

CAMPANIAN NANNOFOSSIL ZONES IN THE MEDITERRANEAN UPPER CRETACEOUS IN SOFIA BALKAN BETWEEN BUHOVO, JELYAVA AND ELESHNITSA

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ABSTRACT. Two lithostratigraphic units of the Mediterranean Upper Cretaceous - Mirkovo and Chugovitsa Formations crops out in the form of a narrow strip in the north-east suburbs of Sofia, between Buhovo, Jelyawa and Elehnitsa. The subject of the present work are reliable measurement of the thickness of the units and biostratigraphic nannoplankton subdivision of the fossiliferous intervals. Mirkovo Formation is composed of 300 m thick motley limestones and marls. The uppermost 60 m of the unit are composed of marls belonging to the Voden Member of Mirkovo Formation. The upper part of the section is composed of the deposits of Chugovitsa Formation represented by 300 m thick turbidite sequence. Four Campanian nannofossil zones are characterized, from lower to upper: Broinsonia parca (lower Lower Campanian), Ceratolithoides aculeus (upper Lower Campanian), Uniplanarius gothicus (lower Upper Campanian) and Uniplanarius trifidus (Upper Campanian). The uppermost one is recognized for the first time in this area and is represented by its lower part, and the others are present in the section by their complete volumes with lower and upper boundaries. Nannofossil content of the Mirkovo Formation is rather poor. The lower 140 m of the unit belong to the Coniacian and Santonian Stages and the following 140 m include Broinsonia parca nannofossil zone. The uppermost 20 m of the marls of the Voden Member and 120 m of the turbidite sequence of the overlying Chugovitsa Formation are referred to Ceratolithoides aculeus nannofossil zone. The rest of the turbidite sequence in the section near Jelyava belongs to Uniplanarius gothicus nannofossil zone, and the topmost level of the turbidite sequence in the section near Elehnitsa indicate the presence of the next younger nannofossil zone Uniplanarius trifidus.

КАМПАНСКИ НАНОФОСИЛНИ ЗОНИ В МЕДИТЕРАНСКИЯ ТИП ГОРНА КРЕДА В СОФИЙСКИЯ БАЛКАН МЕЖДУ БУХОВО, ЖЕЛЯВА И ЕЛЕШНИЦА

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РЕЗЮМЕ. Две литостратиграфски единици от Медитеранския тип Горна Креда - Мирковска и Чуговишка свита, се разкриват под формата на тясна ивица в североизточните предградия на София, между Бухово, Желява и Елешница. Предмет на настоящата работа са достоверното измерване на дебелините на единиците и биостратиграфска подялба по нанопланктон на фосилоносните интервали. Мирковската свита е изградена от пъстри варовици и мергели с дебелина 300 m. Най-горните 60 m от единицата са изградени от мергели, принадлежащи на Воденския член на Мирковската свита. Горната част на разреза е изградена от седиментите на Чуговишката свита, представена от турбидитна последователност с дебелина над 300 m. Характеризирани са 4 кампански нанофосилни зони, отдолу-нагоре: Broinsonia parca (долен Долен Кампан), Ceratolithoides aculeus (горен Долен Кампан), Uniplanarius gothicus (долен Горен Кампан) и Uniplanarius trifidus (Горен Кампан). Последната е установена за пръв път в този район и е представена само от най-долните си нива, а останалите присъстват в разреза с целия си обем, с долните и горните си граници. Нанофосилното съдържание на Мирковската свита е доста бедно. Долните 140 m от единицата принадлежат на Кониаския и Сантонския етаж, а следващите 140 m обхващат нанофосилна зона Broinsonia parca. Най-горните 20 m от мергелите на Воденския член и 120 m от турбидитите на отторележащата Чуговишка свита се отнасят към нанофосилна зона Ceratolithoides aculeus. Останалата част от турбидитната последователност в разреза при Желява принадлежи на нанофосилна зона Uniplanarius gothicus, а най-високите ѝ нива в разреза при Елешница индикират присъствието на следващата по-млада нанофосилна зона Uniplanarius trifidus.

Introduction

Calcareous nannoplankton assemblages, recovered from the Mediterranean type Upper Cretaceous in the north-east suburbs of Sofia, between Buhovo and Elehnitsa are rather poor. Indications of three Campanian nannofossil zones have been established in the studied area 12 years ago – Broinsonia parca, Ceratolithoides aculeus and Uniplanarius gothicus (Quadrum gothicum after Синьовски, 1993).

