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in the Northern hemisphere

Field Symposium

OLIGOCENE – MIOCENE TRANSITION AND MAIN GEOLOGICAL EVENTS IN ROMANIA

28 August – 2 September 1996

A. EXCURSION GUIDE

by

Anatol RUSU, Gheorghe POPESCU, Mihaela MELINTE

B. MATERIAL OF SYMPOSIUM

Institutul Geologic al României
Bucureşti – 1996

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Leader : Dr. Michail A. AKHMETIEV

Field Symposium

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Organizing committee

Dr. Gheorghe POPESCU, Dr. Anatol RUSU, Mihaela MELINTE, Simona PESTREA

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INTRODUCTION

IGCP Project no. 326 "Oligocene-Miocene Transition in the Northern Hemisphere" includes among its objectives the stressing out of the geological and biological events from the Upper Oligocene-Lower Miocene time span and their correlation on widespread areas. An attempt is made to point out some events with a global significance such as the eustatic movements, the climate changes or the orbital cycles. The major changes of the marine and continental flora and fauna are also considered.

Within the programme "Global Stratotype Section and Point" (GSSP) it has been recently proposed that the Paleogene-Neogene, Oligocene-Miocene boundary respectively , should be established at m 35,00 in the Rigoroso Formation from Lemme-Carrosio (North Italy), considered of 23.8 M.y., bracketed by a set of biostratigraphic events of planktonic microfossil group and studied from the magnetostratigraphic point of view (Steininger et al., 1994). It is obvious that any reference to this boundary should be referred to the datum planes stressed out in the Lemme section, as we shall try to make ourselves.

The Excursion route covers cca 1700 km on the itinerary Bucureşti-Vălenii de Munte-Nehoiu-Siriu-Braşov-Sighişoara-Târgu Mureş-Cluj Napoca-Târgu Lăpuş-Alba Iulia-Sibiu-Bran-Câmpulung-Târgovişte-Bucureşti (Fig. 1). The route crosses tectonic units of the East Carpathians (intersected in two different regions), Transylvanian and Getic depressions.

For the field symposium "Oligocene-Miocene Transition and Main Geological Events in Romania" two areas with completely different tectono-structural regions have been chosen: the East Carpathian Bend – an orogenic zone with flysch deposits accumulated in the Carpathian trough and the Preluca Area in NW Transylvania – a post-tectogenetic cover with epicontitental deposits sedimented on the Transylvanian shelf. In both areas no sedimentologic and biostratigraphic evidences for a hiatus across the Oligocene-Miocene boundary were found.

During the field trip ten geological key-sections (Fig. 2), including the so-called "critical time span" for the Oligocene-Miocene boundary, will be presented, investigated and sampled.

The studied stratigraphic sequences start with Kiscellian (Late Rupelian) formations, belonging to the Protoparatethys and end with Eggenburgian (Early Burdigalian) ones belonging to the Eoparatethys.

EAST CARPATHIANS BEND AREA OVERVIEW ON THE OLIGOCENE – LOWER MIOCENE FROM THE OUTER FLYSCH ZONE

The East Carpathians represent an important segment of the Carpathian Orogen. It develops between Tisa and Dâmboviţa valleys. On a distance as long as 600km a mountaneous chain, with picks higher than 2000m, rises. From the geographic point of view the East Carpathians are located between the Transylvanian Depression (westwards), the Moldavian Plateau (eastwards) and the Romanian Plain (southwards).

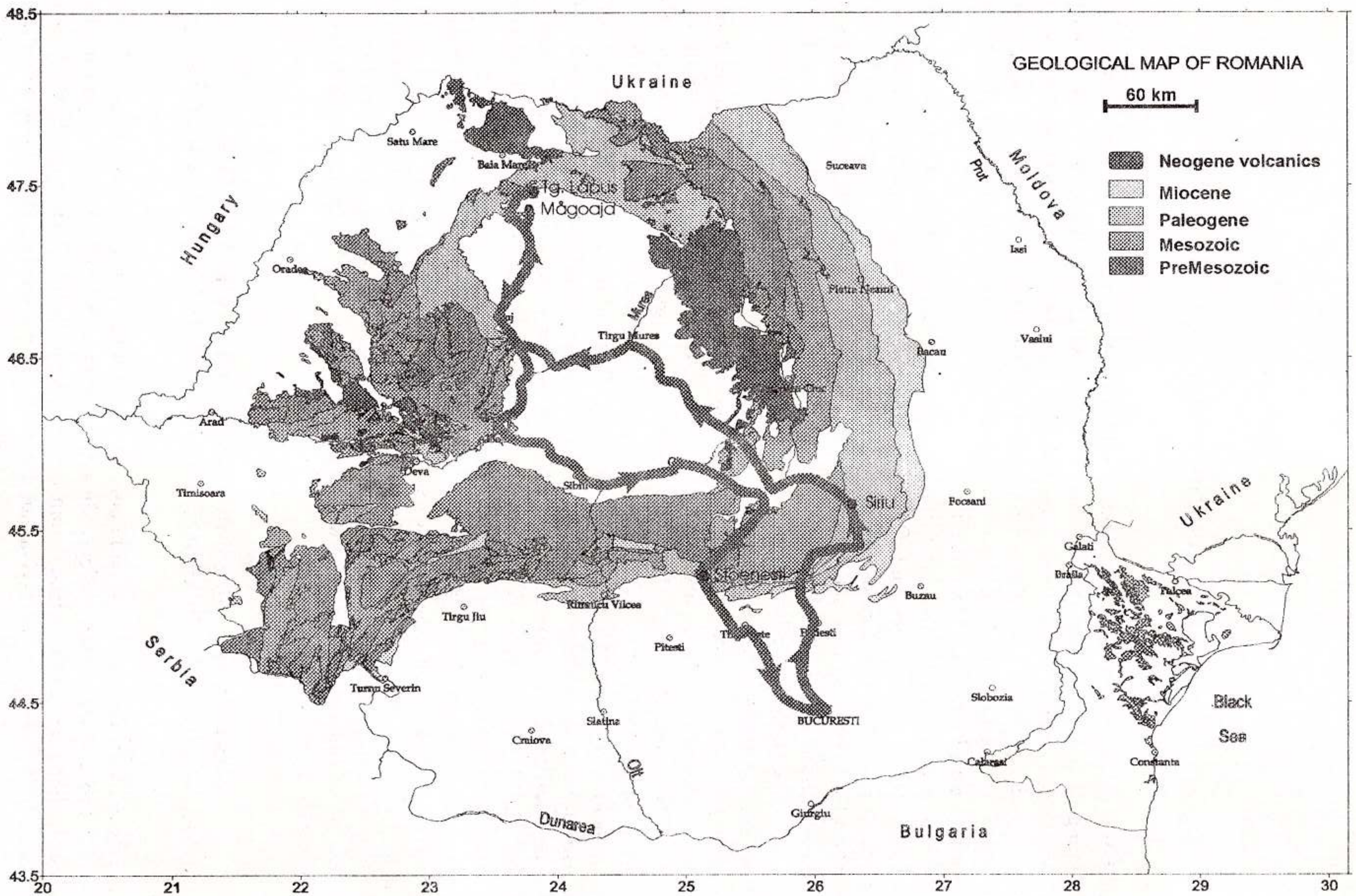


Fig. 1. ITINERARY

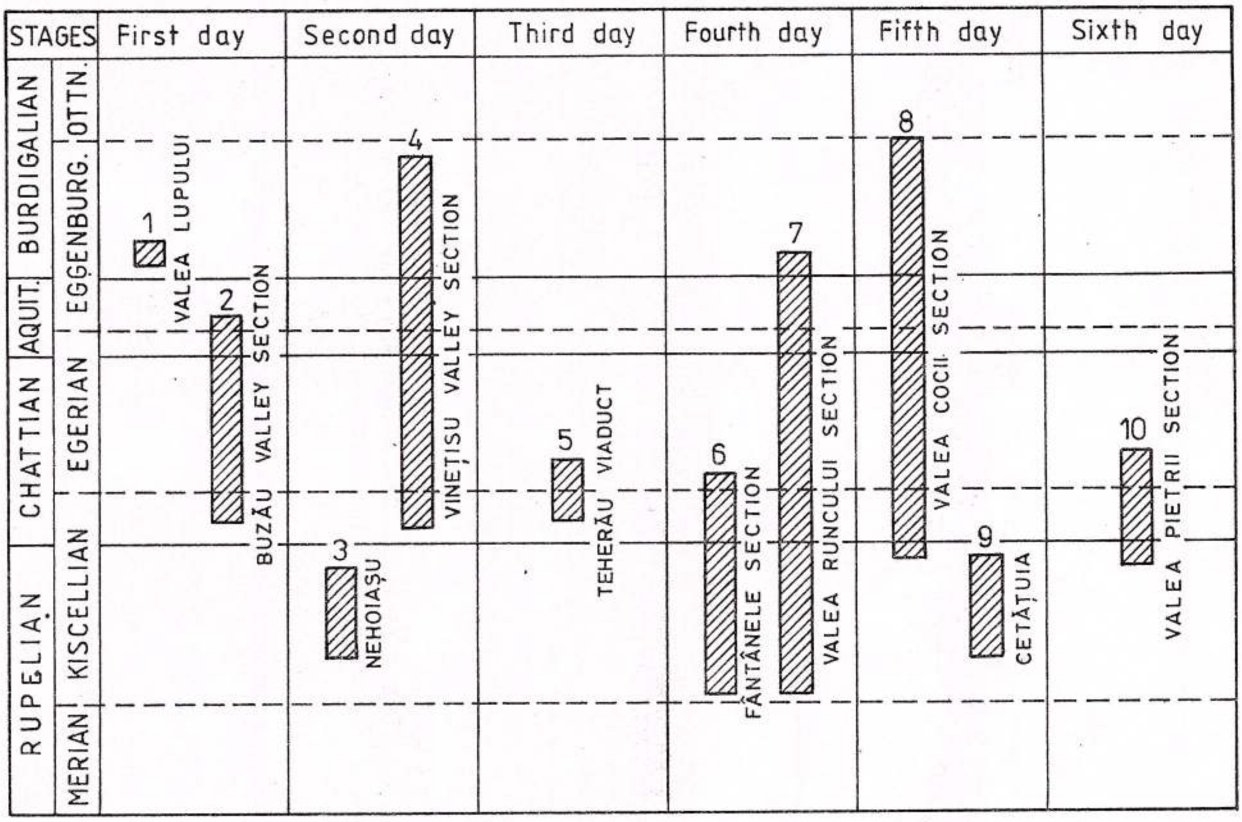


Fig. 2 – Stratigraphic position of the visiting outcrops and sections.

From the main petrographic constitution point of view, from inner (west) towards to outer (east), were distinguished: the Transcarpathian Flysch Zone, the Crystalline - Mesozoic Zone, the Flysch Zone and the Subcarpathian Zone (Fig. 3).

The Flysch Zone is characterized by the prevailing of the flysch facies and develops as a large strip along the East Carpathians.

According to Săndulescu (1984), who used the age deformation criterion, the Flysch Zone belongs either to the Outer Dacides (innermost nappes), of Cretaceous tectogenesis or to the Moldavides, of Neogene tectogenesis. Our interest will be focused only on the Moldavides from the Bend Area.

From inside (west) toward outside (east), the following nappes, grouped in the Moldavides, occur: the Teleajen (=Convolute Flysch), Macla, Audia (Inner Moldavides) and Tarcău, Marginal Folds and Subcarpathian (Outer Moldavides).

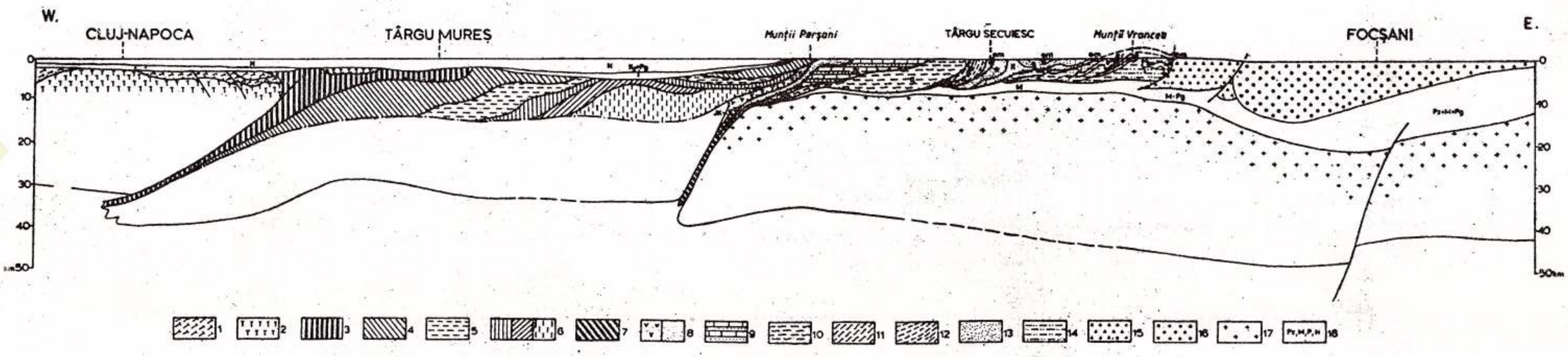


Fig. 3 – General cross-section through the Romanian Carpathians (acc. to Săndulescu, 1984). Inner Dacides (1+2): 1 – Codru-Arieșeni nappe system, 2 – Bihor Unit; Main Tethyan Suture: 3 – Transylvanides; Median Dacides (4-6): 4 – Bucovinian Nappe, 5 – Subbucovinian Nappe, 6 – Infrabucovinian nappes; Outer Dacides (8+9): 8 – Black Flysch Nappe, 9 – Ceahlău Nappe; Moldavides (10–15): 10 – Convolute Flysch, 11 – Macla Nappe, 12 – Audia Nappe, 13 – Tarcău Nappe, 14 – Marginal Folds Nappe, 15 – Subcarpathians Nappe; Foredeep: 16 – Focșani Depression; Underthrust elements (17+18): 17 – Crystalline basement, 18 – Sedimentary formations (Pz-Paleozoic, Mz-Mesozoic, Pg-Paleogene).

The Oligocene - Lower Miocene deposits are well developed in the Outer Moldavides, especially in the Tarcău Nappe and the Marginal Folds.

The trip will cross only the Tarcău Nappe. This unit can be correlated with the Skibas and Krosno zone, from the Ukrainian Carpathians, and with Skole, Subsilezian and Silezian nappes, from the Polish ones (Săndulescu, 1984). The Tarcău is a polyfacial nappe (Fig. 4).

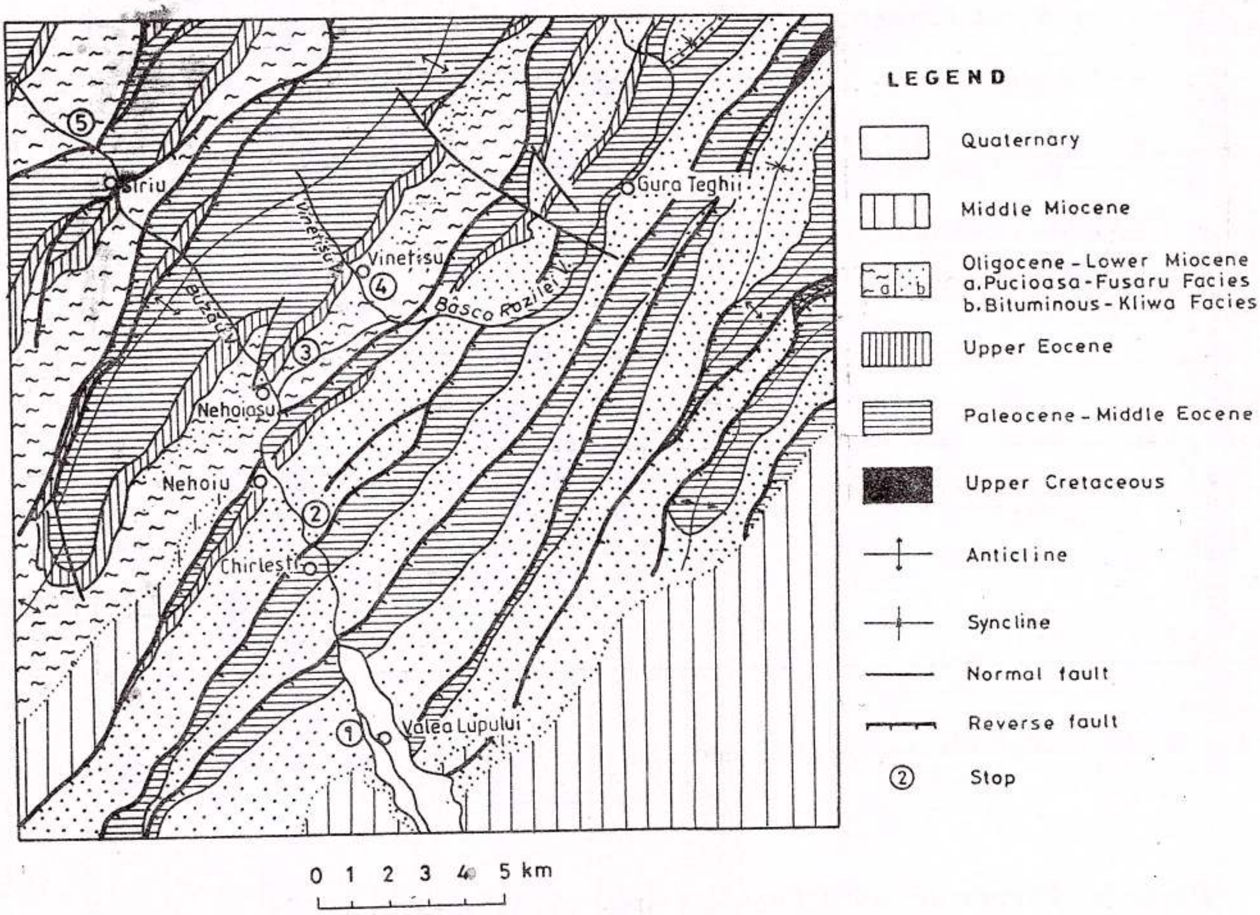


Fig. 4 – Geological map of Buzău Valley region.

The Oligocene - Lower Miocene displays two main facies: the Pucioasa - Fusaru Facies (inner -westernmost), with the source of detritics situated in the Carpathian area and the Bituminous Kliwa Facies (outer - easternmost), sourced in the Foreland (Fig. 5).

The Oligocene - Lower Miocene time span is covered in the inner facies (Pucioasa - Fusaru Facies) by the following formations:

– Lower Dysodilic Formation (Coquand 1867; Stoica, 1944)

Lithology: clayey, bituminous shales, locally associated with menilites. Laminated calcareous shales Tylawa type also occur.

Age: Rupelian (NP22, NP23 and lowermost part of the NP24 nannofossil zones, Melinte 1995).

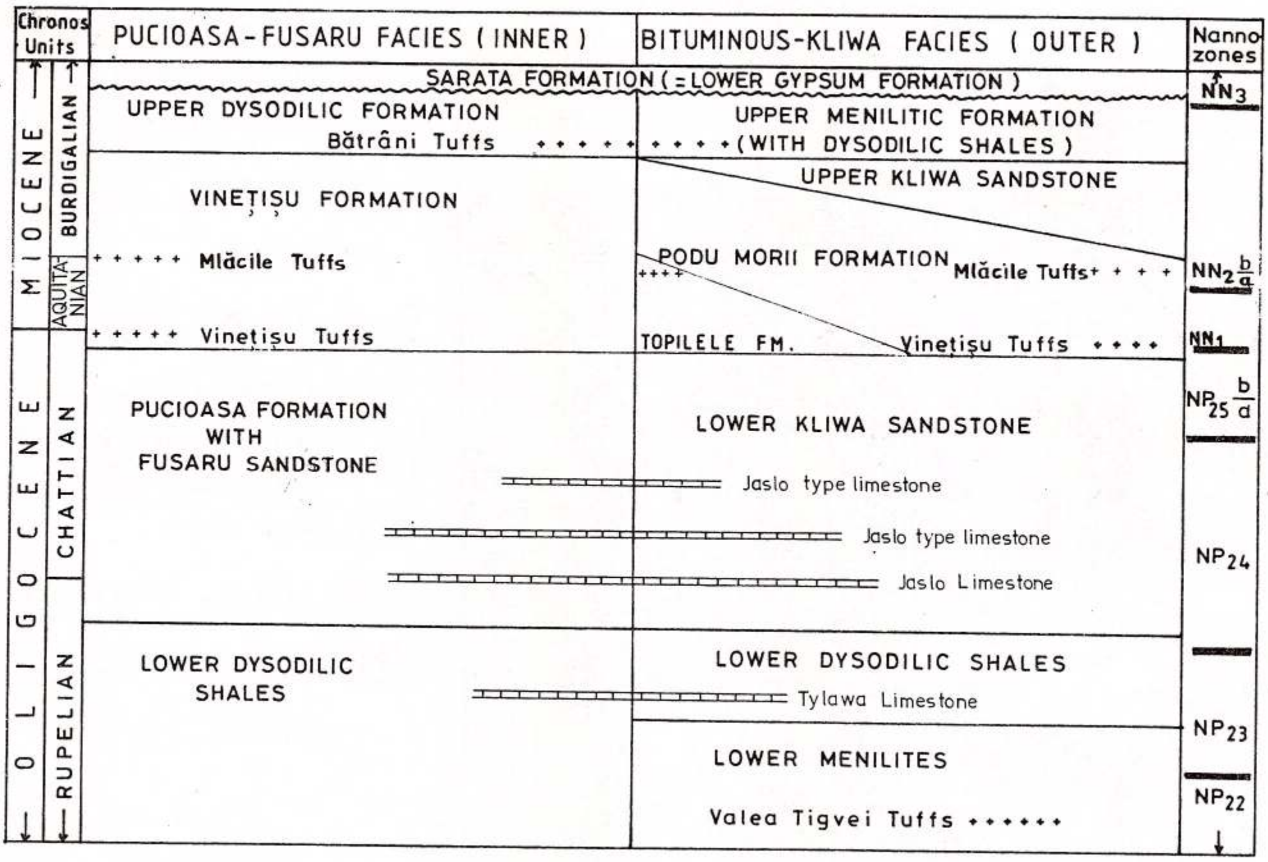


Fig. 5 – Correlation between the Oligocene – Lower Miocene facies from the Tarcău Nappe in Buzău Valley region.

