cretaceous ones (Bozeş and Râmeţi Formations) (Bleahu et al., 1981; Lupu, 1975) (Fig. 2A). Their stratigraphical succession is summarized in figure 3.

2.1. Lower Cretaceous units

Feneş Formation (defined by Bleahu & Dimian, 1967, redefined by Lupu et al., 1980) is represented by a volcano-sedimentary-calcareous olistostrome which includes flysch sequences. At the bottom, a thick sequence of quartz sandstones and gray clays, slumped clays with interbedded tuffs and spilitic lavas can be observed. The succession continues with thin bedded micritic limestones, locally with stromalitic character. The age of the formation is Barremian-Aptian (Bleahu et al., 1981).

Meteş Formation, as defined by Bleahu & Dimian (1967), overlies the Feneş Formation, and shows a wildflysch character. It consists of two sub-units: a "lower" member, characterized by an olistostrome-like marly-silty facies with some interbedded turbiditic and thick layered sandstones, and an "upper" member represented by breccias with silty-marly matrix and olistholits representing Upper Jurassic limestones, ophiolitic and granodioritic rocks, and Lower Cretaceous sandstones (Bleahu et al., 1981). It is latest Aptian – Middle Albian in age.

2.2. Upper Cretaceous units

Râmeţi Formation (Bordea et al. 1968; Bleahu et al., 1981) is build up by the polymictic conglomerates, followed by flysch sequences within which the quartz sandstones, with calcitic cement, alternate with marls and marly clays. Olistoliths of Stramberk-like limestones can be also observed. Based on micropaleontological (Lupu fide Bleahu et al., 1981) and palinological data (Antonescu, 1974), the age of this formation is Upper Aptian – Senonian.

Bozeş Formation (as defined by Ghiţulescu & Socolescu, 1941; Lupu et al., 1980; Bleahu et al., 1981) represents the uppermost unit among the western Transylvanides. It consists of 3000m-thick, turbidite-type sedimentary sequence (mainly grey sandstones and silty marls, with microconglomeratic levels in the upper part). The Santonian age is supported by microfaunal data (Dimian & Popa-Dimian, 1964; Marincaş, 1973). Above the flysch-like sequence, conglomeratic levels occur interbedded with silty sandstones of Campanian –

Maastrichtian age (Bleahu et al., 1981). Therefore, the Bozeş Formation is of Santonian – Campanian – lower Maastrichtian age.

3. MATERIAL AND METHODS

As mentioned, the area selected for study is described as consisting only of Lower Cretaceous deposits, from both Meteş and Feneş Formations. We followed the stratigraphical succession on nine valleys between Ighiel and Mănăstirii valleys, which, according with the geological map of Romania 1:200.000, Turda sheet (Lupu et al., 1967), are considered to display the transition from Meteş to Feneş Formations. However, only three sections, Bucerdea Vinoasă, Craiva and Tibru, as the most representative, are going to be presented herein. All the above-mentioned sections were studied in detail, lithological and sedimentological observations being performed.

To date the studied deposits, calcareous nannoplankton analyses were achieved. Sampling was realized at 30 cm intervals. The samples for calcareous nannofossils studies were prepared with standard smear slides technique for light microscope (LM) observation. The investigations were carried out under LM at a magnification of 1000x using parallel and crossed polars.