Up to now the section near Jelyava has been investigated and dated by Dimitrova et al. (1981), Димитрова et al. (1984), Начев & Начев (1989, 2003). On the map of Bulgaria in scale 1:100 000 the rocks are correlated with the formal lithostratigraphic units established by Moev & Antonov (1976) and Моев & Антонов (1978) in the Chelopech area. The present investigation of the sections near Elehnitsa and

Jelyava provides new data about the thickness of the units and the boundaries and volumes of the Campanian nannofossil zones.

Sections and units

The sections of the Mediterranean Upper Cretaceous near Elehnitsa and Jelyava (Figs. 4, 5) are almost complete outcrops, including the basally disposed Turonian marls and the overlying glauconite sandstones, motley limestones, marls and turbidites, referred to Senonian (Coniacian-Campanian). Цанков (1965) first described Upper Cretaceous section near Jordankino (now Elehnitsa) and dated all carbonate rocks overlying Turonian marls as Maastrichtian. Later Dimitrova et al (1981) subdivided the limestones, marls and turbidites in

the section Jelyava into Coniacian-Santonian (382 m) and Campanian (560 m). Димитрова et al. (1984) subdivided the section into Coniacian (113 m including the basal glauconite sandstone unit), Santonian (200 m) and Campanian (170 m carbonates and 250 m turbidites). Начев & Начев (1989, 2003) accepted this subdivision. None of these authors reported the presence of large-scale slump structures, resulting in significant augmentation of the thickness.



Fig. 1. The Santonian part of the Mirkovo Formation north of Eleshnitsa village is composed of grey and motley limestones with well expressed cyclicity – thick beds with obscure internal structure

In the base of the Senonian is situated 7 to 15 m thick sandstone unit, represented by grey to grey-violet carbonate glauconitic sandstone with inoceramid and rare echinoid shells. Димитрова et al. (1984) described this unit as the base of their "limestone-marl formation". It overlies the Turonian marls by parallel unconformity. In Jelyava section it is represented by medium to coarse-grained glauconite sandstone with grey to grey-violet colour. This unit crops out 500 m NE of Buhovo on the left slope of Buhovchitsa River, where it overlies transgressively red continental Permian rocks. In the section north of Eleshnitsa this sandstone unit is composed of fine-grained grey sandstone with thickness 7-8 m. The next unit is composed of grey and motley limestones and marls. Димитрова et al. (1984) described this portion of the section as "limestone-marl formation" corresponding to the "first", "second" and "third horizon" of the Maastrichtian of Връблянски et al. (1961). They correlated its upper half with the Mirkovo Formation of Moev & Antonov (1976). Чунев (1995) united the two units in the map of Bulgaria in scale 1:100 000. Here the stratigraphic interval between the basally situated glauconite sandstones and the turbidite sequence of Chugovitsa Formation is referred to Mirkovo Formation. It is subdivided into several packets, differing in its lithology and structure. Mirkovo Formation as a whole is represented predominantly by motley, thick bedded to massive limestones and marls (Fig. 1), and rare ash tephroidal rocks (Fig. 2). The uppermost marl packet is correlated with the Voden Member of Mirkovo Formation. The thickness of the unit is 300 m in section Eleshnitsa. In section Jelyava it is not well exposed and contains slump structures, so the thickness could not be measured properly. The outcrops near Buhovo are located on the hills just NE of Buhovo, north and south of Buhovchitsa River.

The Voden Member is composed of grey and violet marls (Fig. 3). It crops out only in the sections Jelyava and Eleshnitsa with thickness about 60 m. North of Eleshnitsa its

lower part is represented by motley marl, and the section near Jelyava is composed entirely by grey marl. The top of the section in both outcrops is composed of turbidite deposits correlated with the Chugovitsa Formation of Moev & Antonov (1976). In the base they are dominated by marl interbeds and thick marl packets (Fig. 6). The thickness of this turbidite unit is more than 300 m.