– Pucioasa Formation with Fusaru Sandstone (Popescu, 1952)

Lithology: a sandy-shaly flysch, composed of dark-gray or brownish marls and shales, gray thin-bedded sandstones, with parallel or cross lamination, sideritic marly limestones and levels of laminated coccolithic limestone of Jaslo type. This formation is similar to the Krosno one from the West Carpathians.

Age: Latest Rupelian - Chattian (the NP24 and NP25 calcareous nannoplankton zones, Melinte 1995).

– Vineţişu Formation (Grigoraş, 1955)

Lithology: a shaly-sandy or "hieroglyphic beds" type flysch, an alternance of gray-bluish calcareous, micaceous, convolute sandstones and light gray clays and marls. From the lower part of this formation two levels of tuffs (Vineţişu Tuffs, a green-black, strong bentonitised tuff and Mlăcile Tuffs, a white one, with biotite) were identified (Ştefănescu et al., 1993).

Age: Latest Chattian - late Early Burdigalian (NP25b subzone, NN1 and NN2 calcareous nannoplankton zones, Melinte 1993, 1995). According to the nannofossil content the Oligocene - Miocene boundary is situated bellow the Vineţişu Tuff.

– Upper Dysodilic Formation (Coquand 1867, Dumitrescu, 1948)

Lithology: the same lithologic composition as in the Lower Dysodilic Shales. It is to mention the presence of some centimetric levels of yellow, bentonitized tuff (Bătrâni Tuff - Ştefănescu et al., 1993) interlayered within the clayey, bituminous shales..

Age: late Early Burdigalian (upper part of the NN2 nannofossil zone, Melinte 1993).

– Sărata Formation (Ştefănescu,1978) (=Lower Gypsum, Mrazec 1914)

The end of the flysch sedimentation is marked by an evaporitic level (the Lower Gypsum), which unconformably overlies the Upper Dysodilic Shales. According to Ştefănescu and Mărunţeanu (1980) this is the beginning of the sedimentation in the molasse facies (the Doftana Molasse - Lower-Middle Burdigalian in age), in the East Carpathians Bend Area.

The Oligocene - Lower Miocene interval is represented in the outer facies (the Bituminous Kliwa Sandstone Facies) by the following formations:

– Lower Menilitic Formation with Bituminous Marls (Coquand, 1867; Stoica 1944; Dumitrescu 1948; Popescu 1952)

Lithology: layered cherts with bituminous marls, interlayered at the lower part of the formation, as well as rare dysodilic shales and locally centrimetric sandstones of Kliwa type.

In the Buzău Valley basin thin tuffs levels were identified, from the lower part of this formation (Valea Tigvei Tuff - Ştefănescu and Melinte, 1994).

Age: Early Rupelian (NP22 and lower part of the NP23 nannofossil zones, Ştefănescu and Melinte, 1994).

– Lower Dysodilic Formation (Coquand, 1867; Stoica 1944)

Lithology: bituminous clays and argillaceous silts, thin layered, with frequent sulfur occurrences. It is also to point out that, from the lower part of this formation, laminated coccolithic calcareous shales could be observed.

Age: Late Rupelian (NP23 and the lower part of the NP24 nannofossil zones, Ştefănescu and Melinte, 1994). The same age was indicated based on the study of the palynomorphs - the Wetzeliella gochtii Zone – (Ionescu and Alexandrescu, in press).

It is to emphasize that the Lower Dysodilic Shales from the outer facies correspond only to the upper part of the Lower Dysodilic Shales from the inner one. Its lower part is replaced, in the Kliwa Bituminous Facies, by the Lower Menilites with Bituminous Marls.

– Lower Kliwa Sandstone Formation (Walter 1880, fide Macovei, 1927)

Lithology: the Kliwa Sandstone is a white, massive, orthoquartzitic sandstone, with a part of the clastics (quartz) of eolian origin, redeposited in the sedimentary basin by currents. Microconglomerates, with elements of crystalline schists in the greenschists facies may be observed, proving that the detritics originated in the Foreland. Thin dysodilic shales interlayered. Intercalations of Jaslo type laminitic limestone were also identified.

Age: Late Rupelian - Chattian (the NP24 and NP25 nannofossil zones, Melinte 1993, 1995).

– Topilele Formation (Ştefănescu et al., 1993)

Lithology: shaly-sandy flysch, represented by an alternance of dysodilic shales and convolute, gray sandstones. This formation was identified so far only locally in the Bend Area and represents a passage between the Lower Kliwa Sandstone and the Podu Morii Formation.

Age: Latest Chattian - Aquitanian. In the Buzău Valley the Oligocene - Miocene Boundary was pointed out, in the lower part of this formation.

– Podu Morii Formation (Teisseyre 1911, emend. Popescu 1952)

Lithology: a sandy-shaly or "hieroglyphic beds" type flysch, characterized by the presence of calcareous, micaceous, gray sandstones, with a large development of Bouma's C sequence as well as micaceous gray marls. From the lower part of this formation the same tuff levels (Vineţişu and Mlăcile Tuffs) as in the inner facies of the Tarcău Nappe were identified (Ştefănescu et al, 1993).

Age: Latest Chattian - Earliest Burdigalian (NP25, NN1 and NN2 -lower part- nannofossil zones, Melinte 1993, 1995).

– Upper Kliwa Sandstone Formation (Grigoraş, 1951)

Lithology: massive, sandy, siliceous sandstones with thin, shaly, bituminous clays.

Age: Early Burdigalian (upper part of the NN2 calcareous nannoplankton zone).

– Upper Menilitic Formation (Stoica 1944)

Lithology: layered cherts (menilites) with interbedded dysodilic shales, frequently associated with diatomites. Thin levels of tuffs (Bătrâni Tuffs) interlayered.

– Sărata Formation (Ştefănescu, 1978) (= Lower Gypsum, Mrazec 1914)

The Upper Menilitic Formation is unconformably overlain by an evaporitic sequence. The base of this formation is situated in the NN3 nannofossil zone (upper part of the Lower Burdigalian).

It is to mention that from the two above described Oligocene - Lower Miocene facies, from the Tarcău Nappe, oil and gas source rocks as well as reservoir rocks are widespread (some of them producing since the last century). Among the source rocks the bituminous shales from the Lower Dysodilic Formation and from the Pucioasa Formation with Fusaru Sandstone can be mentioned, while reservoir rocks are represented by the Fusaru Sandstone and different levels of the Kliwa Sandstone.

All the above mentioned Oligocene - Lower Miocene deposits are still producing hydrocarbons.

GEOLOGICAL SECTIONS AND OUTCROPS

First Day: Bucharest – Vălenii de Munte – Valea Lupului – Chirleşti – Nehoiu – Siriu

From Bucharest the route crosses the Moesian Platform, the Foredeep of the southern East Carpathians and the Subcarpathians, then it enters the Tarcău Nappe (Outer Moldavides). From Cislău the route follows the Buzău River.

Stop 1 : **Valea Lupului Locality : Upper Kliwa Sandstone**

On the left side of the route a good exposure of Upper Kliwa Sandstone Formation can be observed.

Lithology. This formation is a Lower Miocene one of the Bituminous – Kliwa Facies.

The Upper Kliwa Sandstone is a massive sandstone, less lithified than the lower one, without grading and visible structure. Centimetric up to decimetric shaly, bituminous clays are sometimes interbedded.

Some microconglomerates with elements of crystalline schists in the greenshist facies can be also observed. Within this formation siliceous microfossils and calcareous nannofossils were identified.

Concerning the diatoms, two types of asssemblages were observed (Dumitrică and Pestrea, in press): a marine one; – *Actinoptychus thumii* association – from the lower part of Upper Kliwa Sandstone and a freshwater one – *Melosira praegranulata* association – from the upper part of the formation. Both diatom assemblages suggest a subtropical paleoenvironment.

Concerning the silicoflagelates, poor layers alternate which rich ones (with *Corbisena flexuosa* STRADNER, *C. bimucronata bimucronata* DEFLANDRE, *Naviculopsis navicula* EHRENBERG, *N. quadrata* EHRENBERG) (Dumitrică and Pestrea, in press).

The calcareous nannoplankton from the Upper Kliwa Formation was assigned to the Lower Burdigalian (NN2 zone).

Calcareous nannoplankton. The nannofossil assemblages from this outcrop contain: *Reticulofenestra pseudoumblica* GARTNER, *Helicosphaera ampliaperta* BRAMLETTE & WILCOXON, *Helicosphaera kamptneri* HAY & MOHLER, *Coccolithus pelagicus* (WALLICH) SCHILLER, *Coccolithus miopelagicus* BUKRY, *Cyclicargolithus floridanus* (ROTH & HAY) BUKRY, indicating the presence of the upper part of the NN2 Biozone, Early Burdigalian in age.

Stop 2 : **Buzău Valley Section – Upstream Chirleşti Localitty : Oligocene – Miocene Boundary in the Bituminous – Kliwa Sandstone Facies**

On the left bank of the Buzău River, between Stănila and Buzău river confluences and the bridge nearby Şeţu railway station, on a distance around 600 m, a good exposure of the middle part of the Bituminous – Kliwa Facies can be examined (Fig. 6).

Lithostratigraphy. The following formations, in stratigraphic order, occur:

a. Lower Kliwa Sandstone Formation. It is represented by a white, quartzitic sandstone interbedded with bituminous shales and gray clays. Centimetric marly limestones were also observed. Microconglomerates, containing elements of crystalline schists in the greenschist facies may be seen.

From this section, in the upper part of the formation, two centimetric levels of Jaslo type coccolithic limestones were observed.

b. Topilele Formation. It is represented by a rhythmic alternance of convolute, gray, micaceous sandstone and pelites type dysodilic shales. Clastic dykes may be also observed. In this section the Mlăcile Tuffs (a white tuff) can be examined.

c. Podu Morii Formation. It is characterised by a rhythmic alternance of gray-greenish marls and convolute, gray, calcareous sandstones.

Calcareous nannoplankton. From this section rich and diversified nannofossil assemblages, characteristic of the NP24, NP25, NN1 and NN2 zones were identified (Fig. 7).

The age of the Lower Kliwa Formation was established, according to the nannoflora content, as Chattian (NP24 and NP25 Biozones).

The assemblages, which indicate the presence of the NP24 zone, contain the following taxons: *Reticulofenestra ornata* MULLER, *Dictyococcites bisectus* BUKRY and PERCIVAL, *Helicosphaera recta* HAQ, *Reticulofenestra lockeri* MULLER, *Coccolithus pelagicus* (WALLICH) SCHILLER, *Sphenolithus ciperoensis* BRAMLETTE and WILCOXON, *S. moriformis* BRAMLETTE and WILCOXON, *S. distentus* BRAMLETTE and WILCOXON, *Cyclicargolithus floridanus* ROTH and HAY) BUKRY, *C. abisectus* (MULLER) WISE.

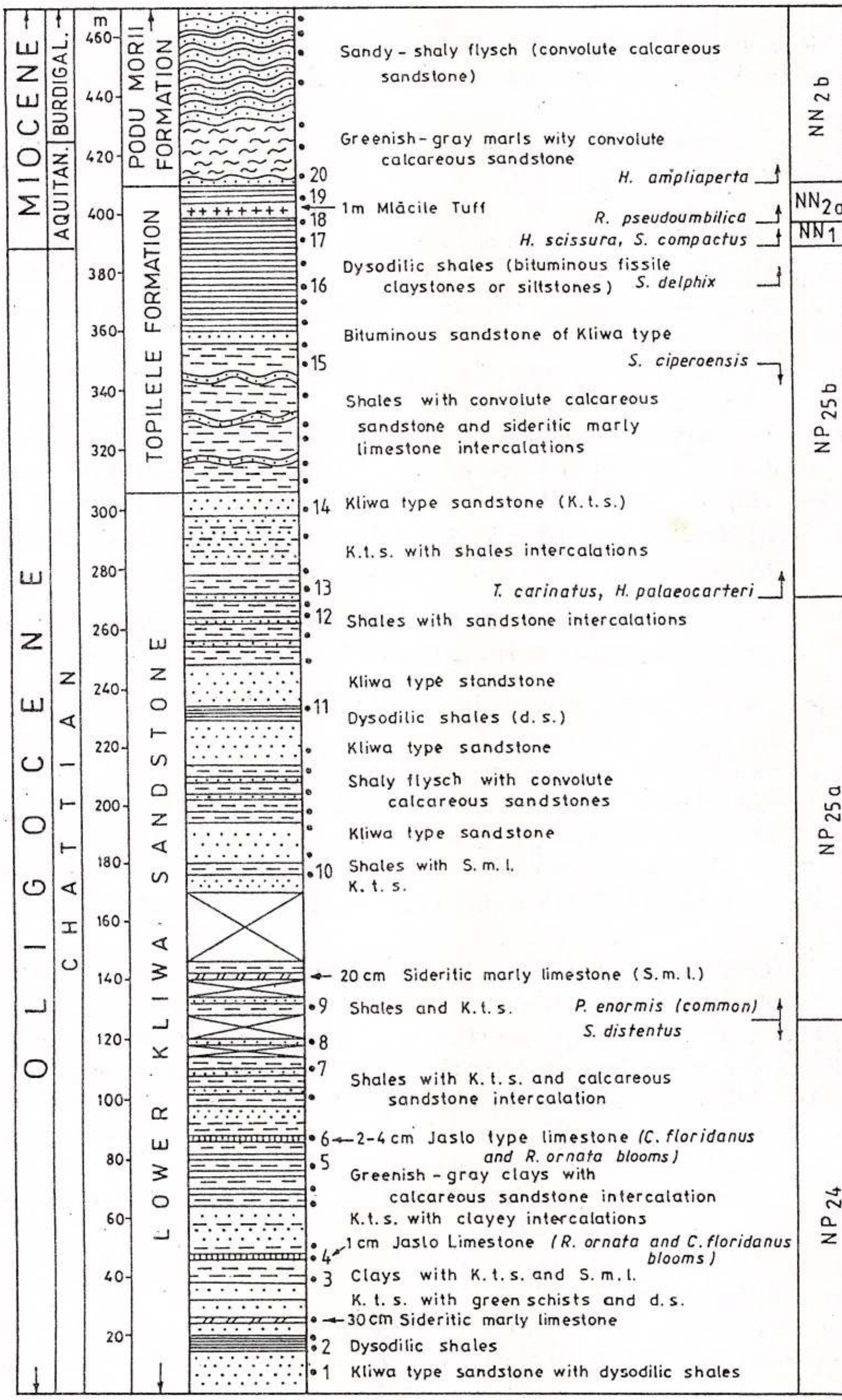


Fig. 6 Buzău Valley section upstream the Chirleşti locality; •1 – Nannoplankton sample number.

Fig. 7 – Calcareous nannoplankton distribution in Chirleşti Section, Buzău Valley

NANNOFOSSILS	SAMPLES																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cyclicargolithus floridanus	c	c	c	b	c	b	c	c	c	c	c	r	c	c	r	c	c	a	c	a
Cyclicargolithus abisectus	r	r	r	r	r	c	c	c	r	r	r	r	r	c	c	c	c			
Coccolithus pelagicus ·	c	c	c	c	c	c	c	c	c	c	c	c	c	c	r	r	c	c	c	c
Dictyococcites bisectus	c	c	c	c	c	c	c	c	c	c	c	c	c	a	a	c				
Helicosphaera recta	r	r		r	r		r	r	r		r		r			r	r			
Pontosphaera latelliptica		r		r		r	r		c	c	c	c	c	c	c	c	c	r	r	
Pontosphaera multipora	r	c	r.	c		c	c	c	r	r	r	r	r	r	r		c		c	c
Reticulofenestra lockeri	c	r	c	r	c	r	c	c	r	r	r	r	c	c	r	r	c	c	r	r
Reticulofenstra minuta	c	c		r		r		r	r				r	c	c	c	c	c		c
Reticulofenestra ornata	c	c	c	b	c	b	c	r	c	r	r									
Sphenolithus moriformis	r	r	r	c	c	c	c	c	c	r	c	r	r	c	r	c	c	c	c	r
Sphenolithus distentus	r	r	r		r		r	r												
Sphenolithus ciperoensis	c	r	r		c		c		c		r	c	c	c	r					
Zygrhablithus bijugatus	r	c		r	c		r	r	r		r·		r	r	c	c				
Pontosphaera enormis							r	r	c			c	r	r	r	r	r			
Sphenolithus conicus									r	r		r	r	r	c	c	c	c	c	r
Sphenolithus dissimilis												r	r	r	c	c	r	r	r	r
Helicosphaera palaeocarteri													r	c	r		r			r
Triquetrorhabdulus carinatus													r	r	r	c	c		r	r
Sphenolithus delphix																r	r	r		
Helicosphaera scissura																	c	c	r	r
Sphenolithus compactus																	r	c		c
Reticulofenestra pseudoumbilica																		c	c	c
Helicosphaera ampliaperta																				r

Legend: b = bloom; a = abundant; c = common; r = rare

From the Jaslo type coccolithic limestone blooms of *Reticulofenestra ornata* and *Cyclicargolithus floridanus* were identified. It is to mention that the same blooms were identified from the coccolithic limestone from other regions (Krhovsky 1982, Krhovsky et al., 1995, Nagymarosy 1991, Nagymarosy and Voronina 1992), indicating that the Jaslo type limestone is an excellent bio- and lithostratigraphic marker in the Upper Oligocene for the entire Paratethys area.

From the upper part of the Lower Kliwa Sandstone Formation, approximately 50m above the uppermost Jaslo laminated limestone level, the NP25 zone was identified.

The base of this zone was pointed out based on the LAD of *Sphenolithus distentus* BRAMLETTE and WILCOXON and FAD (common) of *Pontosphaera enormis* LOCKER.

In the Oligocene deposits from Romania the NP25 zone of Martini's zonation (1970) was divided in two subzones (Melinte 1995): NP25a, interval from the LAD of *Sphenolithus distentus* and/or the FAD (common) of *P. enormis* LOCKER to the FAD of *Helicosphaera paleocarteri* THEODORIDIS and/or the FAD *Triquetrorhabdulus carinatus* MARTINI and NP25b, interval from the FAD of *H. paleocarteri* and/or *T. carinatus* to the LAD of *Dictyococcites bisectus* and/or the FAD of *Helicosphaera scisssura* MULLER.

From the lower part of the NP25 zone *Reticulofenestra ornata* became rare and disappeared, while *Sphenolithus conicus* BUKRY and *S. dissimilis* BUKRY and PERCIVAL have their first occurrences.

It is to mention that in absence of Pontosphaera enormis, the FAD of S. conicus was used to approximate the NP24/NP25 boundary (Báldi - Beke, 1980).

The FAD of *Triquetrorhabdulus carinatus* is an indicative, in Martini's zonation, to point out the base of the NN1 zone (Oligocene - Miocene boundary), but in all the studied sections from Romania it appears before the LAD of *D. bisectus, Z. bijugatus* and/or *S. ciperoensis.*

From the lower part of the Topilele Formation the Oligocene - Miocene boundary (the base of the NN1 calcareous nannoplankton zone) was identified.

The LAD of *D. bisectus, S. ciperoensis, Z. bijugatus*, was used (Biolzi et al., 1981) to approximate the Oligocene/Miocene boundary. These events are supposed to be synchronous with the FAD of *Triquetrorhabdulus carinatus* (Perch-Nielsen K., 1985), so they correspond to the base of NN1 of Martini's Zonation.