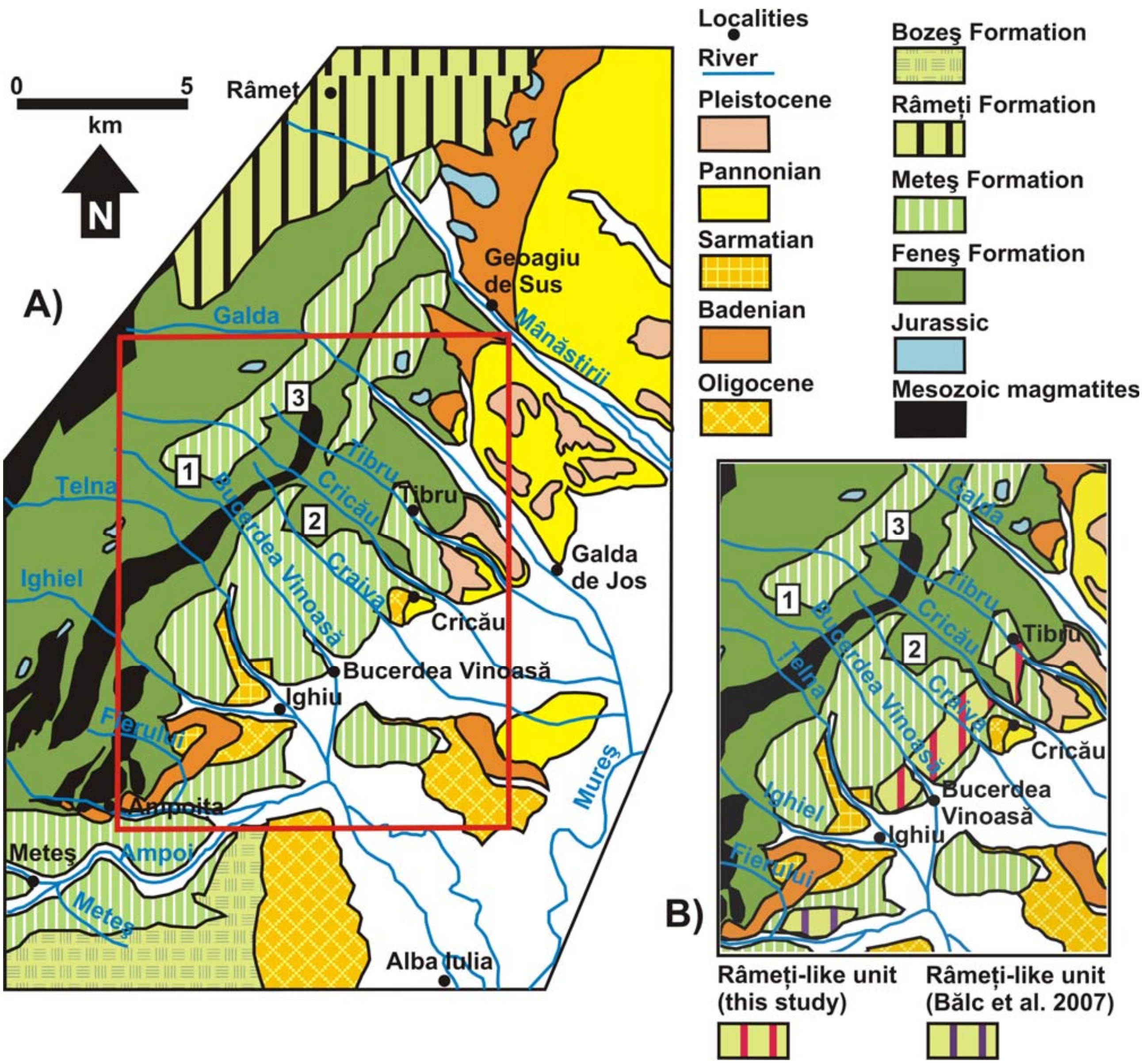


Figure 2. A) Simplified geological map of the studied area.
B) Detail of the studied area (red polygon from A)), showing the approximate location and size of the newly identified Râmeţi-like Upper Cretaceous units.
The numbers (1-3) indicate the valleys presented in this study (redrawn after Lupu et al., 1967).

The present study is based on qualitative analysis of calcareous nannofossils assemblages. Nannofossil zones were recognized using the Tethyan Late Cretaceous zonal schemes of Sissingh (1977) and Perch-Nielsen (1985).

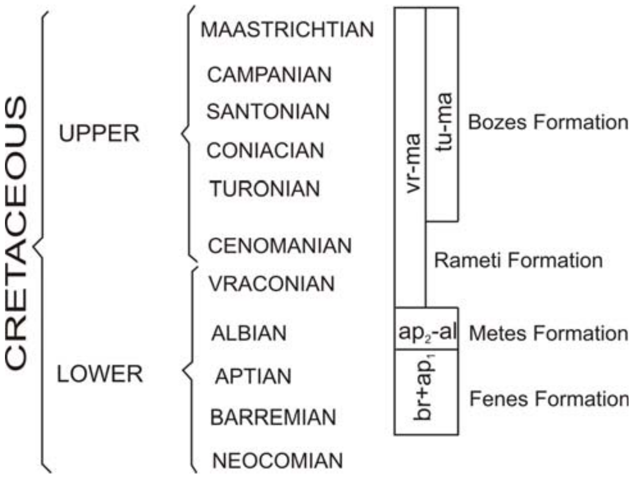


Figure 3. Stratigraphical succession of the Cretaceous formations from the south-eastern Trascău Mts. (simplified after Lupu et al., 1967).