Nannofossil subdivision

The nannofossil content of Mirkovo Formation is rather poor. Nevertheless the frequent sampling allowed to recognize some of the nannofossil events in the base of the unit and to establish the Santonian-Campanian boundary in the upper part of the unit in sections Jelyava and Eleshnitsa. The appearance of *Micula decussata* Vekshina, 1959 is established in the sample situated 14 m above the base of the sandstone unit in section Eleshnitsa. This level is world-wide correlatable event in the middle of Coniacian. The appearance of another stratigraphically important species *Broinsonia parca* (Stradner, 1963) is established in the sample situated 140 m above the base of the sandstone unit. It means that the lower 140 m of the section Eleshnitsa belong to Coniacian and Santonian. The appearance of the next stratigraphically important species for the Campanian Stage *Ceratolithoides aculeus* (Stradner, 1961) is in the sample 20 m below the boundary between Mirkovo and Chugovitsa Formations in both Jelyava and Eleshnitsa sections.

Broinsonia parca Zone

Author: Verbeek (1976).

Definition: Interval from the first occurrence of *Broinsonia parca* (Stradner, 1963) Bukry, 1969 to the first occurrence of *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977.

Age: Early Early Campanian.

Common taxa: *Watznaueria barnesae* (Black, 1959) Perch-Nielsen, 1968, *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968, *Micula decussata* Vekshina, 1959, *Arkhangelskiella cymbiformis* Vekshina, 1959, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *parca*, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *constricta* Hattner et al. 1980, *Bukryaster hayi* (Bukry, 1969) Prins & Sissingh in Sissingh, 1977, *Lucianorhabdus cayeuxii* Deflandre, 1959, *Lucianorhabdus arcuatus* Forchheimer, 1972, *Prediscosphaera microrhabdulina* Perch-Nielsen, 1973, etc.

Remarks: The appearance of the zonal marker is world-wide correlatable event, established slightly above the Santonian-Campanian boundary. In many earlier works it has been accepted as a marker of this boundary. The lowermost Campanian UC 13 zone of Burnett (1998) is defined as an interval between the first occurrence of *Arkhangelskiella cymbiformis* Vekshina, 1959 and *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *parca*. This zone is not recognized in the sections, because of the poor preservation of the material. *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *constricta* Hattner et al. 1980, appears nearly simultaneously with the zonal marker.

Boundaries: The lower boundary is established 140 m above the base of the sandstone unit, and the upper one – at 280 m

(20 m below the transition between Mirkovo and Chugovitsa Formations).

Thickness: 140 m.



Fig. 2. Tephra layers in the middle of the Mirkovo Formation 190 m above the base north of Eleshnitsa Village, *Broinsonia parca* Zone, Lower Campanian

***Ceratolithoides aculeus* Zone**

Author: Verbeek (1976).

Definition: Interval from the first occurrence of *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977 to the first occurrence of *Uniplanarius gothicus* (Deflandre, 1959) Hattner & Wise, 1980.

Age: Late Early Campanian.

Common taxa: *Watznaueria barnesae* (Black, 1959) Perch-Nielsen, 1968, *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968, *Micula decussata* Vekshina, 1959, *Arkhangelskiella cymbiformis* Vekshina, 1959, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *parca*, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *constricta* Hattner et al. 1980, *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977, *Lucianorhabdus cayeuxii* Deflandre, 1959, *Lucianorhabdus arcuatus* Forchheimer, 1972, *Prediscosphaera microrhabdulina* Perch-Nielsen, 1973, etc.

Boundaries: The lower boundary is established 280 m above the basis of the sandstone unit (20 m below the boundary between Mirkovo and Chugovitsa Formations). The upper boundary is 110 m above the boundary between the two formations. Sinnyovsky (1993) reported 250 m thickness of the zone in section Jelyava, but the present investigation shows that the thickness is less than 150 m.

Thickness: 140 m.

***Uniplanarius gothicus* Zone**

Author: Martini (1976).

Definition: Interval from the first occurrence of *Uniplanarius gothicus* (Deflandre, 1959) Hattner & Wise 1980 to the first occurrence of *Uniplanarius trifidus* (Stradner, 1963) Hattner & Wise 1980.

Age: Early Late Campanian.

Common taxa: *Watznaueria barnesae* (Black, 1959) Perch-Nielsen, 1968, *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968, *Micula decussata* Vekshina, 1959, *Arkhangelskiella cymbiformis* Vekshina, 1959, *Broinsonia parca* (Stradner, 1963)

Bukry, 1969 ssp. *parca*, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *constricta* Hattner et al. 1980, *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977, *Uniplanarius gothicus* (Deflandre, 1959) Hattner & Wise 1980, *Lucianorhabdus cayeuxii* Deflandre, 1959, *Lucianorhabdus arcuatus* Forchheimer, 1972, *Prediscosphaera microrhabdulina* Perch-Nielsen, 1973, etc.