In the studied sections the LAD of *Dictyococcites bisectus* and *Zygrhablithus bijugatus* are younger than the LAD of *Sphenolithus ciperoensis.*

The LAD of *Dictyococcites bisectus* is synchronous with the FAD of *Helicosphaera scissura* and *Sphenoliothus compactus*, criteria used to establish the Oligocene/Miocene boundary. From the marker species proposed by Steininger et al. (1994) in the Lemme-Carrosio section to point out this boundary, in the Chirleşti section only the FAD of *Sphenolithus delphix* was observed, above the LAD of Sphenolithus ciperoensis, in a similar position as it was recorded in the above mentioned study.

The LAD of Helicosphaera recta, which was also used by Biolzi et al. (1981) to define the lower limit of the NN1 Zone, was identified nearby the LAD of *Cyclicargolithus abisectus*, within the NN1 Zone.

From the upper part of the Topilele Formation, just bellow the Mlăcile Tuff the base of the NN2 Biozone was identified. *Discoaster druggii*, the marker species from Martini's zonation, is very rare or absent in the East Carpathians Flysch Zone. Frequent overgrow of it can be observed in the poor preserved material.

The base of the NN2 Zone was established based on the FAD of *Reticulofenestra pseudoum-*

bilica. This species is an useful marker species from the Middle Miocene, but in the Paratethys area it appears from the Lower Miocene. Báldi-Beke (1980) recorded even a younger *Reticulofenestra* cf. *pseudoumbilica* from the Egerian (NN1 Zone). The species concept of this taxon varies from one author to another, but the identified specimens from the East Carpathians Flysch Zone as well as from the Transylvania area are similar to the holotype (size range 6-8 microns) and can be assigned to *Reticulofenestra pseudoumbilica.*

In the Miocene deposits from Romania the NN2 Zone was divided in two subzones (Mărunţeanu, 1992): NN2a, interval from the FAD of *Reticulofenestra pseudoumbilica* to the FAD of *Helicosphaera ampliaperta* and NN2b, interval from the FAD of *Helicosphaera ampliaperta* to the FAD (common) of *Sphenolithus belemnos.*

Above the Mlăcile Tuff from the Topilele Formation the NN2b Subzone was identified based on the first occurrence of Helicosphaera ampliaperta. Nearby, the FAD of *Helicosphaera kamptneri* was also observed.

Podu Morii Formation was assigned in this section to the NN2b Subzone. It is to mention that the base of this formation is diachronous. In other areas the Podu Formation (which directly overlies the Lower Kliwa Sandstone) was assigned to the NP25 (upper part), NN1 and NN2 Biozones (Melinte, 1995).

S e c o n d D a y : Siriu – Nehoiaşu – Vineţişu Valley – Siriu

Stop 3 : Lower Oligocene Deposits at the Nehoiaşu

At Nehoiaşu, on the road to Bâsca Rozilei, a good outcrop can be observed. The following formations are exposed (Ştefănescu and Melinte, 1994):

a. Plopu Beds , a shaly flysch, with green pelites, Priabonian in age. At the top of this formation the level of Globigerina Marls, pointing the Eocene/Oligocene boundary, occurs.

b. Lingureşti Formation, grey and brownish shales dysodilic type and yellow weathered marlstones, Early Rupelian in age. Thin cherts are interlayered.

c. Bituminous Marls Formation, white bituminous marlstones, with centrimetric Kliwa sandstone type interlayered, also Early Rupelian in age.

d. Lower Dysodilic Formation, with Tylawa type limestones, Late Rupelian in age. Our atention will be focussed on the Lower Dysodilic Formation

Lithology. The Lower Dysodilic Formation is represented by bituminous, brownish claystones as well as beige marlstones. Centimetric, sometimes limonitized, Kliwa type sandstone can be also observed. Thin chert layers and sideritic limestone are also present. In the lower third part of this formation several layers of Tylawa Limestone occur (Fig. 8)

Calcareous nannoplankton. The Lower Dysodilic Formation was assigned to the NP23 Biozone. Poor taxonomic assemblages with: *Reticulofenestra lockeri*, *Dictyococcites bisectus*, *Zygrhablithus bijugatus*, *Lanternitus minutus*, *Cyclicargolithus floridanus*, *Dictyococcites ornatus*, *Transversopontis latus*, *T. pulcher*, *Pontosphaera multipora* were identified. Rare *Reticulofenestra ornata* and *Transversopontis fibula* were also observed.

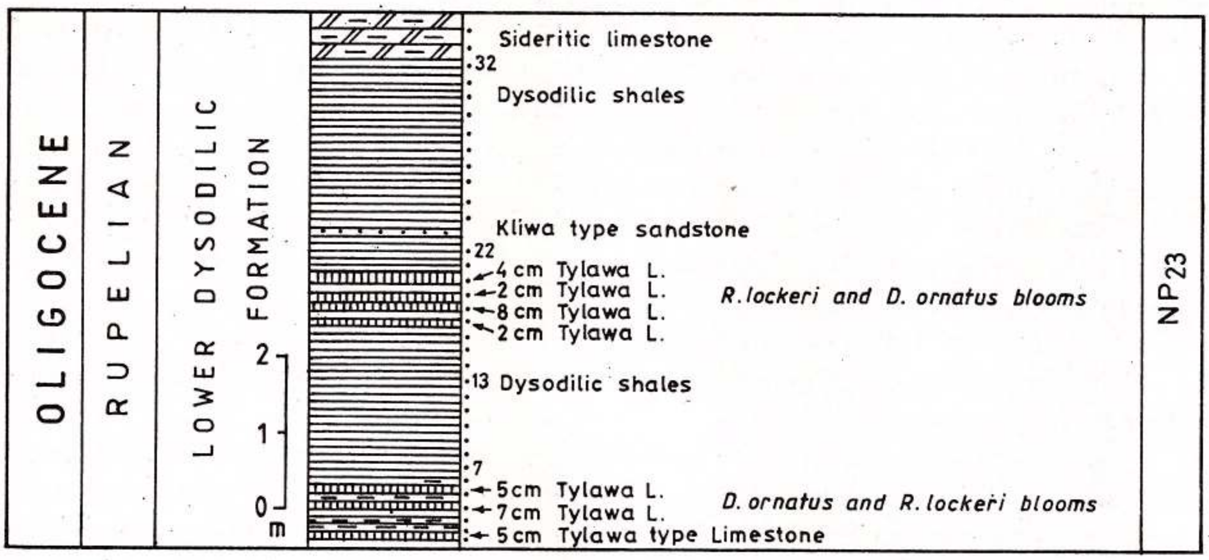


Fig. 8 – Nehoiaşu outcrop

The laminae of Tylawa Limestone contain blooms of *Reticulofenestra lockeri* and *Dictyococcites ornatus*, the same as described by Krhovsky (1992) from the West Carpathians, from the Dynow Marlstone.

This type of nannoplankton assemblages indicates low salinity condition, due to the isolation of the Early Oligocene Solenovian Sea (Rusu, 1988).

Stop 4 : **Vineţişu Valley Section : Oligocene – Miocene Boundary in the Pucioasa-Fusaru Facies**

The Vineţişu Valley is one of the few section in the East Carpathians where the two Oligocene facies (Pucioasa - Fusaru and Bituminous Kliwa) are interfingered. During the Oligocene, the detrital material was supplied from the east, that is from the Foreland, as well as from the west, that is from the orogenic belt.

During the Rupelian the dominant source was from the Foreland, so the deposits are developed in the Bituminous Kliwa Facies, while during the Chattian the two sources alternated and Kliwa type sandstones as well as Fusaru type sandstones occur.

Lithostratigraphy: In the Vineţişu Valley section, up to the confluence of the Bâsca Rozilei Valley, the following formations are exposed (Fig. 9).

a. Lower Kliwa Sandstone is represented by a sandy - shaly flysch, composed of white, orthoquartzitic sandstones and bituminous claystones. The massive sandstones Kliwa type are frequent.

b. Pucioasa Formation with Fusaru Sandstone. The detrital material of this formation is composed both from Fusaru type sandstones (micaceous, gray, calcareous ones) and Kliwa type sandstones (white, quartzitic, with rare glauconite). Centrimetric up to decimetric sideritic limestones are present.

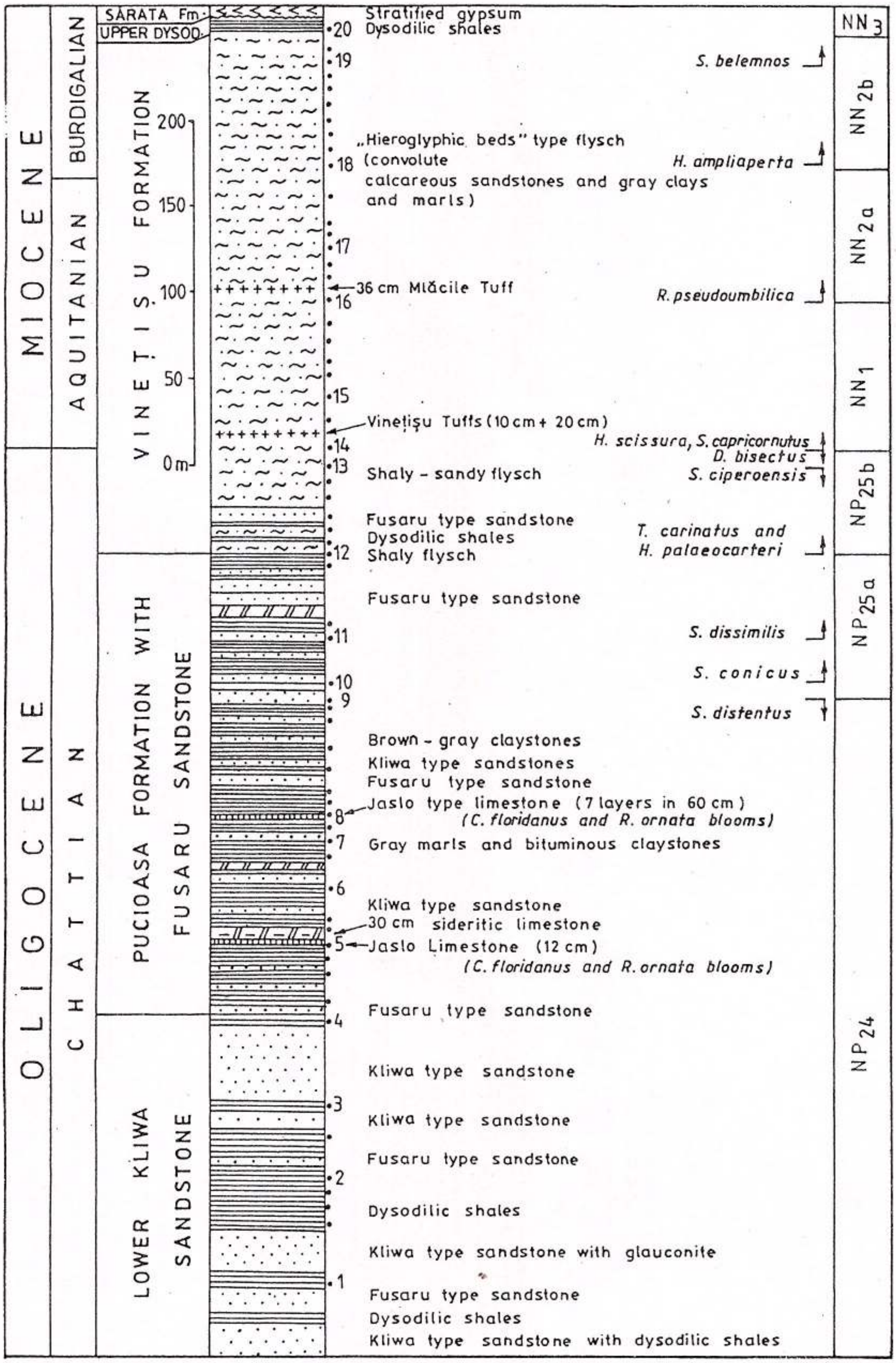


Fig. 9 – Vineţişu Valley section; • 1 – Nannoplankton sample number.

Fig. 10 – Calcareous nannoplankton distribution in the Vinețișu Valley section

NANNOPLANKTON	SAMPLES																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cyclicargolithus floridanus	r	c	c	c	b	c	c	b	c	c	c	c	c	r	c	r	r	r	r	c
Cyclicargolithus abisectus	r	r	r	r	r	r	r	r	r	r	r	r	c	a	c					
Coccolithus pelagicus	c	c	c	c	c	c	c	c	c	c	c	c	a	a	a	a	c	c	c	c
Chiasmolithus altus	r	r	r	r	r															
Dictyococites bisectus s.l.	c	c	c	c	c	c	c	c	a	a	a	a	c	c						
Discoaster deflandrei	r		r	r		r	a	r		r	r	r	r			r				
Discoaster cf. calculosus					r	r	a		r											
Helicosphaera bramlettei		r	r	r	r	c	c		c											
Helicosphaera recta	c	r	r	c		c	c		c	c		c	c		c					
Helicosphaera carteri burkei				r	r			r	r											
Holodiscolithus macroporus		r	r		r				r	r	r	r			c	r	c			
Pontosphaera multipora	r				r		r				r			r	r					
Pontosphaera latelliptica	r	r	r			r			r			r								
Reticulofenestra ornata		c	a	c	b	c	c	b	a	c	r									
Reticulofenestra minuta		r	r	r	r	r	r	r	c		c	c								
Sphenolithus distentus			r			c	c	r	r											
Sphenolithus ciperoensis		c	r	c		c	r	r	c	c	r	r	r							
Sphenolithus conicus										r	r	r	c	c		c		c	c	r
Sphenolithus dissimilis											r	r	r	c	c	c	c	c	c	c
Sphenolithus moriformis		c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c
Zygrhablithus bijugatus	r	r		r		r			r											
Helicosphaera carteri wallichii											r	r	r							
Triquetrorhabdulus carinatus												r	r		r		r	r	r	
Helicosphaera palaeocarteri												r	r	r		r				
Helicosphaera carteri burkei											r	r								
Sphenolithus capricornutus														r	c	r				
Helicosphaera scissura														c	c	r	r	r	c	r
Reticulofenestra cf. pseudoumbilica														r	r					
Helicosphaera cf. ampliaperta														r	r		r			
Coccolithus miopelagicus															r	c	r	c	c	
Rhabdosphaera claviger															r		c	r	c	c
Coronocyclus nitescens														r	r			r		
Discoaster druggii																c	c	r	r	
Reticulofenestra pseudoumbilica																c	c	c	a	c
Helicosphaera ampliaperta																		r	c	c
Helicosphaera kamptneri																			c	c
Sphenolithus belemnos																			r	c

Legend: b - bloom; a - abundant; c - common; r - rare

The green-gray marlstones and dark-bituminous claystones are common. Related to these, secondary sulphate as well as secondary gypsum can be observed. From the lower part of this formation two levels of Jaslo type coccolithic limestone (up to 12 and 60 cm, respectively) were identified.

c. Vineţişu Formation is represented by a "hieroglyphic beds" type flysch, characterised by the development of the Td and Te intervals, sensu Bouma 1962. So, a rhythmic alternance of calcareous, convolute, micaceous sandstones and green-gray pelites can be examined. Some facial recurrences (metric Fusaru type sandstones) were observed from the lower part of Vineţişu Formation. From the lower part of this formation the Vineţişu Tuffs, composed of two centrimetric layers, were identified (Ştefănescu et al., 1993).

Approximately 60 m above it, another Lower Miocene lithostratigraphic marker, the Mlăcile Tuff, occurs.

d. Upper Dysodilic Formation is represented, in this section, by 15m of bituminous fissile claystones as well as rare green-gray ones and by centimetric sandstones of Vineţişu type.

e. Sărata Formation, which discordantly covers the Upper Dysodilic Formation, is composed of stratified gypsum.

Calcareous nannoplankton. Based on the nannofossil assemblages identified in the Vineţişu Valley, the NP24, NP25, NN1 and NN2 Biozones were identified (Fig.10).

The Lower Kliwa Formation and the Pucioasa Formation (lower part) were assigned to the NP24 Biozone. Common *Cyclicargolithus abisectus, Cyclicargolithus floridanus, Sphenolithus ciperoensis, Dictyococcites bisectus, Sphenolithus moriformis, Coccolithus pelagicus, Helicosphaera recta, Pontosphaera latelliptica, Pontosphaera multipora, Chiasmolithus altus* and *Sphenolithus distentus* documented the presence of the NP24 calcareous nannoplankton zone.

The laminae of the two levels of Jaslo type coccolithic limestone, identified within the Pucioasa Formation with Fusaru Sandstone, contain blooms of *Cyclicargolithus floridanus* and *Reticulofenestra ornata.*

It is to mention that, in some layers situated bellow the youngest Jaslo type limestone, a remarkable frequency of the *Discoasterids (D. deflandrei* and *D. cf. calculosus)* as well as of the *Sphenoliths*, with an unusual big size *(S. moriformis, S. distentus, S. ciperoensis)*, was observed. Both genera characterized warm water. So, their abundance can be related to a maximal warming in this area.

In the upper part of the Pucioasa Formation with Fusaru Sandstone the NP24/NP25 was recognized, based on the LAD of *Sphenolithus distentus.*

It is to emphasize that, in this section, from the above mentioned formation and especially from the Vineţişu Formation, the green-gray to green marlstones are very frequent. These pelites are autochthonous and, consequently, the reworkings (common in the flysch facies) are absent (Melinte and Ştefănescu, 1993). So, the last occurrences of the nannofossil species are reliable events.

Just above the LAD of *Sphenolithus distentus* the FAD of *Sphenolithus conicus* was observed, followed by the FAD of *Sphenolithus dissimilis. Pontosphaera enormis* was not identified in this section. However, it seems that the presence of this species can be related to a strong facial control.

The NP25a/NP25b subzones boundary (the FAD of *Helicosphaera palaeocarteri* and *Triquetrorhabdulus carinatus*) corresponds to the base of the Vineţişu Formation. The Vineţişu Formation was assigned to the NP25 (NP25b subzone), NN1 and NN2 Zones.

From the lower part of the above mentioned formation the following nannofossil events were observed: the LAD of *Sphenolithus ciperoensis*, followed by the LAD of *Dictyococites bisectus*, synchronous with the FAD of *Helicopshaera scissura* and *Sphenolithus capricornutus*. It is to mention that the Vineţişu section is the only studied one where *Sphenolithus capricornutus* (marker species proposed by Steininger et al., 1994) was identified. So, based on the FAD of *Helicosphaera scissura* and *Sphenolithus capricornutus* the NP25/NN1 (the Oligocene/Miocene boundary) boundary was established just bellow the Vineţişu Tuffs level.

Bellow the Mlăcile Tuff, the FAD of Reticulofenestra pseudoumblica points out the NN1/NN2 boundary. Above this lithological marker level, based on the FAD of *Helicosphaera ampliaperta*, the boundary between the NN2a/NN2b subzones was identified.

From the upper part of the Vineţişu Formation *Sphenolithus belemnos* appeared.

The Upper Dysodilic Formation was assigned to the NN2b Subzone, while the Sărata Formation was assigned to the NN3 Biozone, based on the presence (common) of Sphenolithus belemnos, from the subjacent pelites.

Third Day : Siriu – Teherău – Braşov – Sighişoara – Cluj Napoca

From Siriu the route follows upstream the Buzău River. Good outcrops of the Eocene and Oligocene deposits of the Tarcău Nappe can be seen.

Stop 5 : **Teherău Viaduct : Jaslo Limestone from the Pucioasa Formation with Fusaru Sandstone.**

Lithology. The studied part of the Pucioasa Formation with Fusaru Sandstone is represented, in this outcrop, by a shaly – sandy flysch, followed by a shaly flysch and by a "hieroglyphic beds" – type one, from where the level of Jaslo Limestone was identified. Above this sequence, 1m above the youngest Jaslo layer, the massive Fusaru Sandstone developed (Fig. 11).

Calcareous nannoplankton. The age of this sequence of Pucioasa Formation with Fusaru Sandstone is Chattian (the NP24 Biozone, documented by the presence of: *Cyclicargolithus floridanus, C. abisectus, Sphenolithus ciperoensis, Helicosphaera recta, Dictyococcites bisectus, Reticulofenestra ornata, R. lockeri*). The laminae of Jaslo Limestone contain blooms of *Cyclicargolithus floridanus* and *Reticulofenestra ornata*.

From Teherău up to Harţagu Brook the route crosses again the Eocene and Oligocene deposits of the Tarcău Nappe, dominated, from structural point of view, by large folds. Upstream Harţagu and Buzău River confluences the field will cross the following nappes of the Inner Moldavides: Audia, Teleajen (=Convolute Flysch) and Macla. From the Poiana Florilor locality the Bobu and Ceahlău Nappes (Outer Dacides Nappes) outcrop.

Between Teliu and Braşov the route crosses the southern part of Sfântu Gheorghe Depression, one of the three Plio – Quaternary depressions (Sfântu Gheorghe, Bârsa and Breţcu), which develops in the inner part of the East Carpathians Bend Area.