4. RESULTS

Although folded, the general orientation of strata is E to ENE and ESE. The stratigraphical succession was observed going upstream, from young to older sediments, respectively from Meteş to Feneş formations.

4.1. Bucerdea Vinoasă Valley

The lithological succession begins with sandstones and clays alternation; upstream it turns into predominantly conglomeratic. The finer grained lower part of succession is not displaying the typical wildflysch characteristics of Meteş Formation. Ophiolites can also be noted as local intrusions. Upstream, the phylites of Feneş Formation were intercepted, similar with those described by Suciu-Krausz et al., (2006).

For calcareous nannofossils analysis marly and clayey levels were sampled. Most of them are barren in calcareous nannofossils. The only levels which provide information are those located at the lowest part of the valley, exactly in the "non Meteş"-like part of the succession. The identified assemblage contains:

- large range taxa: *Watznaueria barnesae, Eprolithus floralis. Zeugrhabdotus scutula, Retecapsa angustiforata, Zeugrhabdotus diplogrammus, Retecapsa crenulata, Zeugrhabdotus erectus, Manivitella pemmatoidea, Tranolithus orionatus. Helenea* cf. *chiastia*.
- Lower Cretaceous taxa: *Diazomatolithus lehmanii, Hayesites* cf. *albiensis, Rhagodiscus asper, Assipetra terebrodentarius, Assipetra terebrodentarius youngii, Tubodiscus burnettiae*.
- Upper Cretaceous taxa: *Eiffelithus turriseiffellii, Stoverius achylosus, Prediscosphaera cretacea, Eprolithus octopetalus, E. moratus, Micula staurophora.*
- few undetermined taxa, due to the overgrowths which made impossible their identification.

Based on the presence of the youngest species, as marker species, *Micula staurophora*, those first occurence (FO) is upper Coniacian, the studied deposits can be considered of a similar age.

The character of the above mentioned calcareous nannofossils assemblage is totally different from those described before in South Apuseni Mountains (Bălc & Chira, 2002; Chira et al., 2004; Bălc et al., 2007).

4.2. Craiva Valley

The lithological succession includes alternations of folded layers of altered conglomerates (downstream) and sandstones, with finer clayey/marly interbeds, the last ones similar with those "non-Meteş" from Bucerdea Vinoasă. Going upstream, in the wildflysch part of the sedimentary succession, Urgonian limestone with Orbitolinides was also identified, Lower Cretaceous in age as constrained by the Orbitolinides. The next deposits are represented by grey sandstones with trovants and high mica and quartz input.

From micropaleontological point of view, the situation is similar to the one described on Bucerdea Vinoasă valley. Only the bottommost levels contain calcareous nannoplankton. The first levels provided few fragments of *Watznaueria barnesae* and *Zeugrhabdotus embergeri*, the calcareous nannofossils assemblage being strongly affected by dissolution and overgrowths. The next levels are richer in nannoplankton species, and contain Lower Cretaceous taxa (e.g. *Watznaueria britannica, Helenea chiastia, Retecapsa surirella, Cruciellipsis cuvillieri, Anfractus* cf. *harrisonii*), and large range taxa. From Upper Cretaceous taxa, have been identified here only *Micula staurophora* and *Quadrum gartneri*, which constrain the age for the nannoplankton-bearing deposits as upper Coniacian.

4.3. Tibru Valley

This valley displays a similar situation with the two already mentioned sections, Bucerdea Vinoasă and Craiva, from both, lithological and micropaleontological points of views. The lithological succession is also similar: a rhythmical alternation of conglomerates, sandstones and finer clayey/marly sediments.

Only in the lowest part of the valley, microfossils have been identified. The calcareous nannoplankton assemblage is characterized by low abundance, the following species being identified: *Watznaueria barnesae, Tranolithus orionatus, Cyclagelosphaera reinhardtii, Zeugrhabdotus scutula, Z. embergeri, Retecapsa crenulata, Assipetra* sp., *Cylindralithus* sp., *Eprolithus* sp., *Micula staurophora.* The age is upper Coniacian, as pointed by the presence within the assemblage of the *Micula staurophora*.

5. DISCUSSIONS

5.1. Calcareous nannofossils assemblages and their significance

Representative nannoplankton specimens from the study area, photographed under LM, are illustrated in Plate 1, while their occurrence in the Cretaceous is listed in table 1.

The assemblage containing large range taxa is characteristic for Upper Aptian – Middle Albian. *Assipetra terebrodentarius youngii* is Aptian taxa (Tremolada & Erba, 2002). Also from Aptian *Tubodiscus burnettiae* is described (Bown in Kennedy et al., 2000).