Remarks: Martini (1976) defined this zone in the Pacific as a middle Campanian interval. Verbeek (1977) gave it a very restricted range confirmed by Stradner (1984) in site 530 in the Angola Basin, Atlantic Ocean. Late Campanian age of the zone was reported by many authors. First indication in Bulgaria was reported by Синьовски & Желев (1992) in the transition between Draganovo and Emine Formations near Tunkovo Village in East Srednogorie. Синьовски (1993) defined its boundaries in several sections from West Srednogorie.

Boundaries: The lower boundary was described by Синьовски (1993) in the studied section Jelyava. The upper boundary was described by the same author in the sections near the villages Izvor and Nedyalkovo, Pernik District. The upper part of the zone is established at Cape Emine where it includes more than 100 m of the section of Emine Formation (Sinnyovsky, 2004). For the first time it is described in its full volume in a single section north of Eleshnitsa Village in this work.

Thickness: more than 100 m.



Fig. 3. The marls of the Voden Member in the upper part of Mirkovo Formation 240-300 m above the base of the section Eleshnitsa, *Broinsonia parca*–*Ceratolithoides aculeus* Zones, Lower Campanian

***Uniplanarius trifidus* Zone**

Authors: Bukry & Bramlette (1970).

Definition: Interval of the total range of *Uniplanarius trifidus* (Stradner) Hattner & Wise.

Age: Late Late Campanian.