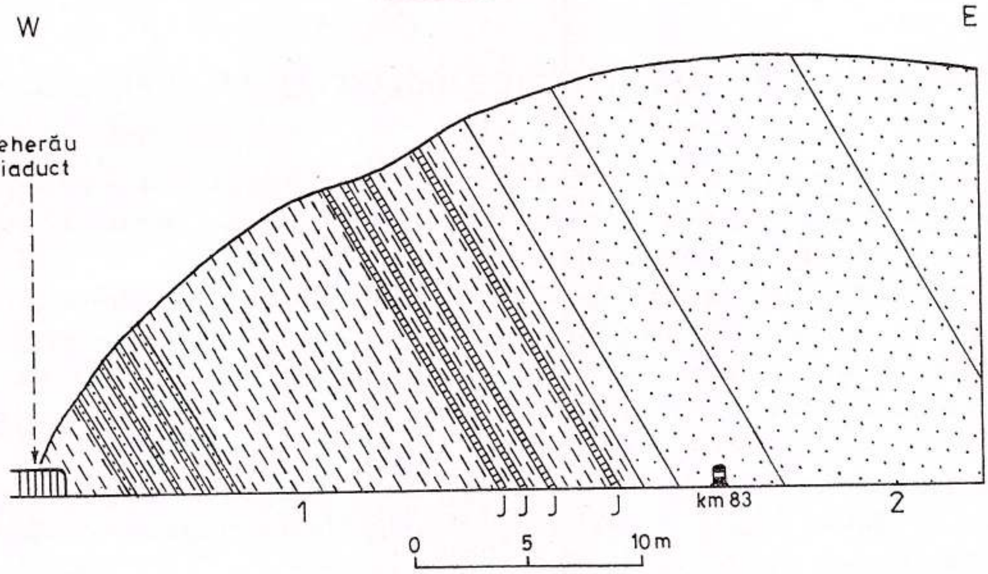


Fig. 11 – Teherău Viaduct outcrop; 1) Pucioasa Formation, J - Jaslo type limestone; 2) Fusaru Sandstone.

Nearby the Braşov town a nice panorama of the southern East Carpathians can be seen: northward the Baraolt Mts and southward the Piatra - Mare and Ciucaş - Zăganu Mts Westward the Postăvaru Mts rises, dominating the Braşov town, located at the foot of the Tâmpa Hill. From the Braşov town the route crosses the Perşani Mts, where the Upper Cretaceous post-tectogenetic cover of the Median Dacides as well as basaltic rocks of the Neogene alkali - basaltic volcanism can be seen, then it enters the Transylvanian Depression. From Hoghiz up to Cluj, the route crosses the Transylvanian (Middle-Upper Miocene) molassic deposits (Langhian, Kossovian, Sarmatian and Pannonian in age).

Our field trip will stop in the Sighişoara town, situated approximately in the central part of Transylvania. The town of Sighişoara is a jewel of Medieval architecture.

The settlement was established by German colonists in 1191. The first mention of its name, "Schespurch", is known since 1298 in a papal document, while the Hungarian name, Segésvar dates from 1367, and the Romanian one, Sighişoara, from 1431. It have got the rank of town in 1367. Worthwhile to visit are the Clock Tower and the other 13 towers belonging to the guilds of craftsmen who mostly inhabited the town in the Middle Age, as well as the Dominican Monastery Church and the Church on the Hill.

GENERAL OUTLOOK ON THE TRANSYLVANIAN DEPRESSION

The Transylvanian Depression represents an intermountainous area bordered by Apuseni Mts to the west, South Carpathians to the south, East Carpathians to the east and nord-east and Preluca – Ţicău crystalline massifs to the north.

This Transylvanian Depression became a sedimentation area at the end of the Alpine tectonics (Upper Cretaceous). The post–tectogenetic cover consists of normal and brackish marine epicontinental formations, mainly carbonatic, alternating with continental deposits, all of them belonging to the Senonian–Lower Oligocene interval. During the Upper Oligocene to Lower Miocene, the marine and continental-lacustrine terrigenous deposits prevail.

The outlining of the Transylvanian Depression started in the Lower Miocene but the present geomorphologic aspect (Fig. 1) was set during Middle Miocene (Langhian) when the active molasse sedimentation started.

The sedimentary deposits overlie two tectonic stages: the first made up by fragments of Dacides and Transylvanides, and the second, by the post–tectogenetic Senonian–Burdigalian cover (Săndulescu, 1984).

The sedimentary deposits accumulated between the Upper Oligocene and the Lower Miocene are preponderantly marine in the northern and north–eastern part and marine–continental facies alternations in north-western, western and southern Transylvania. This distribution suggests the existence of some continuous features with the Carpathians and the Pannonian Depression. These connections were also maintained during the Middle and Upper Miocene.

A great variability in the lithological constitution of the deposits situated at the same stratigraphic level is to be noticed in Transylvania. Some problems concerning their correlation still exist, but many of them have been solved, at least partially, by the researches carried out during the last decade.

Oligocene–Lower Miocene Formation in the Preluca Area

The Paleogene-Lower Miocene deposits in NW Transylvania belong to the post-tectogenetic cover of the Inner Dacides (Săndulescu, 1984). According to the lithofacial characteristics of the Paleogene formations three deposition areas have been distinguished in this region from north to south, as follows: Preluca Area, Meseş Area and Gilău Area (named after the adjacent crystalline massifs).

During our field trip we shall study formations from the Preluca Area (Fig. 12), which in the Oligocene- Lower Miocene time span was a marine submerged zone. During the Upper Priabonian and Lower Rupelian (Merian) interval the Preluca Area functioned as an uplifted shallow carbonatic platform, whereas during the Upper Rupelian (Kiscellian) and especially during the Chattian-Burdigalian (Egerian-Eggenburgian) it became a deeper zone (outer shelf and continental slope, dipping toward the Maramureş trough).

The deposition of the Cuciulat Formation (Lower Rupelian), equivalent to the Mera Formation in the Gilău Area, with mesogean faunas (Mészáros et al., 1989), is followed by two formations belonging to the Dolheni Group (Bizuşa Beds and Ileanda Beds) with peculiar lithology and fauna.

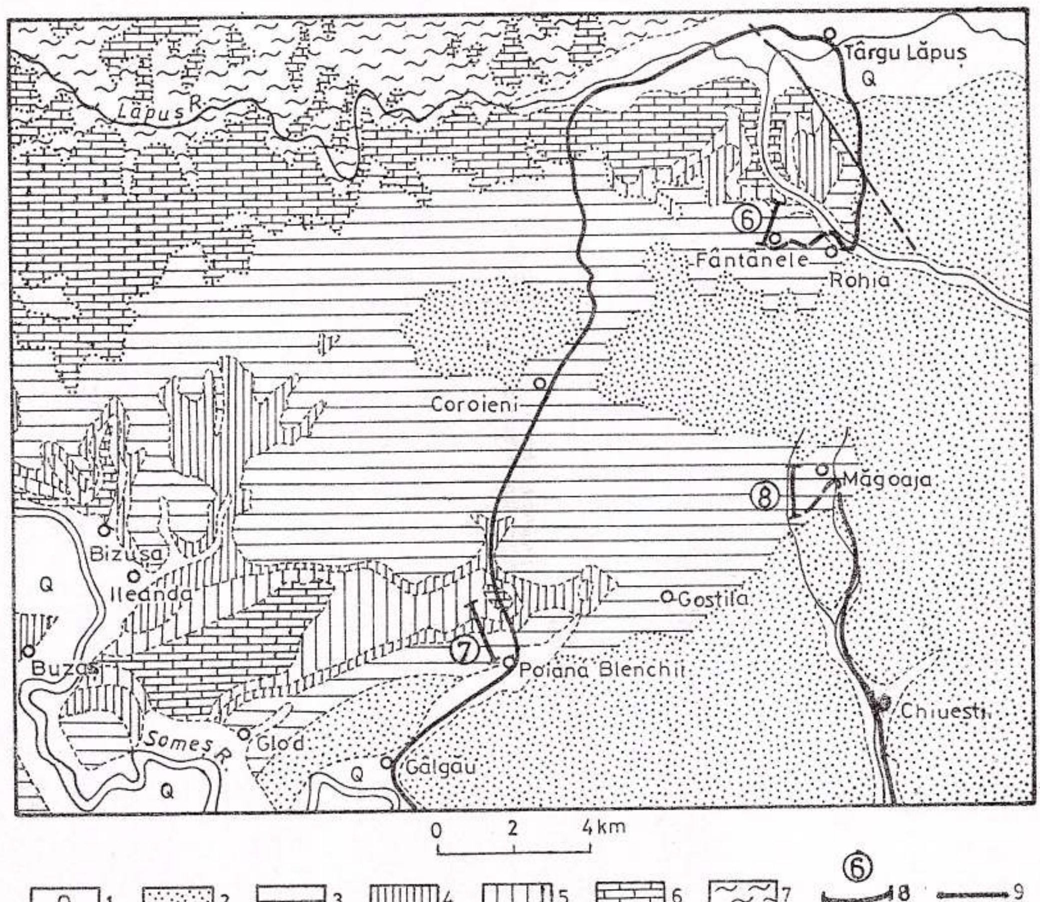


Fig. 12 - Geological map of the Preluca Area; 1) Quaternary, 2) Ciceu-Giurgeşti and Someş Fms., 3) Vima and Buzaş Fms., 4) Bizuşa and Ileanda Fms., 5) Cuciulat Fm., 6) Eocene formations, 7) Metamorphic rocks, 8) Section, 9) Itinerary.

Bizuşa Formation (Dumitrescu, 1957) consists mainly of poorly bituminous grey-whitish marlstones and calcareous marlstones, that form a lithostratigraphic entity petrographically flatly distinct from the adjacent formations (Fig. 13).

In some places this formation (10-15 m in thickness) can contain bituminous shales (at Fântânele) or siltic clays, marly clays and fine marly sandstones (all of them poorly bituminous) situated in the basal part of the formation (at Glod). The clay fraction of the rocks is illito-kaolinitic (Ghergari et al., 1989). At Glod, the clay sequence includes a 3-5 cm layer of bentonitized tuff - the "Glod Tuff" (Rusu et al., 1995) - coeval with one of the tuffs of the Tard Clay situated within the Cardium lipoldi- Ergenica Zone in Hungary (Báldi, 1984).

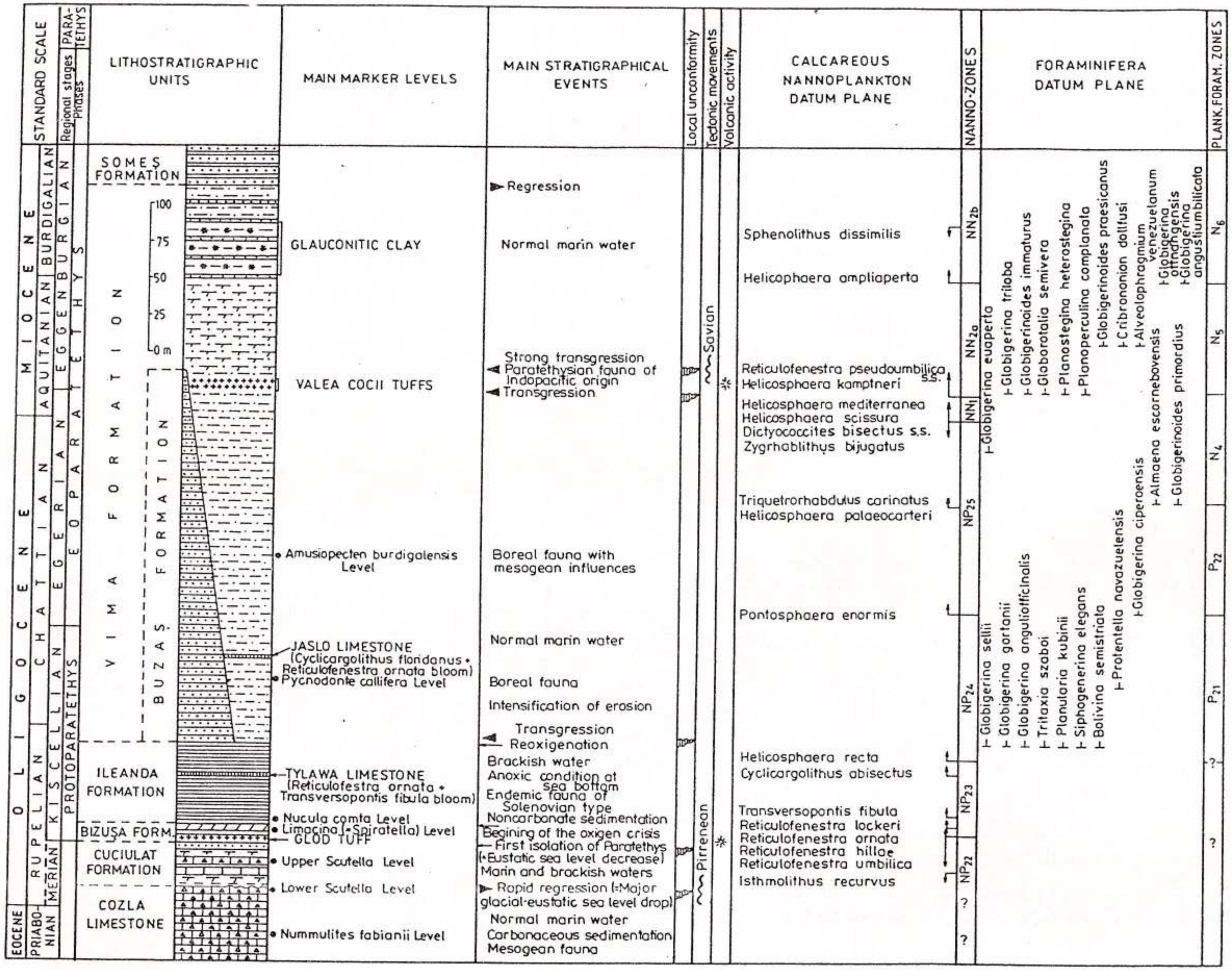


Fig. 13 – Generalized Oligocene – Lower Miocene succession in Preluca Area.

Bizuşa Formation preserves remains or imprints of molluscs, ostracods, crabs, fishes, plants and nannoplankton. The malacologic assemblage consists of "*Cardium*" *lipoldi* ROLLE, *Janschinella garetzkii* (MERKLIN) (= *J. vinogrodskii* MERKLIN)= *J. melitopolitana* (NOSSOVSKI), *Ergenica cimlanica* (POPOV), *Urbnisia lata* GONTSCH., *Abra brevis* (BOSQ.), and *Limacina* sp. This is a low salinity endemic fauna (9–16.5 %o = pliohaline brackish waters) belonging to the Janschinella garetzkii Zone of the Paratethys. Janschinella garetzkii Zone has been established as total-range zone (Rusu, 1995), intercalated in Transylvania between two local mollusc zones: Tympanotonos labyrinthum/Ampullinopsis crassatina Zone (concurrent range zone), in the base, and Pycnodonte callifera Zone (asemblage zone), in the top. Imprints of *Limacina* shells forms, due to their abundance, a real biohorizon which is, however, situated at another stratigraphic horizon than the well-known Limacina Horizon (= *Spiratella=Planorbella*) from Central and Eastern Europe which occurs in a normal marine formation under the deposits with Solenovian-type faunas.

The richer ostracod community towards the upper part of the formation belongs, according to Olteanu (1980), to the following taxa: *Thracella apostolescui* SÖNMEZ, *Cytheridea ventricosa* GOERLICH, *Cytherissa spatacea* (LNKS.), very frequently found, and *Cyamocytheridea* aff. *bouendensis* (LNKS.), *Bosquetina* sp., *Loxoconcha subovata* (MÜNST.), *L. kuiperi* KEIJ, less frequently found. It is to note that the Bizuşa Formation corresponds to the Ostracod Beds (Ostracodovy Plast) in the Eastern Paratethys and it is only the lack of data that makes the two regions seem different.

Remains of fossil plants have been recently stressed out by Petrescu et al. (1989) as spore-pollen and well preserved foliar imprints. Thus, in the base of the formation, at Mesteacăn, occurs a rich pollinic spectrum, dominated by the species *Momipites punctatus* (R.POT) NAGY, *Tricolporopollenites cingulum* (R.POT) TH-PF., *T. microhenrici* (R.POT), W.KR., *Porocolpopollenites vestibulum* (R.POT) TH.-PF. and *Boehlensipollis hohli* W.KR. This assemblage could be assigned to the terminal part of the Pg 20b Zone from Krutzsch's zonation or SP.7b Subzone from Sittler's zonation.

Towards the upper part of the formation, Mesteacăn, Bizuşa and Ileanda localities, a level with foliar imprints of *Pteridium blechnoides* (HEER), *Lygodium kaulfussii* HEER, *Doliostrobus taxiformis* (STEINB.) KV., *Athrotaxis couttsiae* (HEER) GARTNER, *Libocedrites salicornioides* (UNGER) ENDL., *Chamaecyparites haardtii* (GOEPP.) ENDL., *Dryophyllum furcinerve* (ROSSM.) SCHM., *Embothrites borealis* UNGER, *Palaeocarya macroptera* (BRGT.) J.,F.,T., *Cassiophyllum berenices* (UNGER) KRAUSEL, *Zizyphus zizyphoides* (UNGER) WEYL., *Laurophyllum* sp., *Betula* sp. etc. has been identified.

On the basis of the identified flora it has been considered that the land in the vicinity of the marine basin had a warm climate with a mean annual temperature of about 18°C and the mean annual rainfall rate around 1800 mm.

The calcareous nannoplankton of the Bizuşa Formation was assigned to the NP22 and NP23 Biozones. The lower part of this formation comprises rich and diversified assemblages.

From the upper part of it (upper part of the NP22 Zone) layers containing poor nannofossil associations, as well as mono and duospecific ones were also identified.

The presence of the NP22 Zone was documented based on the following species: *Reticulofenestra umbilica, Dictyococcites bisectus, D. filewiczii, Lanternitus minutus, Orthozygus aureus, Coccolithus pelagicus, Cyclicargolithus floridanus, Sphenolithus moriformis, Pontosphaera rothii, P. multipora, P. latelliptica, Transversopontis pulcher, T. pulcheroides, Reticulofenestra* cf. *tokodensis*. Blooms of *Reticulofenestra lockeri* MÜLLER, *Dictyococcites ornatus* (MÜLLER), BISTRICKA and *Braarudosphaera bigelowii* GRAAN and BRAARUD (low salinity resistant species), identified also in other areas of the Paratethys (Krhovsky et al., 1992; Nagymarosy 1991; Nagymarosy and Voronina, 1992), were observed in the upper part of the Bizuşa Formation. The presence of these levels can point out the first isolation of the Paratethys , in the upper part of the NP22 nannofossil zone.

Reticulofenestra ornata MÜLLER as well as *Transversopontis fibula* GHEŢA are rare, while *Dictyococcites ornatus* (MÜLLER) BISTRICKA and the morphotypes of this species described by Krhovsky et al., (1992) are common to abundant.

At the uppermost part of the Bizuşa Formation the NP22/NP23 boundary was identified based on the LAD of *Reticulofenestra umbilica*.

The Bizuşa Marls deposited in a sublittoral zone have as littoral equivalent the arenitic Creaca Beds in the Meseş Area, to which a sedimentary gap corresponds in the Gilău Area.

Bizuşa Formation marks the beginning of the oxygen crisis that occurred as result of the first isolation of the Transeuropean Realm=Paratethys (Rusu, 1977; Báldi, 1979), when a haline stratification with more brackish surface waters could have taken place (see Haczewski, 1989).

The age of the Bizuşa Formation, based on the fossil content, particularly the calcareous nannoplankton that belongs mainly to the upper part of the NP22 Zone, is earlier Kiscellian, a time equivalent to the Late Rupelian.

Ileanda Formation (Hofmann, 1879, emend. Dumitrescu, 1957) displays a relatively sharp boundary with the underlying Bizuşa Formation and a gradual passage to the upper part to the Buzaş Formation or the Vima Formation respectively. This develops in its typical bituminous fissile claystones or siltstones facies in the Preluca Area, where the thickness reaches maximum 50–60 m. The clays have been determined as illito-kaolinitic (Ghergari et al., 1989), comparable with those of the preceding formation. "Fischschuppenschiefer" (Fish scales schists) known from Hauer and Stache (1863) include rare intercalations of sideritic marly limestones, locally as concretions, and of fine siliciclastic sandstones, more frequently found towards the upper part.

Recently, within the Ileanda Formation, Tylawa type coccolithic laminitic limestones situated at two stratigraphic levels, have been stressed out (Rusu et al., 1995). The lower level, found at Fântânele in the lower half of the formation, consists of several coccolithic layers of some centimetric up to 20 cm each. The upper level is well exposed on the Imoasa Valley nearby Vima Mare and on the Valea Poienii at Ileanda and it is formed of one calcareous bed of 15–30 cm, situated towards the top of the formation. It is noteworthy that the coccolithic laminas are represented by the blooms of the species *Reticulofenestra ornata* and *Transversopontis fibula*.