Concerning the genus *Eprolithus*, the most abundant is *Eprolithus floralis* that has the FO (first occurrence) in Aptian and goes continuously up to Upper Cretaceous. It is a dissolution resistant species. Together with *Watznaueria barnesae* it is frequently present in assemblages starting with Aptian. Roth & Krumbach (1986) have mentioned this species as characteristic taxa for northern latitudes being an indicator for cold and fresh waters.

Eprolithus octopetalus has a short range in the Late Cenomanian-Early Turonian (Varol, 1992). Gorostidi & Lamolda (1993) had reported it only in the upper part of Late Cenomanian. Burnett (1998) identified it only in Early Turonian below the FO of *Quadrum gartneri*, at the base of UC6b subzone. Luciani & Cobianchi (1999) report the FO of *Eprolithus octopetalus* in CC11 Zone, in the lower part of *Helvetoglobotruncana helvetica* Zone. This species was identified in lower Turonian deposits from the southern part of the east Carpathian (Gura Beliei marls) (Cetean et al., 2008).

Table 1. Stratigraphic ranges of indicative Lower and Upper Cretaceous calcareous nannofossils from the studied area.

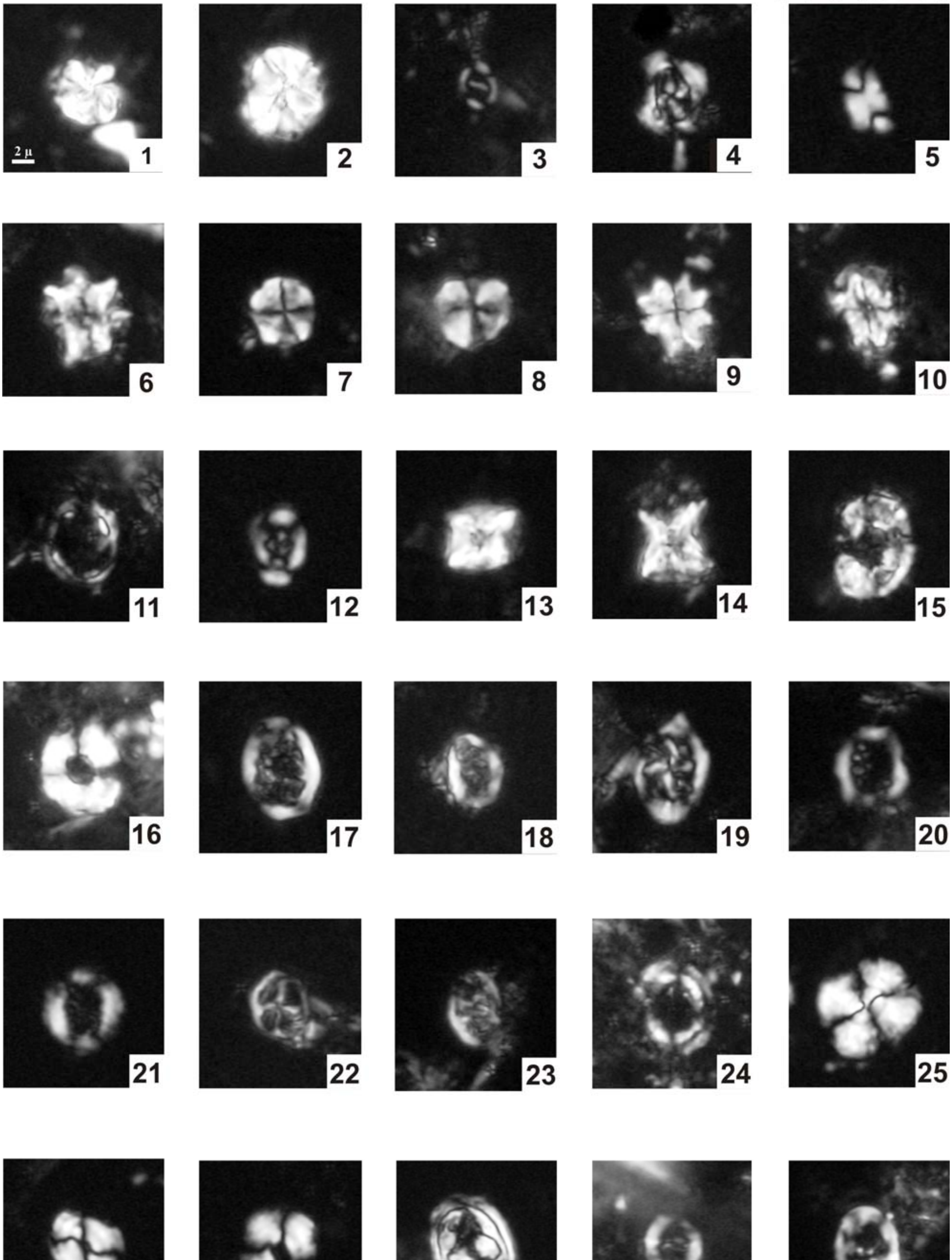
Taxon \ ***Geological Time***	**Rhyazanian**	**Valanginian**	**Hauterivian**	**Barremian**	**Aptian**	**Albian**	**Cenomanian**	**Turonian**	**Coniacian**
	LOWER CRETACEOUS						**UPPER CRETACEOUS**		
Rhagodiscus asper	----------	----------	----------	----------	----------	----------	----------	----------	----------
Diazomatholithus lehmanii	----------	----------	----------	----------	----------	-----|			
Zeugrhabdotus diplogramus		|-----	----------	----------	----------	----------	----------	----------	----------
Zeugrhabdotus scutula			|--------	----------	----------	----------	----------	----------	----------
Assipetra terebrodentarius				|----|					
Eprolithus floralis					|-----	----------	----------	----------	----------
Hayesites albiensis						|----|			
Tranolithus orionatus						|--------	----------	----------	----------
Eiffelithus turriseiffellii						|-----	----------	----------	----------
Prediscosphaera cretacea							|--------	----------	----------
Quadrum gartneri								|--------	-------|
Eprolithus octopetalus							|--------|		
Eprolithus moratus								|-----	----------
Micula staurophora									|----