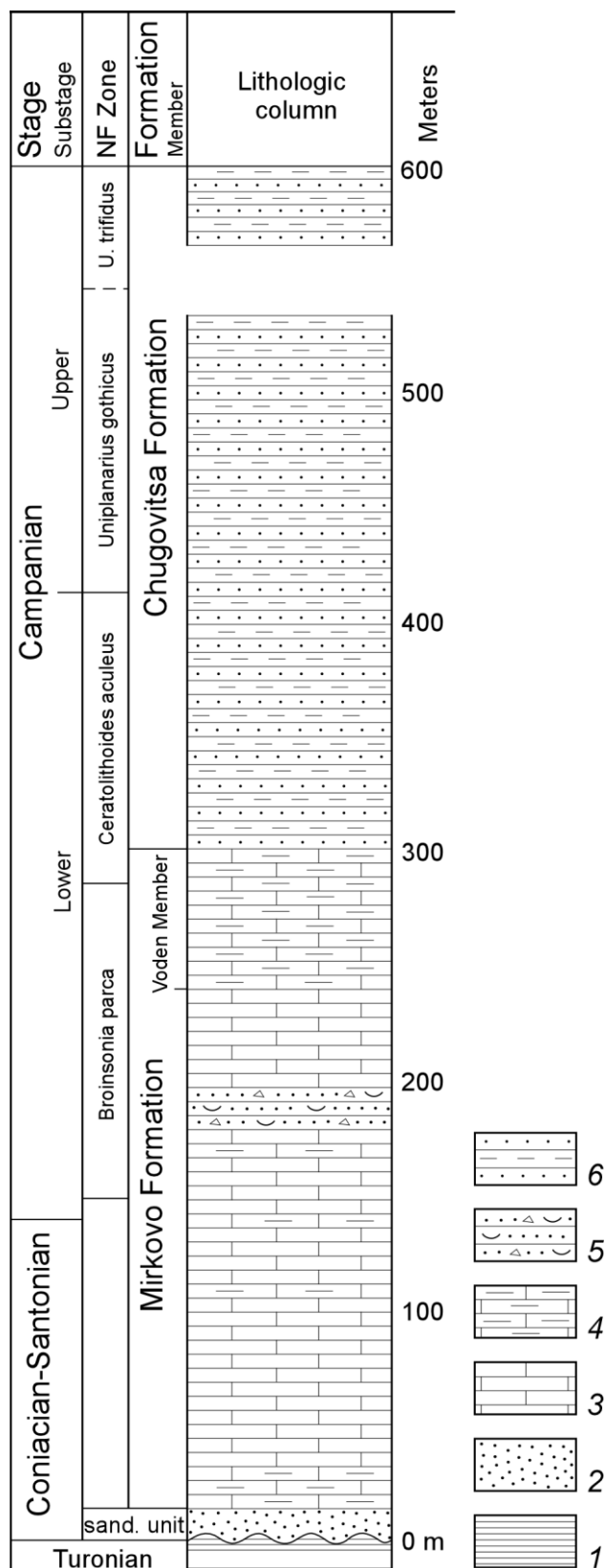


Fig. 4. Section Eleshnitsa. Mirkovo Formation is described north of the village, along the road to Vitinya; Chugovitsa Formation is described on the east slope of Eleshnitsa River in the weekend house estate. 1 – marl; 2 – sandstone; 3 – limestone; 4 – marl; 5 – tephra layers; 6 – turbidite

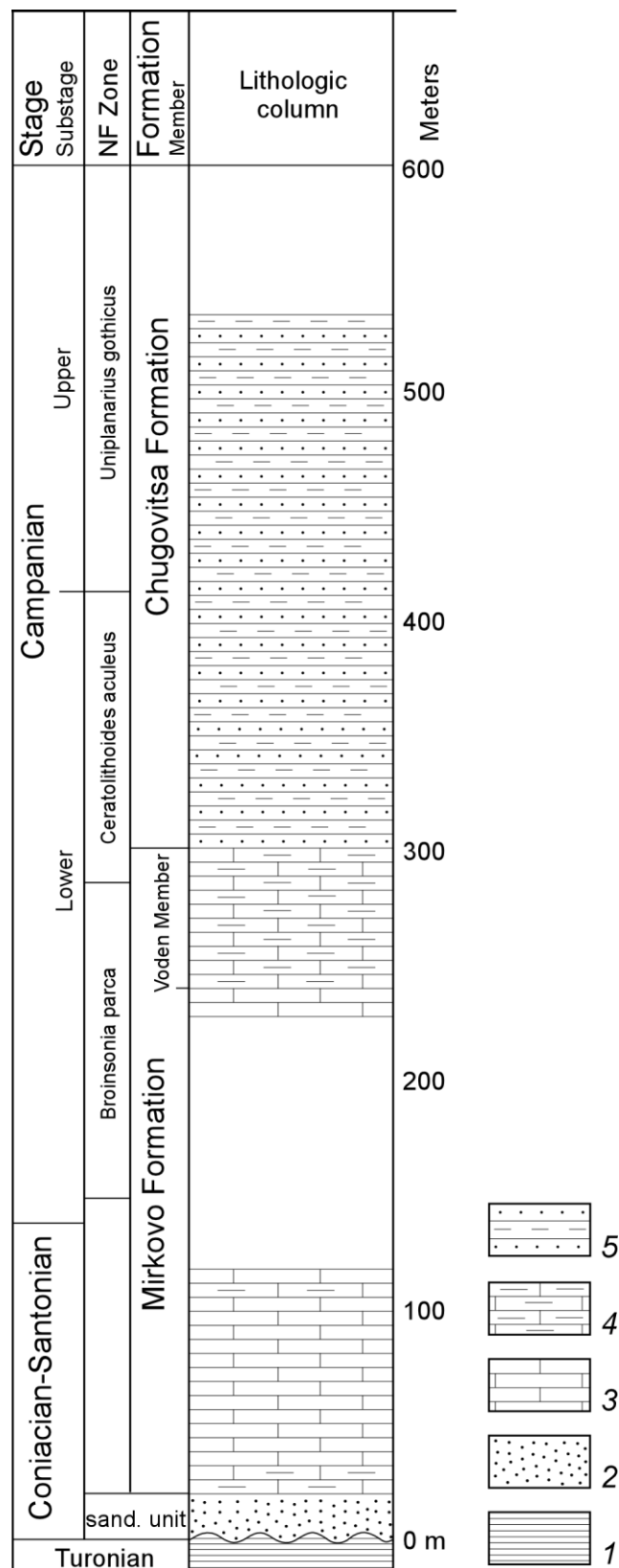


Fig. 5. Section Jelyava. The section is described along Jelyava River. The outcrops of the Mirkovo Formation are incomplete and uppermost levels of Chugovitsa Formation are in the river bed in the centre of the village. 1 – marl; 2 – sandstone; 3 – limestone; 4 – marl; 5 – turbidite