The presence of the Tylawa Limestones in Transylvania makes possible a better correlation of the Ileanda Formation with the Lower Dysodile Formation in the East Carpathians (Haczewski, 1989; Ştefănescu et al., 1993; Melinte, 1993) and with a part of what in the West Carpathians is assigned to the Menilitic Formation (Haczewski, 1989; Krhovsky, Djurasinovic, 1993).

The Ileanda Beds contain two distinct fossils communities. The former community, widespread on the whole thickness of the formation, consists of brackish molluscs, such as *Janschinella garetzkii*, *"Cardium" lipoldi* and *Cerastoderma serogosica* (NOSS), and nannoplankton tolerant to salinity decrease (9–16.5 ‰ - pliohaline waters). The latter community, situated in a basal horizon of compact clays or marls (maximum 2.5 m thick), is formed of euhaline marine biotic assemblages that constitute the Nucula comta Level (Rusu, 1972). This marker level is quite significant for the regional correlations and contains several groups of organisms, as follows: Moluscs - *Nucula comta* GOLDF., *Nuculana westendorpi* (NYST), *Angulus nysti* (DESH.), *Polinices achatensis* (RECL.) (Rusu, 1977); Foraminifers - *Nonion granosum* (D'ORB.), *Pyrulina fusiformis* (ROEMER), *Glandulina aequalis* REUSS, *Dorothina* aff. *textilaroides* (HANTK.), (Rusu 1977); Ostracods - *Cytheridea helvetica* LNKS.. *C. intermedia* (REUSS), *Bairdia* aff. *oviformis* SPEYER, *Loxoconcha* aff. *kuiperi* KERJ., *Cytheromorpha* aff. *zindorfi* (LNKS.), *Aglaiocypris* aff. *enigmatica* ((SPEYER), *Cytheretta* aff. *tenuistriata* REUSS, etc. (Rusu et al., 1978; Olteanu, 1980); Nannoplankton - *Reticulofenestra ornata* (MÜLL.), *Dictyococcites dictyodus* (DEFL., FERT), *Ortozygus aureus* (STRAD.), *Transversopontis fibula* GHEŢA (Gheţa et al., 1976). The faunal elements of this biohorizon point out the short episode of reestablishing the connections of the Solevonian Sea with the ocean, through the North Sea region.

The calcareous nannoplankton assemblages identified by us in the studied sections of the entire Ileanda Formation contain marker species of the NP23 Biozone, characterizing the Paratethys: *Transversopontis fibula, Dictyococcites ornatus, Reticulofenestra ornata, Reticulofenestra lockeri.*

Transversopontis fibula (whose holotype was described by Gheţa, 1976, from the Ileanda Formation) is common. Blooms of this species (generally recorded together with blooms of *Dictyococcites ornatus* or *Reticulofenestra lockeri*) occur in the lower part of the NP23 Biozone. In the upper part, *Transversopontis fibula* became rare and disappeared before the FAD of *Cyclicargolithus abisectus.* Except *Sphenolithus moriformis*, other *Sphenoliths* were not identified.

Cyclicargolithus floridanus as well as the morphotypes described by Bubik (1992) are common.

Zygrhablithus bijugatus, Lanternitus minutus, Transversopontis latus, T. pygmeus, T. obliquipons, T. pulcher, Pontosphaera plana, P. multipora, P. latelliptica, Cocccolithus pelagicus are also present in the NP23 assemblages.

It is to mention that this formation was assigned so far (Mészáros, 1992) only to the NP24 nannofossil zone, based on the presence (common) of *Sphenolithus ciperoensis, Pontosphaera enormis* and *Cyclicargolithus abisectus.*

Our studies pointed out that the boundary between the NP23/NP24 Biozones, documented by the FAD of *Cyclicargolithus abisectus*, is situated in the uppermost part of the Ileanda Formation.

The unpublished palynological analyses (A. Ionescu) rendered evident the presence of the spore-pollen elements (*Boehlensipollis hohli* association) and of Dinoflagelates (*Tythodiscus* and *Batiacosphaera*), pointing to a deterioration of the climate, beginning with the Bizuşa Formation. The age of the Ileanda Formation is Kiscellian or, on the standard chronostratigraphic scale, Late Rupelian and is based mainly on the presence of the NP 23 and NP 24 nannoplankton zones (lower part).

The noncarbonatic sedimentation starts with the Ileanda Formation and the anoxic regime of the bottom waters is more marked, which led to the formation, in the sublittoral zone, of the sapropelic muds. They correspond in the littoral zones to the bivalve coquina sands, that constitute the Gruia Sandstone (= Cetate Sandstone - partim).

The endemic Solenovian-type fauna is the result of the isolation (during the Late Rupelian) for the first time of the "Transeuropean realm" or the Paratethys. The Paratethys disconnection from the Tethys and the northern realm was due to a contemporaneous global eustatic sea level drop, which determined the separation of the Solenovian Sea (Rusu, 1988) - extending from Czechia and Slovenia to Turkmenia and Kazakhstan. The isolation of the first Paratethys in Protoparatethys phase was total, excepting some unsignificant interruptions, in contrast with the next phase (Eoparatethys) during which in fact the Paratethys realm communicated widely with the open seas.

Buzaş Formation (Dumitrescu, 1957) represents the lithostratigraphic unit separated by Hofmann (1887) as "Die seichte marine Sandsteinfazies" (shallow marine sandstones facies) in his "Aquitanischen Schichten". This formation is gradually passing to the Ileanda Beds (Fig. 13) and consists of massive marly sandstones and sands as metric beds, with intercalations of calcareous sandstones and, in places, of siltic marls.

In the area west of the type locality (Buzaş), where this formation is wholy developed, its thickness reaches 400-500 m. East of the mentioned locality the upper terms of the Buzaş Formation are lithofacially replaced by the clays of the Vima Formation, so that in the Poiana Blenchii this formation reaches 150-200 m and at Măgoaja only 50 m. Nearby the crystalline of the Preluca Massif it is obvious the transgressive character of the Buzaş Beds which rest directly on the Priabonian limestones. The deposits of the Buzaş Formation laterally interfinger to the west with the of brackish and continental deposits assigned to the Valea Almaşului Formation.

The fossil content of the Buzaş Formation is represented by molluscan shells or moulds, foraminifera tests and nannoplankton coccoliths.

The molluscan assemblages form typical biohorizons which, from old to new, are: Pycnodonte callifera Level, Turritella and Thracia Level, Amussiopecten burdigalensis Level, Callista lilacinoides Level and Chlamys gigas Level. For details on the constitution and characteristics of these levels see Rusu's paper in this volume. Here, we point out that, based on the molluscan fauna, the Oligocene-Miocene boundary would be situated somewhere below the Callista lilacinoides Level. It is also noteworthy that, including in the top of the formation elements of the Chlamys gigas Level, the Buzaş Beds end with an equivalent of the Coruş Beds (which here is not lithologically individualized).

The foraminiferal assemblages, generally poor, are dominated by the benthonic forms (especially agglutinated) of which we mention only the species *Spiroplectinella carinata* (D'ORB.), *Almaena hieroglyphica* SIGAL, *Planulina costata* (HANTK.) and *Karreriella chilostoma* REUSS. (see Rusu, 1975). Some forms of planktonic foraminifers, such as *Globigerina ciperoensis* BOLLI, *G. parva* BOLLI and *Globoquadrina venezuelana* HEDBERG, occurring within the Amussiopecten burdigalensis Level, would indicate, according to M. Iva, the presence of the P 22 Standard Zone corresponding to the Neochattian (Rusu, 1977). This interpretation is in agreement with the results obtained by Mészáros et al. (1975) who emphasized at this level the presence of the NP 25 Zone of calcareous nannoplankton. The deposits overlying the Amussiopecten burdigalensis Level have not been studied from the nannofossil content point of view. The ones underlying this level were assigned to the NP 24 (partim) and NP 25 Zones.

In the NP24 Zone rich and diversified nannofossil assemblages, indicating that the normal salinity restored, are present. Rare *Sphenoliths (S. moriformis, S. distensus, S, ciperoensis)*, common species of *Pontosphaera*, as well as abundant *Helicosphaera* were observed.

Other common species are: *Cyclicargolithus abisectus, C. floridanus, Dictyococcites bisectus, Reticulofenestra lockeri, R. ornata, R. minuta.*

The NP24/NP25 boundary was established based on the presence (common) of *Pontosphaera enormis* and FAD of *Sphenolithus conicus.*

Sphenolithus distensus sporadically occurs, so its LAD is not a reliable event.

From the upper part of the Buzaş Formation, within the NP25 Biozone, the first occurrences of *Triquetrorhabdulus carinatus* and *Helicosphaera paleocarteri* were identified. Bellow these events the FAD of *Sphenolithus dissimilis* was also observed.

Above the FAD of *Triquetrorhabdulus carinatus* and *Helicosphaera paleocarteri* the FAD of *Sphenolithus delphix* was recorded.

The deposits of the Buzaş Formation, sedimented in a shallow - and medium - sublittoral zone, represent a new open sea sedimentation cycle, marked by the increase of the erosion and the reoxygenation of the basin waters.

The age of the Buzaş Beds is Late Kiscellian-Early Eggenburgian, corresponding on the classical chronostratigraphic scale to Latest Rupelian-Aquitanian.

Vima Formation, (Lăzărescu, 1957, emend. Rusu, 1969)

The marine, pelitic deposits, which overlie the Ileanda Formation and are overlain by the Somes Formation, represent a well defined lithostratigraphic unit in the northern part of transylvania (south and south-east of the crystalline Preluca Massif): Vima Formation. This formation surpasses the stratigraphic interval between Upper Rupelia and Lower Burdigalian (Popescu, 1972), Upper Kiscellian -Eggenburgian repectively on the regional chronostratigraphic scale. The lateral counterparts of this unit (wesward) are the Buzaş and Chechiş formations.

The transition from the marine to the marine brackish facies is gradual, from east to west, by the replacement of the fine-grained facies with coarse-grained facies types. Such a situation occurs at Poiana Blenchii, where the lower part of the formation is invaded by the marine sandy facies (Buzaş Formation). The thickness of the formation, on the Imoasa Valley (north of Vima Mare locality) and Cocii Valley (west of Mogoaja locality), was estimated at about 300–350 m. In the lower part, the formation contains an important marker level represented by coccolithic limestone. The marker level has been mentioned by Haczewski (1989) south of the locality of Cerneşti (on the route Tg. Lăpuş - Baia Mare, km 33). It will be seen during our Excursion at Fântânele.

The Vima Formation includes rich fossil assemblages, mainly represented by molluscs, foraminifers, ostracods, palynomorphs and calcareous nannoplankton.

The molluscs fauna was mentioned from the lower and middle part of the Vima Formation (deposits overlying the coccolithic limestone) by Hofmann (1887) and re-examined by Mésáros & Marosi (1957). The assemblage consists of *Pecten (Semipecten) unguiculus, Variamusium fallax [= Pecten (Amusium) bronni], Amusium semiradiatus, Limnopsis retifera, Nucinella microdus, Leda* cf. *perovalis, Axinus* cf. *unicarinatus*. This Oligocene assemblage contains boreal taxa.

The lower part of the Vima Formation contains a Kiscel-type foraminiferal assemblage (Popescu, 1975) which extincted near the laminitic limestone. In the middle part of the Vima Formation, a particular fossil foraminiferal assemblage with *Globigerina megaperta, Globigerina ciperoensis, "Protentella" navazuelensis, "P." rohiensis* occurs. In this upper part a foraminiferal assemblage characteristic of the Chechiş–type (in which *Globigerinoides triloba* is a common taxon) is occurring.

The ostracods occur in the middle part of this formation. They are represented by the following community: *Cytherella* aff. *transversa, Bairdia* aff. *subdeltoidea, Occultocythereis bituberculata, Henryhowella asperrima, Krithe* aff. *papillosa* (Olteanu, 1980).

As concerns the palynomorphs content, in this formation Boehlensipollites hohli Zone (in the lowermost part of the formation), and Wetzeliella gochtii Zone (with *Wetzeliella symmetrica, Rhombodinium draco* and *R. perforatum*) were identified. In the middle part of this formation, besides the mentioned species, *Deflandrea spinulosa* and *Slowakipollis* occur. In the upper part of the Vima Formation the palynomorphs assemblage contains *Chiropteridium* and *Neogenisporites* (Ionescu & Popescu, 1995).

The nannoplankton content indicates zones NP 24 to NN 2. It is woth mentioning the occurrence of the *Sphenolithus delphix* and *S. compactus* identified on Valea Cocii section, in the middle part of the Vima Formation. Here, the NP25/NN1 boundary could be pointed out based on the first occurrence of *Helicosphaera scissura* and *H. mediterranea*, coeval event with the last occurrence of *Dictyococcites bisectus.*

GEOLOGICAL SECTIONS AND OUTCROPS

Itinerary: Cluj Napoca – Dej – Târgu Lăpuş – Rohia – Fântânele

Stop 6 : **Valea Poienii Section (Fântânele locality) : Bizuşa Fm., Ileanda Fm., Vima Fm.** (Fig. 14)

This section is situated 4.5 km to the west of Rohia locality, in Valea Poienii, left tributary stream of Rohia Valley.

There, Bizuşa, Ileanda and Vima formations are well exposed.

Bizuşa Formation (15 m calcareous bituminous marlstones) is outcropping near the Poienii-Valea Rohiei confluence. It is overlain by the Ileanda Formation (45 m of bituminous fissile shales).

Two levels of laminited coccolithic limestone (in the same biostratigraphical position as Tylawa Limestone from the Carpathians) are interbedded in its lower part (Fig. 14). In the upper part of the Ileanda Formation an alternance of siltic clays and bituminous shales occurs (a gradual transition to the overlaying lithostratigraphic unit: Vima Formation).

Vima Formation is constituted of siltic clays in which, in the lower part, thin sideritic limestones (10-15 cm thickness) are interbedded.

From the upper part of this section a level (10-15m) of coccolithic limestone of Jaslo type occurs.

All the samples collected from this section contain fossil remnants (abundant foraminifera and calcareous nannoplankton) (Figs. 14, 15).

Biostratigraphy.

Both the Ileanda and the Vima formations were studied from the nannofossil point of view.

The Ileanda Formation was assigned to the NP23 and lower part of the NP24 Biozones.

Common *Dictyococcites bisectus, Coccolithus pelagicus, Dictyococcites ornatus, Reticulofenestra lockeri* are present in the NP23 Zone.

In the laminae of the Tylawa type cocccolithic limestone, interbedded at the lower part of the Ileanda Formation, blooms of *Reticulofenestra lockeri* and *Dictyococcites ornatus* were identified.

At the upper part of the above-mentioned formation (also upper NP23 Biozone) a bloom of *Braarudosphaera bigelowii*, species characterising a brackish environment, was observed.

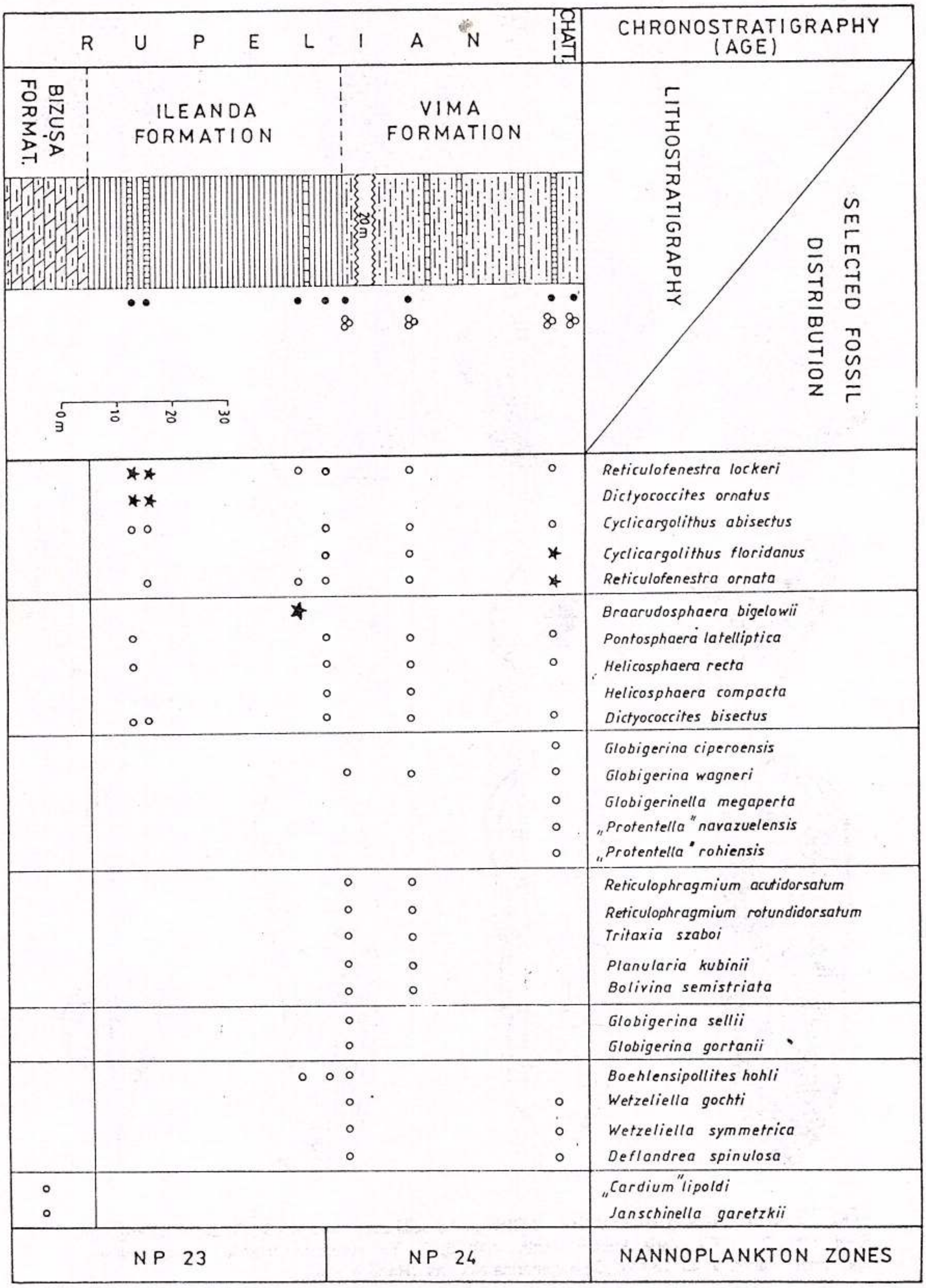


Fig. 14 – Valea Poienii Section, Fântânele village.

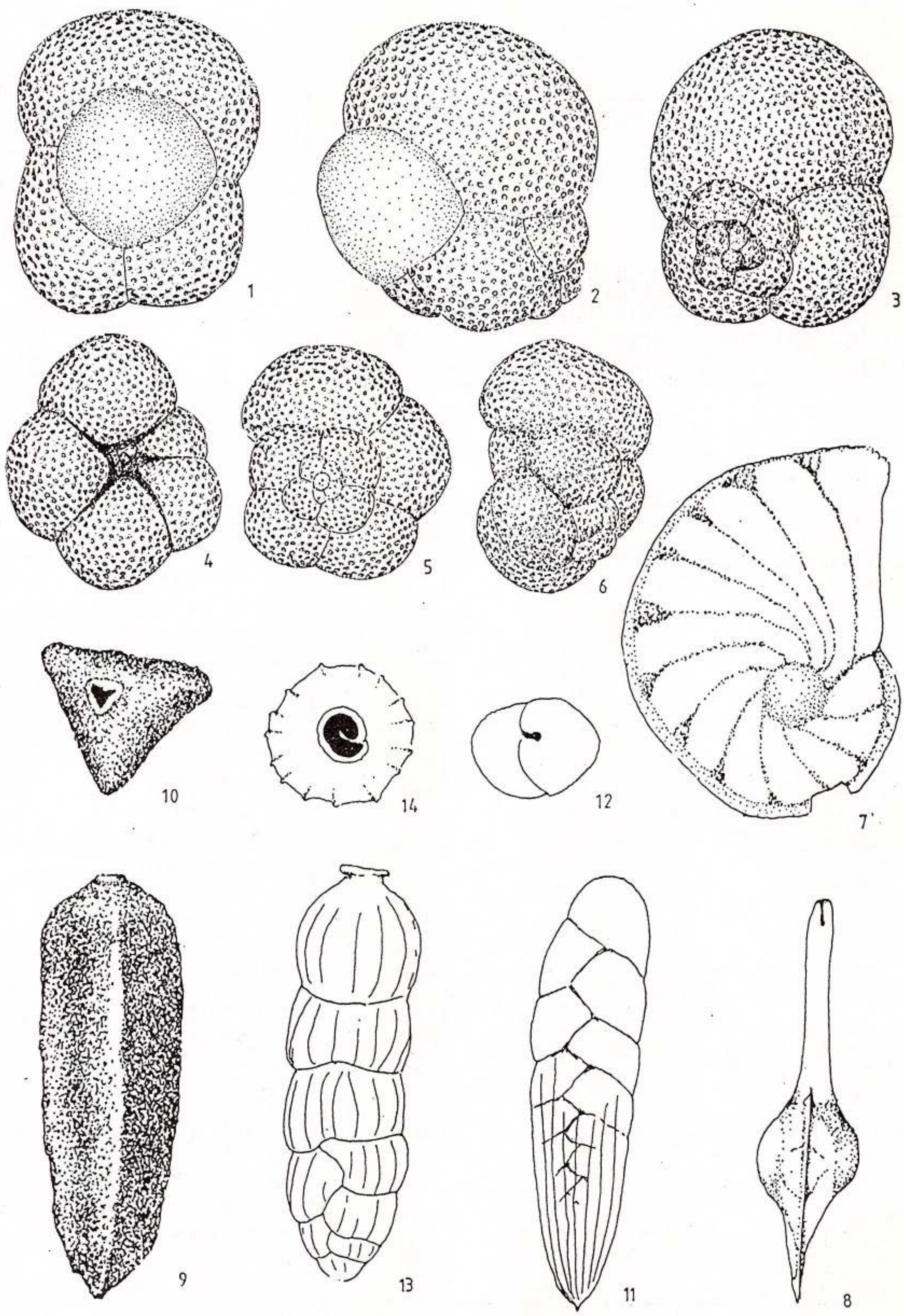


Fig. 15. **RUPELIAN - CHATTIAN:** 1 - 3 Globigerina sellii Bors., x95; 4 - 6, Globigerina wagneri Rogl , x95; 7 - 8, Planularia kubinii Hantk., x20; 9,10, Tritaxia szaboi (Hantk.), x145; Bolivina semistriata Hantk., x145; 13 • 14 ,Siphogenerina elegans (Hantk.), x145.