PLATE I

All images were captured as crossed polars

Figure 1. *Assipetra terebrodentarius* (Applegate et al. in Covington & Wise, 1987) Rutledge & Bergen in Bergen, Bucerdea Valley,
Figure 2. *Assipetra terebrodentarius* (Applegate et al. in Covington & Wise, 1987) Rutledge & Bergen in Bergen, *youngii,* Bucerdea Valley,
Figure 3. *Corollithion signum* Stradner , Craiva Valley,
Figure 4. *Cruciellipsis cuvillieri* (Manivit) Thierstein emend. Wind & Cepek, Craiva Valley,
Figure 5. *Calculites anfractus* (Jakubowski) Varol & Jakubowski, Craiva Valley,
Figure 6. *Eprolithus eptapetalus* Varol, Bucerdea Valley
Figures 7 – 8. *Eprolithus floralis* (Stradner) Stover, Bucerdea Valley and Craiva Valley,
Figures 9 – 10. *Eprolithus octopetalus* Varol, Bucerdea Valley and Craiva Valley,
Figure 11. *Ethmorhabdus hauterivianus* Black, Tibru Valley,
Figure 12. *Helenea chiastia* Worsley, Craiva Valley,
Figures 13 – 14. *Micula staurophora* (Gardet) Stradner, Bucerdea Valley and Craiva Valley,
Figures 15 – 16. *Nannoconus* sp., Kamptner, Craiva Valley,
Figures 17 – 18. *Rhagodiscus asper* (Stradner) Reinhardt, Bucerdea Valley and Craiva Valley,
Figure 19. *Retecapsa angustiforata* Black, Craiva Valley,
Figure 20. *Retecapsa crenulata* (Bramlette & Martini) Grün, Tibru Valley,
Figure 21. *Retecapsa surirella* (Deflandre & Fert) Grün in Grün & Allemann, Craiva Valley,
Figure 22. *Staurolithites crux* (Deflandre & Fert) Caratini, Craiva Valley,
Figure 23. *Tranolithus orionatus* (Reinhardt) Reinhardt, Tibru Valley,
Figure 24. *Tubodiscus burnettiae* Bown in Kennedy et al., Bucerdea Valley,
Figure 25. *Watznaueria barnesae* (Black) Perch-Nielsen, Craiva Valley,
Figures 26 – 27. *Watznaueria ovata* Bukry, Bucerdea Valley and Craiva Valley,
Figure 28. *Zeugrhabdotus embergeri* (Noël) Perch-Nielsen, Craiva Valley,
Figures 29 – 30. *Zeugrhabdotus scutula* (Bergen) Rutledge & Bown, Bucerdea Valley and Tibru Valley.