Common taxa: *Watznaueria barnesae* (Black, 1959) Perch-Nielsen, 1968, *Uniplanarius trifidus* (Stradner) Hattner & Wise, *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968, *Micula decussata* Vekshina, 1959, *Arkhangelskiella cymbiformis* Vekshina, 1959, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *parca*, *Broinsonia parca* (Stradner, 1963) Bukry, 1969 ssp. *constricta* Hattner et al. 1980, *Ceratolithoides aculeus* (Stradner, 1961) Prins & Sissingh in Sissingh, 1977, *Uniplanarius gothicus* (Deflandre, 1959) Hattner & Wise 1980, *Lucianorhabdus cayeuxii* Deflandre, 1959, *Lucianorhabdus arcuatus* Forchheimer, 1972, *Prediscosphaera microrhabdulina* Perch-Nielsen, 1973, *Reinhardtites levis* Prins & Sissingh in Sissingh, 1977, etc.

Remarks: Originally the stratigraphic range of the zone was Upper Campanian – lowermost Maastrichtian. After emendation of the Campanian-Maastrichtian boundary by Rawson et al. (1996), the whole stratigraphic range of the zone remained in the frame of the Upper Campanian, and the disappearance of both *Uniplanarius trifidus* (Stradner) Hattner & Wise and *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968 could be used for definition of the Campanian-Maastrichtian boundary, although the latter disappears a bit earlier. The zonal marker is established in isolated outcrops west and east of Eleshnitsa village in scarce outcrops of the uppermost levels of Chugovitsa Formation.

Distribution: Up to now, indications of the zone have been established in many Bulgarian sections of both Epicontinental and Mediterranean type Upper Cretaceous. The zone is established for the first time in this area.

Thickness: The zone includes at least 50 m of the section near Eleshnitsa village.

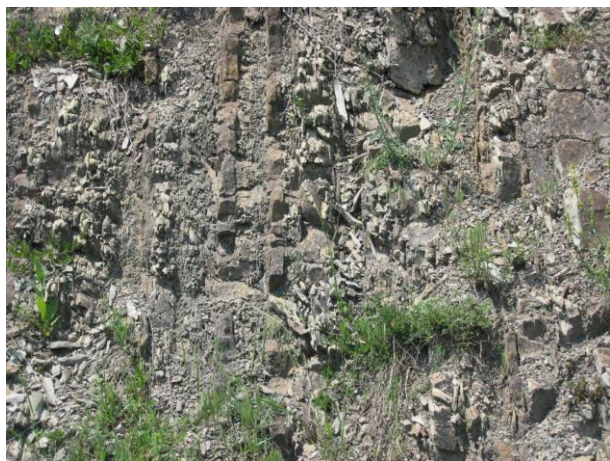


Fig. 6. The lower part of the turbidite sequence of the Chugovitsa Formation 320 m above the base of the section north of Eleshnitsa Village, *Ceratolithoides aculeus* Zone, Lower Campanian

Conclusion

The outcrops between Buhovo and Eleshnitsa provide a complete section and a good possibility for dating the Senonian sediments of the so called "Buhovo-Negushevo strip". Zonation of the Coniacian-Santonian stratigraphic interval is not possible because of the poor nannofossil content. The appearance of *Micula decussata* Vekshina dates the middle of Coniacian 14 m above the base of the

Senonian deposits. Santonian nannofossil markers are not recognized. The base of the Campanian is considered to be slightly below the appearance of *Broinsonia parca* (Stradner, 1963) Bukry, 1969, marking the lower boundary of *Broinsonia parca* Zone at 140 m above the base. Into this zone a packet of tephra layers and breccia, containing particles of Palaeozoic rocks. This proves lasting volcanic activity through the Campanian Stage. The stratigraphic volume of *Ceratolithoides aculeus* Zone is defined more precisely by defining the upper boundary on the basis of first appearance of short-rayed forms of *Uniplanarius gothicus* (Deflandre, 1959) Hattner & Wise 1980. Thus the thickness of the zone is calculated on 140 m.

Uniplanarius gothicus Zone is defined by the presence of the marker species in an interval about 100-150 of the section. For the first time in the area is recognised the uppermost Campanian zone – *Uniplanarius trifidus*, which confirms the absence of Maastrichtian rocks in these outcrops of the Mediterranean Upper Cretaceous.

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