The FAD of *Cyclicargolithus abisectus*, indicating the NP23/NP24 boundary, was observed at the uppermost part of the Ileanda Formation.

The lower part of the Vima Formation belongs, in this section, to the NP24 Biozone. Blooms of *Cyclicargolithus floridanus* and *Reticulofenestra ornata* were observed, related to the Jaslo type coccolithic limestone.

Itinerary: Fântânele – Târgu Lăpuş – Poiana Blenchii

Stop 7 : Valea Runcului Section : Bizuşa Fm., Ileanda Fm., Buzaş Fm., Vima Fm. (Fig. 16)

In Valea Runcului, right tributary of the Valea Poienii in the west of the Poiana Blenchii locality (Fig. 12), the party will follow, from upstream to downstream and from old to new, on a length of about 1.2 km, the succession of Oligocene–Lower Miocene formations in the southern limb of the Glod Anticline.

a. Bizuşa Formation

Lithology. Poorly bituminous, compact calcareous marlstones, poorly bituminous marlstones, bituminous shaly marly clays.

Thickness. 15 m

Fossil content.

- Molluscs: *"Cardium" lipoldi, Janschinella garetzkii, Urbnisia lata, Limacina* sp. (pliohaline brackish assemblage).

- Calcareous nannoplankton: *Dictyococcites bisectus, D. filewiczii, D. ornatus* (bloom), *D. hesslandii, Cyclicargolithus floridanus, Orthozygus aureus, Lanternitus minutus, Zygrablithus bijugatus, Helicosphaera compacta, H. salebrosa, H. bramlettei, Tranversopontis pulcheroides, T. pulcher, Pontosphaera multipora, P. latelliptica, P. magna, Reticulofenestra ornata, R. lockeri* (bloom), *Transversopontis fibula* (bloom), *T. latus*, etc.

- Spore–pollen (undetermined).

Biostratigraphy. Limacina Level (would represent Limacina Upper Level in the Paratethys)

Janschinella garetzkii Zone

NP 22 Zone (upper part) and NP 23 Zone (basal part)

The boundary between the NP 22 and NP 23 zones has been established at the LAD of *Reticulofenestra umbilica*.

Age: Earlier Kiscellian = Late Rupelian

b. Ileanda Formation (Fig. 16)

Lithology. Claystone and siltstone fissile bituminous shales with fish scales. In the basal part – the level with more compact marly clays. Sedimentary deposits in an anoxic environment poisoned with H_2S, similar to the actual Black Sea.

Thickness. 45 m.

Fossil content.

- Molluscs: *"Cardium" lipoldi, Cerastoderma serogosica, Janschinella garetzkii* (pliohaline brackish assemblage), *Nucula comta, Nuculana westendorpi* (euhaline marine assemblage).

- Calcareous nannoplankton: *Dictyococcites* ex gr. *bisectus, D. ornatus, D. hesslandii, Cyclicargolithus floridanus, Braarudosphaera bigelowii, Orthozygos aureus, Lanternitus minutus, Zygrhablitus bijugatus, Helicosphaera compacta, H. bramlettei, Transversopontis pulcheroides, T. pulcher, T. fibula* (bloom), *T. latus, Pontosphaera multipora, P. latelliptica,* *P. magna, Reticulofenestra ornata, R. lockeri, Cyclicargolithus abisectus, Helicosphaera recta, Chiasmolithus altus, Sphenolithus moriformis* etc.

– Spore–pollen (undetermined).

Biostratigraphy. Nucula comta Level in the basal part of the formation.

Janschinella garetzkii Zone

NP 23 and NP 24 zones (basal part).

The boundary between the NP 23 and NP 24 zones has been established at the *Cyclicargolithus abisectus* FAD.

Age: Kiscellian = Late Rupélian.

c. Buzaş Formation (lower part) (Fig. 16)

Lithology. Marly sandstones, sands, calcareous sadstones (intercalations and concretions), clay sands with glauconite.

Thickness. 180 m. This is the sector in which the upper part of the Buzaş Formation is lithofacially replaced by the clays of the Vima Formation.

Fossil content.

– Molluscs: *Pycnodonte callifera, Thracia speyeri, Angulus nysti, Arctica islandica rotundata, Callista beirichi, C. splendida, Pitar incrassata, Isocardia subtransversa, Pholadomya puschi, Nemocardium tenuisulcatum, Turritella venus* etc. (euhaline marine assemblage).

– Foraminifers: *Spiroplectinella carinata* (D'ORB.), *Almaena hycrogliphica* SIGAL, *Heteroplea, Cibicidoides, Nodosaria, Lenticulina, Amphycorina, Karreriella, Vaginulina.*

– Calcareous nannoplankton: *Dictyococcites bisectus, Zygrhablithus bijugatus, Cyclicargolithus floridanus, Sphenolithus moriformis, S. distensus, S. ciperoensis, S. conicus, S. dissimilis, S. compactus, Coccolithus pelagicus, Pontosphaera multipora, P. enormis, P. latelliptica, Helicosphaera euphratis, H. recta, H. palaeocarteri, Reticulofenestra lockeri, R. gartneri, R. ornata, Cyclicargolithus abisectus, Triquetrorhabdulus carinatus* (euhaline marine assemblage).

Biostratigraphy. Pycnodonte callifera Level (Kiscellian)

Turritella and Thracia Level (Egerian)

NP 24 and NP 25 zones

The boundary between NP 24 and NP 25 zones has been established based on FAD of *Sphenolithus conicus* and the presence (common) of *Pontosphaera enormis.*

Age: Late Kiscellian – Egerian = Latest Rupelian – Chattian.

d. Vima Formation (upper part) (Fig. 16)

Lithology. Glauconitic sandy clays, siltic clays, marly clays.

Incomplete thickness (60 m). The lower part of the formation is replaced here by the arenitic deposits of the Buzaş Formation. In the upper part of the Vima Formation in the Valea Runcului Section only the lower third is occurring.

Fossil content.

– Foraminifers: *Spiroplectinella carinata* (D'ORB.), *Saccamina* sp., *Cyclamina cancellata* BRADY, *C. praecancellata* VOLOSH., *Bathysiphon* sp., *Amphicarina* sp., *Nonion* sp., *Uvigerina* cf. *hantkeni* (CUSH., EDW.), *Plectofrondicularia* cf. *striata* HANTK., *Hemirobulina hantkeni* (BRANDY), *Stilostomella* sp., *Lenticulina* sp.

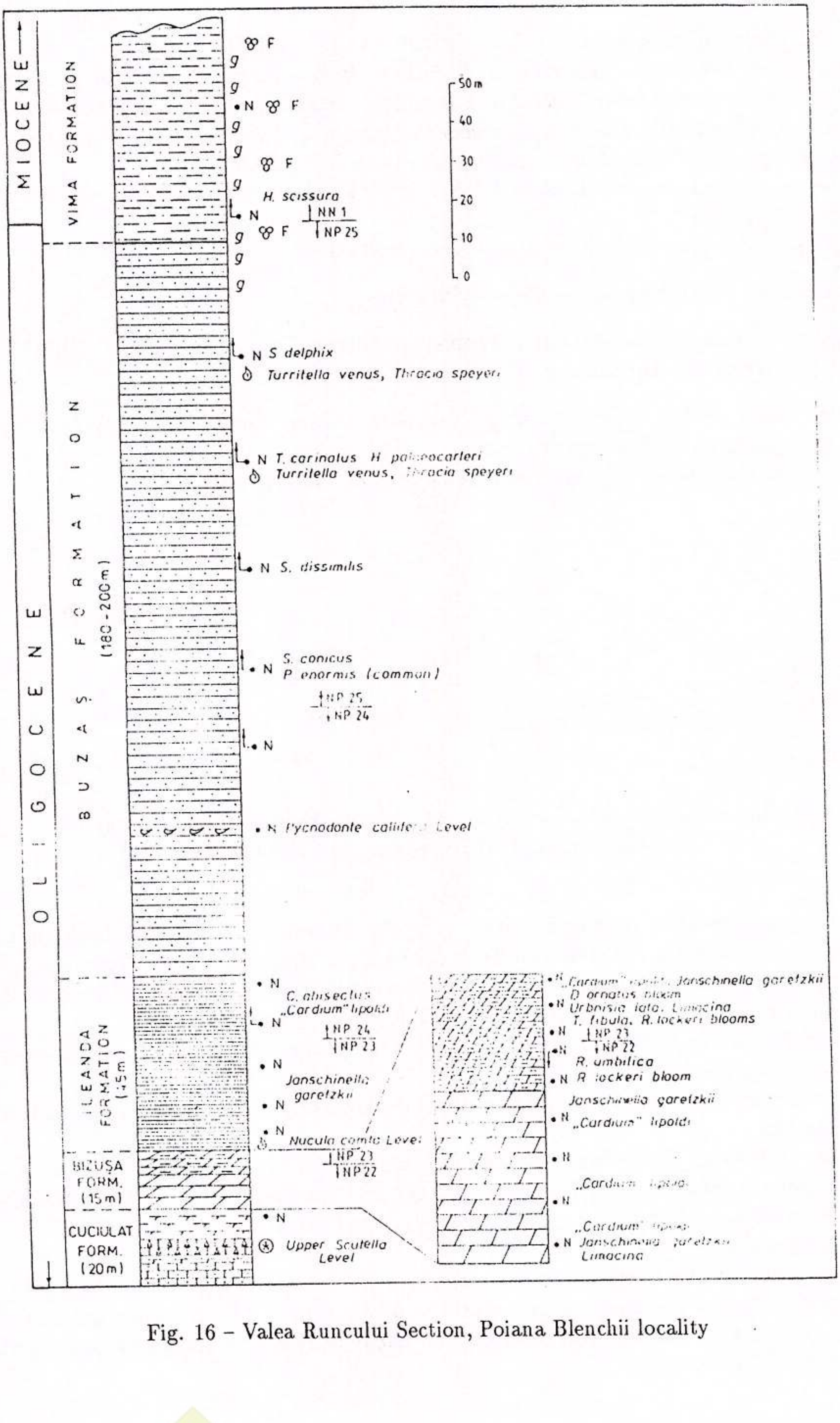


Fig. 16 – Valea Runcului Section, Poiana Blenchii locality

– Calcareous nannoplankton: *Pontosphaera enormis, Sphenolithus conicus, S. dissimilis, S. ciperoensis, Reticulofenestra minuta, R. lockeri, Helicosphaera recta, H.* cf. *ampliaperta, H. scissura, Triquetrorhabdulus carinatus, Coccolithus pelagicus, Cyclicargolithus floridanus, C. abisectus, Dictyococcites bisectus, Zygrhablithus bijugatus, Sphenolithus ciperoensis.*

Biostratigraphy. NP 25 Zone (terminal part) and NN 1 Zone

The boundary between NP 25 and NN 1 zones has been established at the *Helicosphaera scissura* FAD.

Age. Late Egerian-Early Eggenburgian = Aquitanian.

Itinerary: Cluj Napoca – Dej – Măgoaja

Stop 8 : **Valea Cocii Section (Măgoaja): Buzaş Fm., Vima Fm.; Oligocene – Miocene Boundary** (Figs. 17, 18)

Valea Cocii section is situated at 1,5 km west of Magoaja locality, in Valea Cocii, right tributary stream of the Sălătruc Valley.

In this section the Buzaş and Vima formations are outcropping.

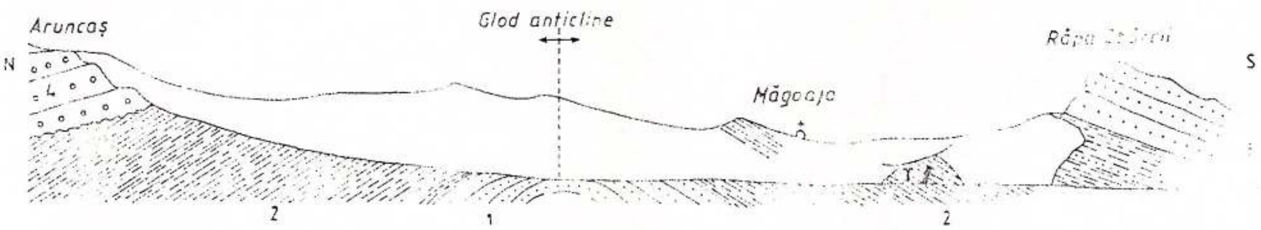


Fig. 17 – Cross section on Valea Cocii at Măgoaja village; 1) Buzaş Fm., 2) Vima Fm. (T - Valea Cocii Tuffs outcrop), 3) Someş Fm., 4) Ciceu-Giurgeşti Fm.

The Buzaş Formation is constituted of blue-gray, calcareous sandstones, friable sandstones and sands, occurring on the southern flank of the Glod Anticline. They are overlain by silty clays and clays, lithostratigraphically belonging to the Vima Formation. Here, the thickness of the Vima Formation was estimated at 300–350 m.

The main outcrop (10 m thickness) exposes siltic clays in which 9 thin (centimetric) tuff levels are interbedded (Fig. 19).

This outcrop includes the Oligocene-Miocene boundary established based on calcareous nannoplankon.

In the underlying deposits a rich foraminifera assemblage (Fig. 20) containing *Reticulophragmium rotundidorsatum, R. acutidorsatum, Martinottiella* sp., *Tritaxia szaboi* occurs. They are accompanied by molluscs (*Chlamys* spp.) and calcareous nannoplankton.

Biostratigraphy.

The deposits of the Vima Formation comprise, in the major part of the beds, diversified and rather abundant calcareous nannoplankton assemblages. The presence of *Pontosphaera enormis*, together with *Sphenolithus dissimilis, Triquetrorhabdulus carinatus*, documented the presence of NP25 Biozone.

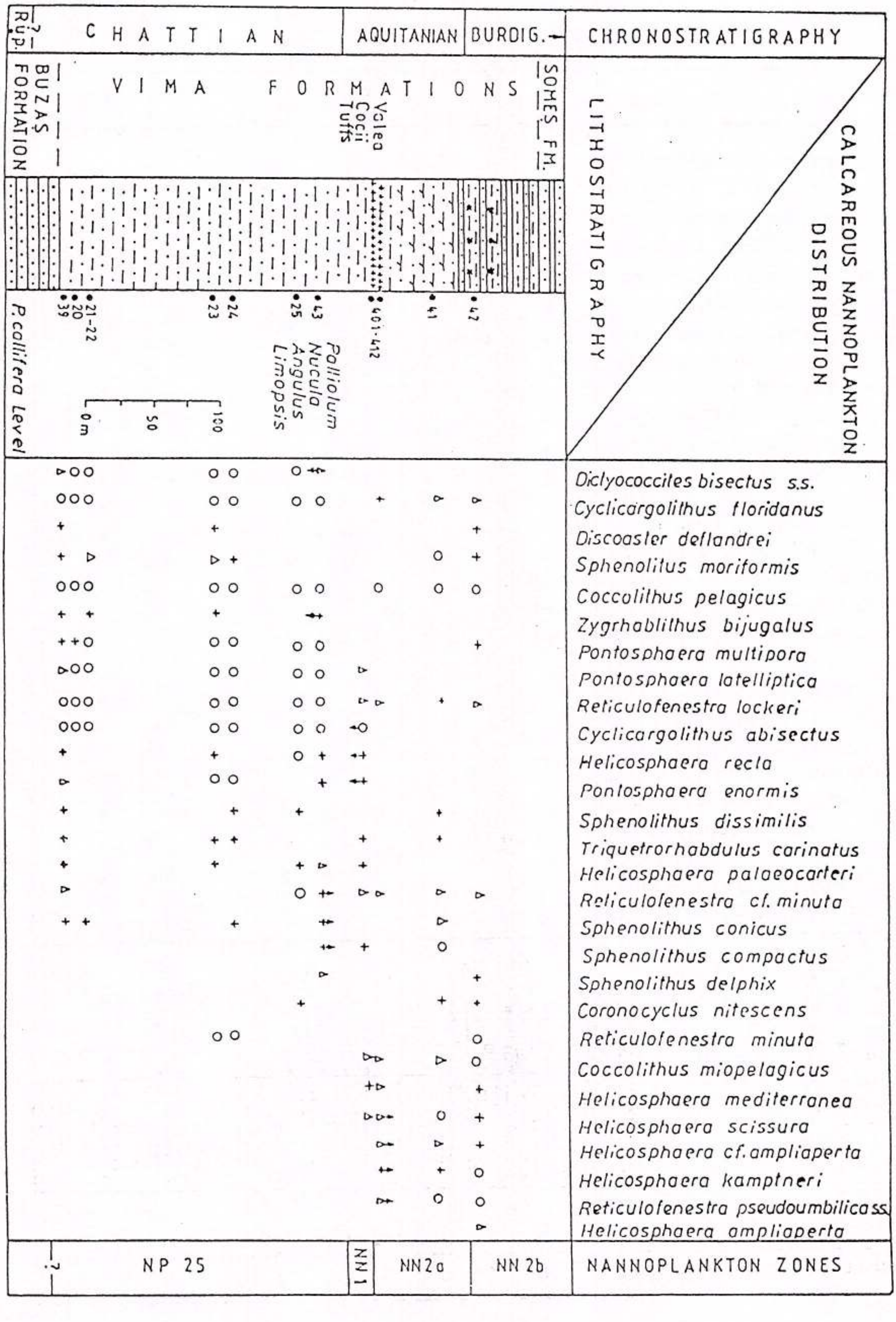


Fig. 18 – Valea Cocii Section, Măgoaja village.