PLATE I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FO of *Eprolithus moratus* defines the base of UC6b subzone (Burnett, 1998). This event is placed after the LO (last occurrence) of *Eprolithus octopetalus* as it was identified in Bohemian Basin, too (Čech et al., 2005).

Eiffelithus turriseiffelli is a marker species that has the FO in Upper Albian and defines the base of CC9 Zone (Sissingh, 1977; Perch-Nielsen, 1985) or BC27a Zone (Burnett, 1998). It has a continuous range in the entire Upper Cretaceous.

The youngest identified species on the Bucerdea Vinoasă section is *Micula staurophora*. This taxon is used to define the base of CC14 Zone (Sissingh, 1977; Perch-Nielsen, 1985) or UC10 (Burnett, 1998).

Other Upper Cretaceous taxa, identified on Craiva section is *Quadrum gartneri.* FO of this species defines UC7 Zone (Burnett, 1998) or CC11 Zone (Perch-Nielsen, 1985) for lower Turonian and LO is mentioned in upper Coniacian at the top of UC11a Zone (Burnett, 1998).

Thus, based on calcareous nannofossils, between Ighiel and Mănăstirii valleys, Upper Cretaceous deposits have been identified in an area where only Lower Cretaceous deposits were mentioned. This is concordant with some previous, generally ignored, studies which indicated Upper Cretaceous deposits in the same area, based on spore-polinical studies (Antonescu 1973, 1974).

5.2. New Upper Cretaceous deposits and their stratigraphical affiliation

The observations performed along the studied valleys, going upstream, shows the presence of both lithologies, of wildflysch character from Meteş Formation and schistose deposits of Feneş Formation. The boundary between these two formations is not sharp, but rather is represented by a transition zone, where Feneş and Meteş-like sediments alternate.

An important feature is showed by the sediments from the lowest part of all three valleys. Only these sediments, represented by a rhythmic alternation of sandstones and clays/marls, provided calcareous nannofossils, which constrained the age of these deposits to Upper Cretaceous.

In order to check if these new Upper Cretaceous deposits represent an individual unit, or can be related to one of the two Upper Cretaceous formations from the area, namely Râmeți and Bozeş, the lithological features were taken into account.

Bozeş Formation (Santonian – Maastrichtian) can be excluded from the list of possible affiliations, because it is younger that the mentioned deposits, Coniacian in age. In turn, when compare the lithology with that of Râmeți Formation, the sandstone and clays/marls rhythmic alternations of the new unit show striking similarities with those of Râmeți one.

Therefore, based on the lithology similar to that of Râmeți Formation, and on the Upper Cretaceous age as constrained by the calcareous nannofossils assemblages, the presence of Râmeți-like Upper Cretaceous deposits in the lower part of the studied valleys can be inferred. This is not a unique situation, as Campanian (CC18 biozone), Râmeți-like deposits were identified on Fierului Brooke (Fig. 2B), located south from Ighiel Valley (Bălc et al., 2007), and also in a narrow outcrop on Galda valley.

Our studies of the Râmeți Formation (*sensu stricto*) deposits along Mănăstirii Valley reveal the sediments of a similar age and lithology. Therefore we consider that the turbiditic deposits, Upper Cretaceous in age, occurring as a band in the eastern part of Trascău Mountains, can represent a south-eastern prolongation of Râmeți Formation up to Fierului Valley (Fig. 2B). The precise boundaries of this Upper Cretaceous band have to be established through detailed sedimentological studies, and represent a challenge to be accomplished in the future.

In the last years, the number of newly identified Upper Cretaceous units in the southern and south-eastern part of Apuseni Mts. increased, being either sedimentary deposits (e.g. this study; Bălc et al., 2007) or volcanic rocks (Constantina et al., 2009). This situation changes radically the geological distribution of the Upper Cretaceous units in an area which is very important for deciphering the formation and geodynamic evolution of the Apuseni orogen.

5. CONCLUSIONS

Calcareous nannofossils identified in the deposits from the south-eastern area of Trascău Mountains, between Ighiel and Mănăstirii valleys, constrain the age of a part of the sediments as Upper Cretaceous (upper Coniacian) for an area considered to be entirely as Lower Cretaceous. The lithology of these calcareous nannofossils-bearing deposits (rhythmic alternation of sandstones and clay/marls) is consistent with that of Râmeți Formation. These deposits can represent a south-eastern prolongation of Râmeți Formation up to Fierului Valley (Fig. 2B).

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