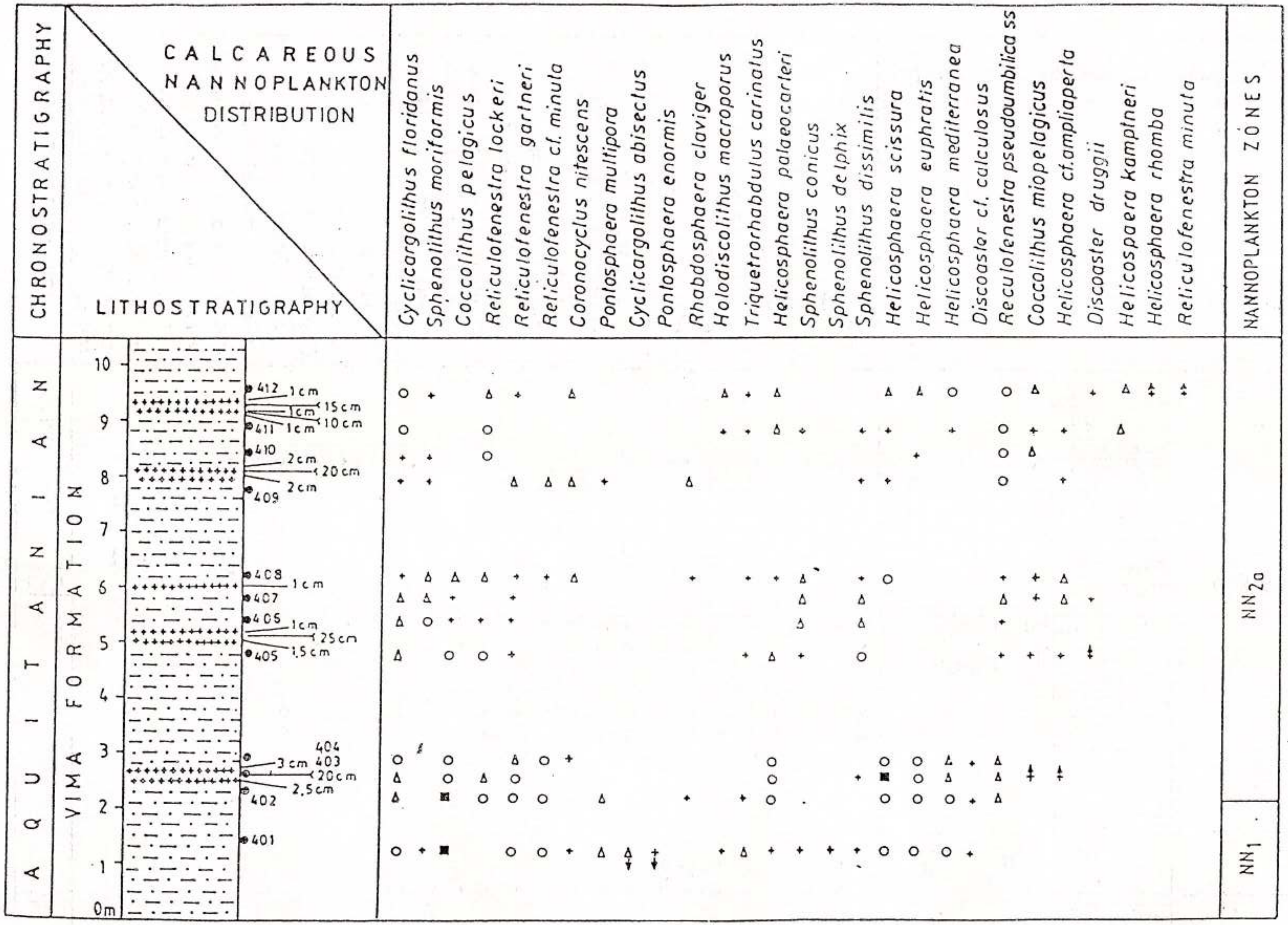


Fig. 19 – The outcrop with volcanic ash layers (Valea Cocii Tuffs) on the Valea Cocii, Măgoaja village.

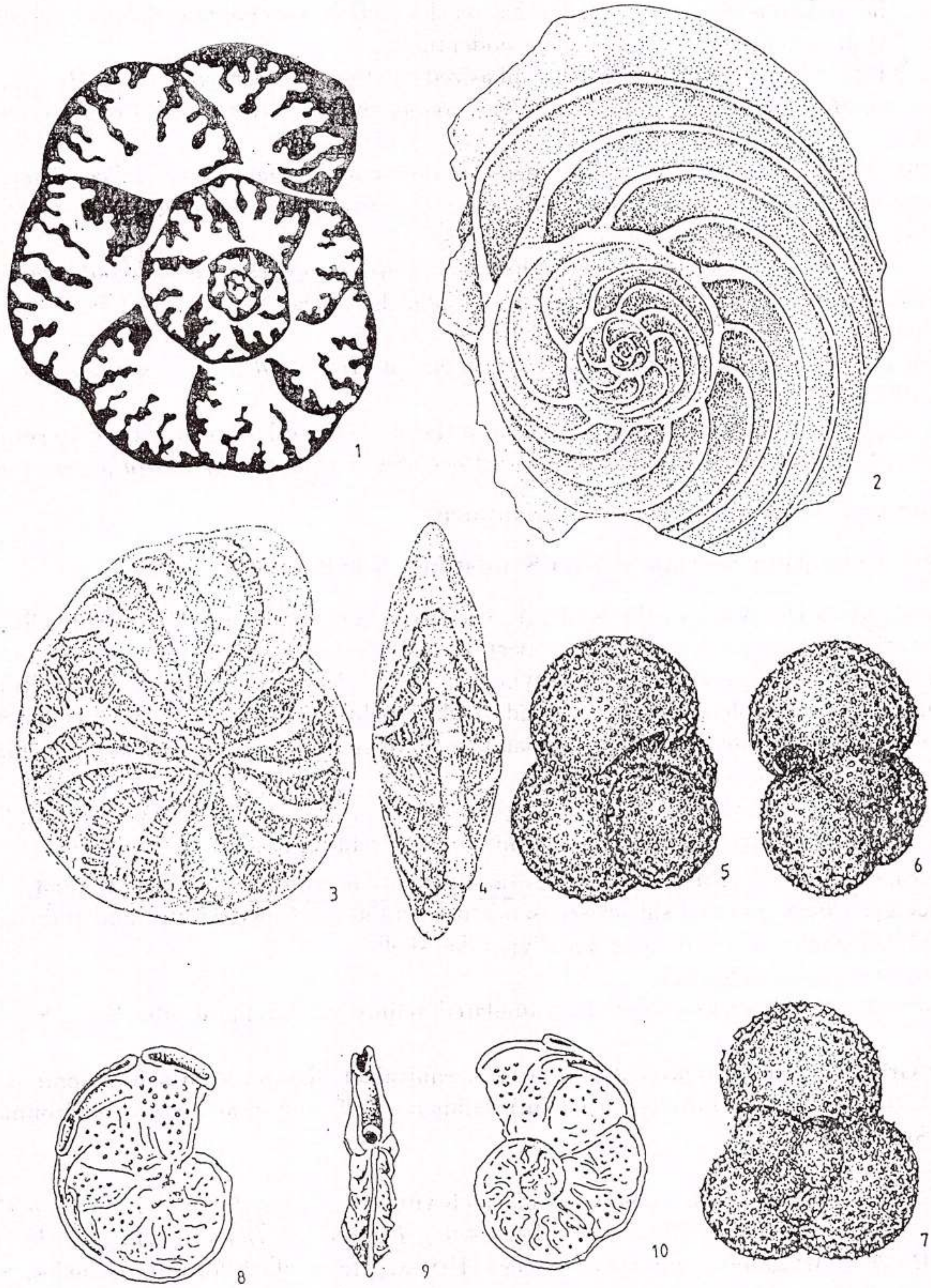


Fig. 20 . **EARLY MIOCENE:** 1, Reticulophragmium venezuelanum (Maync), x300, equatorial section; Planoperculina complanata (Defr.), x97, equatorial section; 3, 4, Cribrononion dollfusi Cushman, x135; 5 - 7, Globigerinoides primordius Blow, x95;
LATE OLIGOCENE: 8 - 10, Almaena escornebovensis Sigal, x85;

From the middle part of the Vima Formation the FAD of *Sphenolithus delphix* and followed by the FAD of *Sphenolithus compactus* were identified.

The NP25/NN1 boundary can be emphasized by the first occurrences of *Helicosphaera scissura* and *Helicosphaera mediterranea*, synchronous events with the LAD of *Dictyococcites bisectus.*

Within the NN1 Biozone the assemblages are dominated by species of *Helicosphaera.*

Common *Coccolithus pelagicus, Cyclicargolithus abisectus, C. floridanus* were also identified. *Discoaster* cf. *calculosus* sporadically occurs.

Just bellow Valea Cocii Tuffs levels the FAD of *Reticulofenestra pseudoumbilica* pointed out the base of the NN2 Biozone. *Discoaster druggii*, the marker species of the NN2 zone from the Martini's zonation (1971), was not identified.

From the base of this biozone some specimens of *Helicosphaera* cf. *ampliaperta*, sensu Müller 1981, are also present.

The upper part of the Vima Formation from the studied section was assigned to the NN2b Subzone (Mărunţeanu 1992), based on the first occurrence of *Reticulofenestra pseudoumbilica.*

Itinerary: Măgoaja – Dej – Cluj Napoca

Stop 9 : **Cetăţuia Section: Gruia Sandstone, Var Sandstone**

The Cetăţuia Hill north of the Someşul Mic River offers a splendid view on the Cluj town for the turist and an ideal stratigraphic section for the geologist. In the southern scarp of the hill the Moigrad Formation (red-bed type continental deposits of Merian=-Early Rupelian age), Dâncu Beds (oligohaline lacustrine and brackish pelitic deposits of Early Kiscellian=Late Rupelian age), Gruia Sandstone and Var Sandstone are cropping out. The last two formations will be studied in outcrop.

The above-mentioned formations belong to the Gilău Area and display entirely different lithofacial features from their time equivalents in the Preluca Area .

a. Gruia Sandstone (Rusu, 1989) [= Cetăţuia Beds - partim (Hauer, Stache, 1863)]

Lithology: Coarse-grained siliciclastic sandstone and sands (microrudites and rudites; subordinately), Coquina of Corbulidae and Cyrenidae shells.

Frequent cross-stratification.

Shell material has been sorted and accumulated mainly hydrodynamically (Hosu, Sylvester, 1995).

The Gruia Sandstone represents the littoral equivalent, deposited in a well-aerated environment, to the Ileanda Formation (partim) sedimented offshore in an euxinic environment.

Thickness. 12 m.

Fossil Content:

- Molluscs: *Lenticorbula sokolovi sokolovi* (KARLOV), *L. sokolovi subtriangulum* (MOISESCU), *L. helmerseni transylvanicum* (MOISESCU), *Polymesoda convexa* (BRGT.), *P. brongniarti* (BAST.), *Melanopsis impressa hautkeni* (HOFM.), taxa which form lumachelles. Specimens of *Lentidium nitidum* (SOW.), *Congeria tenuissima* MOISESCU, *Teodoxus* sp., etc. rarely occur (Moisescu, 1975; Rusu, 1995).

Biostratigraphy. Janschinella garetzkii Zone.

Age. Kiscellian=Late Rupelian.

b. Var Sandstone (Răileanu, Saulea, 1955) [= Cetăţuia Beds-partim (Hauer, Stache, 1863)].

Lithology. Kaolinitic, siliciclastic sandstones, microconglomerates, breccias, pointed out by Hosu and Sylvester (1995) as fluvial / deltaic deposits.

The Var Sandstone represents the littoral equivalent to the basal part of the Buzaş Formation and is deposited by a sedimentary gap over the Gruia Sandstone.

Incomplete thickness (5m). In the Cetăţuia Hill only the basal part of the formation occurs. The whole thickness reaches 50 m.

Fossil content - is lacking here.

Age. Late Kiscellian = Latest Rupelian - Earlier Chattian (?).

Itineray: Cluj Napoca – Alba Iulia – Sibiu – Bran – Câmpulung – Stoeneşti

Leaving Cluj Napoca town the route runs near the western border of the depression crossing Middle and Upper Miocene deposits. In the neighbourhood of the Alba Iulia and Sebeş towns, older deposits (belonging to the second tectonic stage) represented by Paleogene red sedimentary beds (Râpa Roşie Formation) occur. They are transgressively overlain by Middle Miocene (Langhian) light grey deposits.

From Sibiu to Braşov towns, the excursion route runs across the Transylvanian Depression from the south-western border to the south-eastern one crossing Middle and Upper Miocene molassic deposits (Langhian, Kossovian, Sarmatian, Pannonian and Pontian) which constitute the "padding" of the depression.

Near the south-eastern boundary of the Transylvanian Depression (Perşani locality), on the Brădet Valley (Vlădeni passage), a package of compact clays (Burdigalian) occurs which started with a level of glauconitic sandstones rich in fragments of larger foraminifera *(Planostegina)*. These deposits transgressively overlie the dark laminated clays which resemble the Oligo-Miocene Pucioasa type facies, and are overlain by the Perşani Conglomerates (Langhian).

Stop 10 : **Valea Pietrii section (Stoeneşti): Pucioasa Fm.** (Fig. 21)

Valea Pietrii section is situated to the NW of Stoeneşti locality. Piatra Valley, is a right tributary stream of the Dâmboviţa Valley.

Upstream the bridge to the Piatra locality, one of the best section in the Pucioasa Formation is exposed. Pucioasa Formation (Mrazec, fide Mrazec & Popescu-Voiteşti, 1914), overlies the Lower Dysodilic Formation; it is constituted of marls, clays, argillaceous, bituminous shales in which, in this section, four calcareous levels, (Şeţurile Limestone, Ştefănescu et al., 1983) all of them containing 2, 3 thin strata of laminated coccolithic limestones are interbedded (Fig. 21). The thickness of the Pucioasa Formation exposed in this section was estimated up to 300 m.

The paleontologic content is represented by palynomorphs and calcareous nannoplankton. Some small, indeterminable, planktonic foraminifera occur in the laminitic limestones. The palynomorphs assemblage is constituted of *Lingulodinium macherophorum, Hystrichokolpoma salacia, Operculodinium placitum, Deflandrea spinulosa, Spiniferites ramosus, Pentadinium taeniagerum, Oligosphaeridium complex, Polysphaeridium subtile* and *Wetzeliella symmetrica* (A. Ionescu, unpublished). This assemblage emphasized the Wetzeliella gochtii Zone.

Biostratigraphy.

The studied sequence of the Pucioasa Formation was assigned to the NP 24 Zone. Rich and diversified calcareous nannoplankton assemblage with *Cyclicargolithus abisectus, C. floridanus, Dyctiococcites bisectus, Reticulofenestra ornata, Coccolithus pelagicus, Sphenolithus ciperoen-*

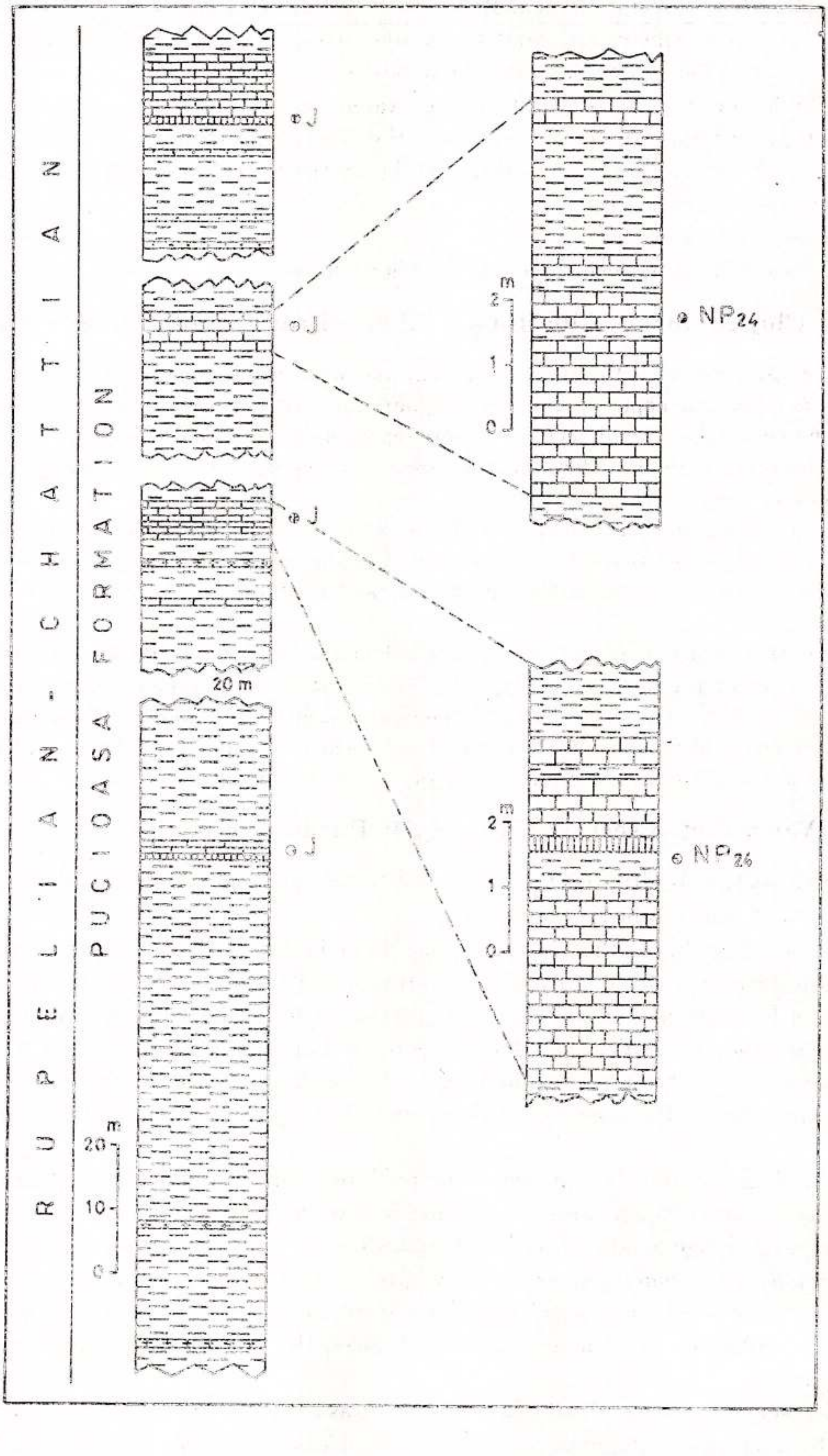
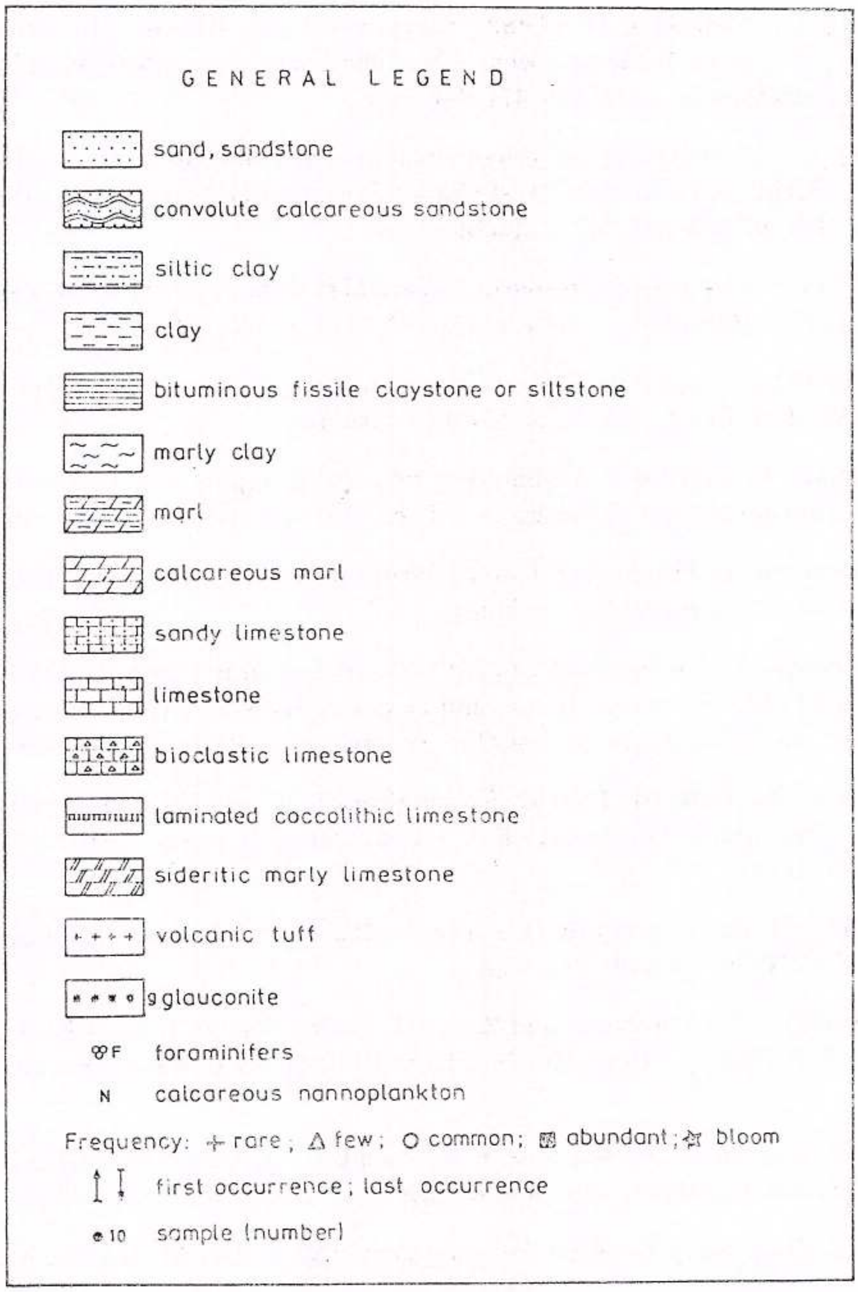


Fig. 21 – Valea Pietrii Section, Stoenești locality; J) Jaslo type limestone.

sis, S.moriformis, Helicosphaera recta and rare specimens of *Pontosphaera enormis* were identified. As the FAD of this last species has been alredy recorded alredy from the NP 24 Zone, these outcrops were assigned to the NP 24 Biozone. The LAD of *Sphenolithus distenus*, which pointed out the NP24/NP25 boundary was not identified.

From the Jaslo type coccolithic limestone the same blooms of *Cyclicargolithus floridanus* and *Reticulofenestra ornata*, as recorded in the East Carpathian Flysch Zone and NW Transylvania, were observed.



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B. MATERIAL OF SYMPOSIUM

THE OLIGOCENE–MIOCENE TRANSITION IN THE SOUTHERN RUSSIA AND KAZAKHSTAN

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The sequence of the Oligocene–Miocene transition corresponds to the Maikopian Group of Paratethys. It presents marine shallow–water deposits of the Western Turanian plate and continental groups of the East European platform (Voronezh anteclise and its bordering structures), Turgai basin and Middle Asia. The continental sedimentation along the Paratethys periphery was dependent on eustatic fluctuation in this basin. Sea-level changes of the Polar ocean influenced the character of the continental sedimetation in the West Siberian plate and Central and East Kazakhstan depression. During Oligocene and Oligocene–Miocene transition intervals there are several isochronous levels marking geological and biotic events in the Paratethys and outside it. One of this marker is the Ostracod strata at the base of the Soleny horizon. It corresponds to the first stage of Paratethys isolation from the World Ocean and its freshening environments responsible for stagnation. Endemic assemblages of molluscs, ostracods, dinocysts effor to trace a possibility this reference level from Hungary, Romania, Slovenia and Eastern Czechia in the west to the Northern Aral region and Middle Asia in the east. The Early Oligocene age of Soleny horizon was substantiated by nannoplankton assemblage NP23 and Wetzeliella gochtiidinocysts zone. Remains of fossil plants and mammals co-occurring with *Ergenica cimlanica* in Aralian and Usturt section provide a chance to trace this level of Turgai and Zaissan basins in the continental sequence. This level yielded here the earliest representative of the *indricotherium* assemblage including this taxon proper and mixed fossil flora, which includes in additional warm temperate turgaian elements, diverse evergreen species of the preceeding Eocene subtropical flora. Gray deposits of the Central Turgai basin grade eastward into red sediments of III and Alakul' basins. Several red beds of the Zaissan depression mark respectives phases of maximum aridization. The climate of the Soleny time was seasonally more dry and warm than at the beginning of the Oligocene. In central and Southern Kazakhstan it was arid. This is evident from occurrences of microfoliated and xeromorphic *Palibinia*, *Rhus turcomanica* in some localities and Fagaceae and Pinaceae dominants in palynological assemblages. In Mongolia red beds of the Shand Gol formation correspond to the Soleny horizon and bear earliest Mammalia fauna of the Shand Gol type.

The second reference level is correlated with the Chattian. It marks the regressive stage of the Antarctic glaciation. In Paratethys this was the time of sandy sedimentation with hiatuses. In continental sequences of the Aral, Turgai and Zaissan regions, sandy deposits with deciduous mesophyllic Turgai flora (most cryophyllic in the Late Chattian) overlie red clays with a hiatus. They usually fill the erosional troughs, which were formed during the minimum sea level. The respective humid climate was unfavourable to fossilization, however there are several localities of *Paraceratherium* fauna recovered from sandy deposits of Kazakhstan. The third reference level corresponds directly to the Oligocene-Miocene boundary. This time stagnation environments transection from Septarian and Zelenchule to Karadzhalga formations appear in the deepest areas of Paratethys. The NP25-NN1 transition is recorded near the boundary between these formations (acc. to J. Krhovsky). Approximately at this level or somewhat lower *Chiropteridium* disappeares from dinocysts assemblages and *Deflandrea spinulosa* epibol is distinguished in the Septarian formation. The respective palynological assemblages display a higher proportion of graises elements. The *Engelhardtia* pollen is dominant in Juglandaceae spectra. The erosional activity was minimum in Kazakhstan at that time. Chegrai sands grade into lacustrine clay, marls and limestone of the Aral formation including rodent remains of the MN1 zone, and late *Paraceratherium* in basal beds (Lopatin, 1996). Palynological assemblages of the Aralian formation display a lower diversity of arborean pollen. A zone of meridional rises is the isolated Eastern Aral and Turgai regions northward of the Tshe-bas bay of the Aral sea and resulted information of vast lacustrine basins in the east of the Turan plate. Thus, the Oligocene-Miocene boundary marks the beginning of the " great lake stage" in Kazakhstan. The clay-carbonate sedimetation in fresh and brackish water lates replaced the coastal-marine terrigenous sedimentation.

BIOSTRATIGRAPHIC CHARACTERISTICS OF OLIGOCENE–MIOCENE DEPOSITS IN THE PORKULEN RIVER SECTION (THE UKRAINIAN CARPATHIANS)

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The deposits of the transitional Oligoce-Miocene interval in the Ukrainian Carpathians are represented by two types of sequences: Menilite (Andrejeva-Grigorovich et all., 1986) and Krosno (Dosin, Gruzman, 1977; Gruzman, 1991). The fullest and well exposed sequences of Krosno type are seen in the north-west Krosno and south-east Skiba tectonic zones. The studied sequence is situated in the extreme south-west in the Porculen brook, right-hand tributary of the Putila river, near the Putila valley.

The Oligocene part of the sequence starts in the upper Porkulen, at about 3 km from the mounth. The Lower Menilite Subformation is uncovered here (120 m). Accordingly, the Upper Eocene Globigerina marls (zone NP 19–21) are overlaine by the alteration set of black and brown argillite marls and sandstones. The complex of nannoplankton of the zone *Helicosphaera reticulata* and the association of dinocysts with *Deflandrea phosphoritica* are found in the carbonate argillites above the lower siliceous horizon (35 m). They are represented by black cherts and silicified argillites in the lower part and by silicified limestones in the upper part, overlain by the succession of black bituminous argillites intercalated with grey and greenish-grey argillites (Fig. 1). There is a 140 m set of Kliwa thick-bedded fine-grained sandstones in the upper part of the section. Nannoplankton is not found in these deposits, and dinocysts are represented by the impoverished association with single *Spiniferites* ex gr. *ramosus*, *Defladrea* spp.

Verets Formation (100 m). Alternation of black, dark-grey, brown limy and non-limy argillites and light-grey micaceous sandstones. Up the section the become lighter and limy acquiring "lopianets" appearence. Sandstones become lighter and micaceous which is characteristic of the Krosno deposits. This formation is called a transitional succession (Fig. 1). Foraminifers: *Cibicides borislavensis* AISEN., *Virgulina pertusa* REUSS, *Chilostomella cylindroides* (REUSS), *Globigerina* sp. Nannoplancton: zone *S. predistentus*. Dinocyst: akme zone *Rhombodinium draco*.

Krosno Formation (Fig. 1).

Lower Krosno Subformation (400 m) is represented by coarse-rhythmical flysch, alteration of massive grey micaceous sandstones with thin interbeds of grey limy argillites and marls. There follow foraminifers in the upper part of section: *Cibicides borislavensis* AISEN., *Virgulina pertusa* (REUSS). Nannoplankton: zone *S. distentus* – *S. ciperoensis*. Dinocysts: *Chiropteridium partispinatum* GERLACH, *Pentadinium laticinctum* GERLACH, *Phthanoperidinium amoenum* DRUGG et LEOBLICH.

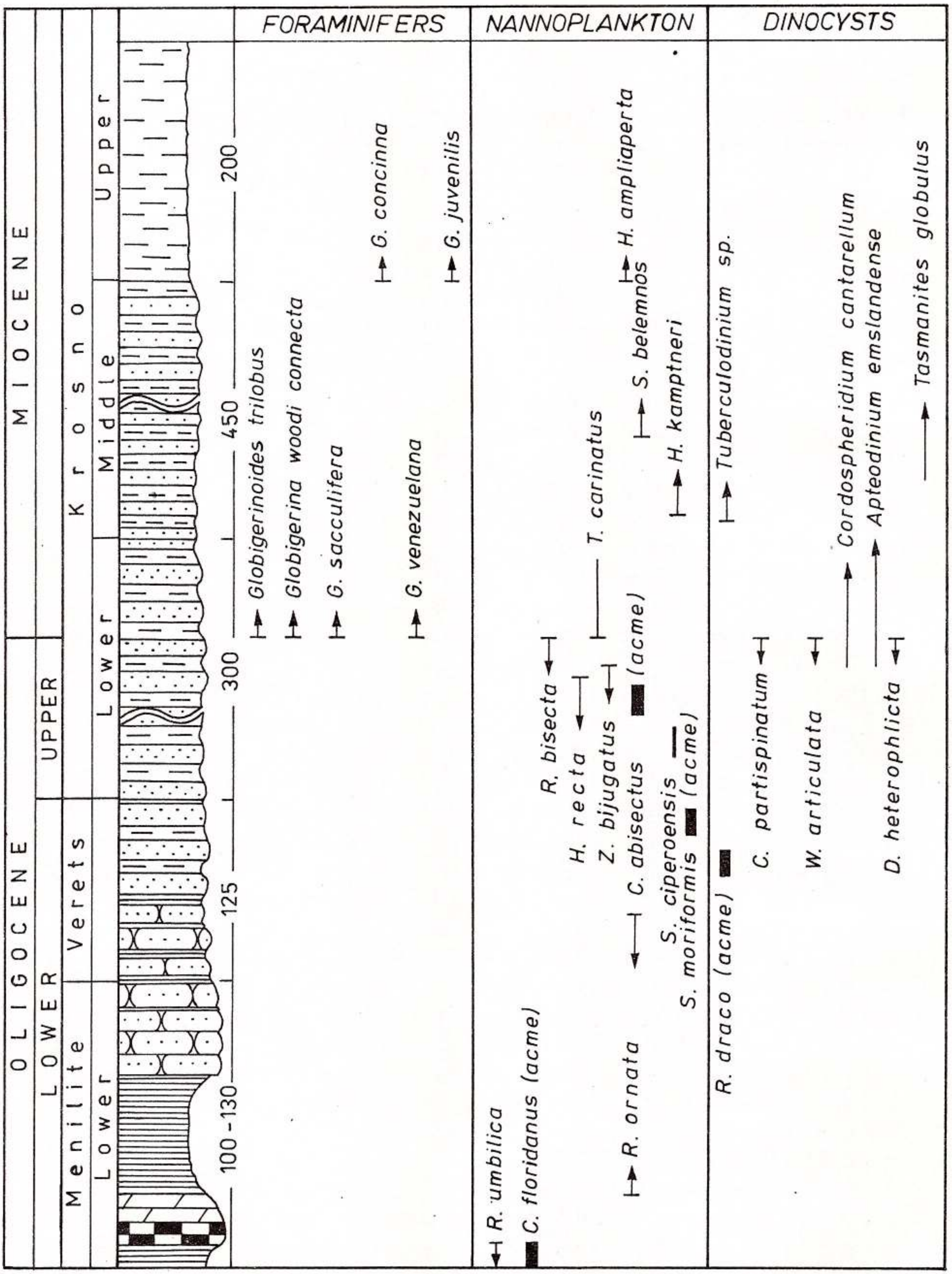

Fig. 1. – Distribution of the microplanktonic groups in the Porkulen river deposits

Middle Krosno Subformation (450 m) is composed of sandy-clayey thin-rhythmical flysch. The presence of bluish-grey limy cross- and wavy-bedded aleurolites with streaks of calcite is characteristic. In the lower part of the subformation there were found foraminifers: *Globigerinoides trilobus* REUSS, *G.* aff *sacculifer* BRADY, *Globigerina woodi connecta* JENKINS, *G. venezuela* HĖDB.. Nannoplankton: lower part – zones *T. carinatus – D. druggii*; upper part – zone *S. belemnos.* Dinocysts: *Deflandrea phosphoritica* subsp. *vozzhennikova* GRIGOR., *Cordospaeridium cantharellum* (BROSIUS), *Apteodinium emslandense* GERLACH, *Tasmanites globulus* GOCHT.. These associations are characteristic of the Lower Miocene (Upper Egerian – Eggenburgian).

Upper Krosno Subformation (200 m) is composed of grey limy argillites with rare interbeds of grey aleurolites, marls and limestones. At the subformation bottom the set of black flaggy argillites usually accompanies the tufaceous horizon in other sections (Dosin, 1964). The small foraminifers complex: *Globigerina concinna* REUSS, *G. juvenilis* BOLLI, *Turborotalia brevispira* (SUBB.). Nannoplankton: zone *S. belemnos* and complex with *Helicosphaera ampliaperta, H. kamptneri* HAY & MOHLER, *Cyclicargolithus leptoporus* (MURRAY & BLACKMAN). Dinocysts: *Deflandrea hialina* BALT., *Cyclopsiella elliptica* DRUGG & LOEBL., *Millioudodinium tenuitabulatum* (GERLACH), *Thalassiphora pelagica* (EISENACK).

The data of the study planktonic microorganisms allow us to place the boundary between Oligocene and the Miocene in the upper part of the Lower Krosno Subformation based on the appearence of the complex with *Globigerinoides trilobus* and on the floor of zone *T.carinatus - D. druggii* (the level of the last appearence of the species *Reticulofenestra bisecta*). Lithologically this boundary is not expressed. The Oligocene part of the section is represented by relatively poor associations of foraminifers, nannoplankton and dinocysts. It is characteristic that there are three lavels of monocomplexes of dinocysts and nannoplankton (Fig.1).

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SOME PROBLEMS IN USING THE CALCAREOUS NANNOPLANKTON STANDARD ZONATION IN THE OLIGOCENE – LOWER MIOCENE DEPOSITS FROM ROMANIA

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The main areas from Romania where the Oligocene – Lower Miocene deposits occur are: the Eastern Carpathians Flysch Zone, the Getic Depression and the NW Transylvania.

The deposits of the above mentioned interval are developed mainly in flysch and molasse facies, where many reworked nannoflora species are present.

The standard zonations (Martini, 1971; Okada & Bukry, 1980) are based on the study of pelagic deposits and consequently, the biozones are also defined based on the LAD of calcareous nannoplankton species, criterion which can not be used in flysch and molasse facies. Besides, many Oligocene nannofossil zones are related to the presence of Sphenoliths, which characterized the low latitudes and which are rare in the Oligocene of Eastern Carpathians Flysch Zone and absent or very rare in the Transylvania area, with one exception - *S. moriformis*, with the range covering the Lower Eocene-Middle Miocene.

In exchange, in the semi-isolated basins from the Eastern Paratethys (including Romania) endemic species, with characteristic blooms, appear from the early NP23 Nannofossil zone. The range of these species is very short and useful to recognize the stages of the Oligocene.

The Oligocene-Lower Miocene boundary is pointed out in the standard zonations based on the LAD of three species, criterion which can not be used in Eastern Carpathians, Getic Depression and/or Transylvania area.

The FAD of some taxa (e.g. *Triquetrorhabdulus carinatus, Helicosphaera paleocarteri, H. scissura, Sphenolithus conicus, S. dissimilis*) can be useful to approximate this boundary.

Marker species from the standard zonation of the nannozones characterized the Lower Miocene are also difficult to use in the Paratethys.

Discoaster druggii (its FAD points out the base of NN2 Zone) is absent in the Transylvania area and Getic Depression and very rare in the Eastern Carpathians Flysch Zone, where is difficult to recognize in the overgrown material.

The NN1/NN2 boundary may be pointed out by the FAD of *Reticulofenestra pseudoumbilica*, species which is although very useful for the world-wide Middle Miocene.

In conclusion, regional scales based on the study of Oligocene-Lower Miocene from different Paratethys areas can be very useful to indicate an accurate age of the above mentioned interval and to understand the particular palaeoecology of the semi-isolated basins.

PALEOGENE/NEOGENE BOUNDARY IN EASTERN PARATETHYS

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To determine the Paleogene/Neogene boundary in Paratethys it is necessary to start from concrete observations, to consider all points of existing paleontological data and then to draw conclusions based on the principles of event stratigraphy. In Eastern Paratethys this boundary lies inside the deposits of Maikop series characterized by steady lithologic composition of argillites, traced along the vast spaces of EuroAsia from the lowlands of Mangyshlack, in the Pamir and the Tien Shan. In nonintermittent sections the argillites date back to the period from Early Oligocene to Early Miocene inclusive.

Several types of sections are characterized by paleontological peculiarities as well as heterogeneous biotope in this huge basin, while various conditions of segmentation are observed along a territory over 2,000 km long.

The principal types of sections: 1.**The Dniepr Region** including the Black Sea hollow and the submerged part of the southern slope of the Ukrainian crystalline shield; 2.**Kertch section**-within the frontiers of the South-Western plane of the Kertch peninsula; 3.**North Caucasian**-with basic sections in the Kuban river, in Stavropol area, and between the Volga and the Don; 4.**Caucasian** - with typical sections in the Kartlian (Uplictzich) and Achaltzichian depressions; 5. **Mangyshlackian** - in the Caspian region; 6. **Ustyrt** - in the Aral Sea region.

The problem of Paleogene/Neogene boundary in Eastern Paratethys should be treated beginning with the deposits containing brackish fauna in Serogosian, Tzraudonian, Ikiburulian, Tzchrutian and other layers; in Central Paratethys - especially along the Transylvanian Tertiary basin in the Romanian Preluca Area, where analogous mollusc fauna has been found in the Bizusa and Ileanda beds.

Within this fauna the following molluscs are known: *Corbula (Lenticorbula) sokolovi* (KARL.), *Janschinalla vinogrodskii* MERKL., *J. mlitopolitana* NOSSOV., *J. triangulum* (NYST), *Polymesoda convexa* BAST., *Cerastoderma seragosicum* NOSSOV., *C. lipoldi* (ROLLE), *Glycymeris pilosa lunulata* (NYST), *Melanopsis hantkeni* HOFFM., etc.

Despite the difficulty of determining the age of this fauna, taking into account the predominance of endemic species found in the section of chinks by the village of Nyzhnie Serogosy in Kherson area, we name this stage Serogosian and characterize it as the time of the final stage of the Late Oligocene Paratethys biotopes formation under the conditions of abrupt freshening of the basin in the Post-Rupelian time.

Change in its salinity probably connected with the confirmed fact of deep Chattian regression, occurring in many countries of the world, caused not only global eustatic fluctuations, but also descent of the sealevel, which resulted in maximum isolation of the Paratethys from the world ocean in the Late Oligocene.

In the upper zone of the section there can be distinguished a Caucasian regional stage which represents a transgressive cycle of deposit development with two horizons: Askanian

In the upper zone of the section there can be distinguished a Caucasian regional stage which represents a transgressive cycle of deposit development with two horizons: Askanian and Gornostayan. Sufficient reasons allow to suggest that Askanian deposits were formed on the transgressive branch in a completely salty basin, while the upper ones - Gornostayan - on the regressive one under conditions of slightly diminished salinity which further developed in the Kotzachurian time ("oncophora" fauna).

Foraminifera assemblage from Askanian deposits is characterized as polihalinian complex of Spiroplectammina terekensis-Sphaeroidina variabilis Zone, while Gornostayan ones are known as *Uvugerinella californica- Porosononion dentricus* considerably lacking some forms of polihalinian bentos.

The same peculiarities in the distribution of organic remnants in the deposits of the above-mentioned horizons are reflected in molluscs and ostracods assemblages. In both horizons there are representatives of intermediate Oligocene-Miocene habitus between the faunas of Boreal and Mediterranean bioprovinces. Pectenides, inherited from the Oligocene boreal basin - *Palliolum decussatum* (GOLDT.) and *Palliolum (Delectopecten) simile* (LASKAREV) - are present here as examples of the above-said phenomenon.

It is natural to try and investigate the paleogeographic links of the Eastern Paratethys sea-basin, existing after the Upper Oligocene Serogosian beds formation.

It might be assumed that those links were achieved along the area of the Central Paratethys and the Gulf in the place of Rheingraben, connecting the boreal basin of the Norwegian - Groenlandian Sea with the Paratethys. Hence the variety of Mollusc fauna of Torokbalint in North Hungary, in Kovachov beds in South Slovakia, and of Askanian - Gornostayan fauna in South Ukraine, which comprises not only predominant Miocene elements of the Atlantic and Mediterranean bioprovinces but also relict boreal species. Though there seem to be several contradictions in defining the age of the Oligocene/Miocene boundary, especially by Dinoflagellate cysts based on the principles of event stratigraphy, we can accept the formation of the Caucasian region stage as the starting point of the Lower Miocene in Eastern Paratethys.

PALEOGEOGRAPHY AND ANOXIC REGIME IN THE OLIGOCENE - EARLY MIOCENE EASTERN PARATETHYS

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1. The Oligocene - early Miocene (Majkopian) Eastern Paratethys as well as Carpathian Menillitic sea characterised by water stratification, recurrent stagnation and accumulation of deposits enriched by undecomposed organic matter (anoxic sediments).

2. It is important to distinguish two types of the anoxic regimes:
   - environments of oxigen deficit in sediments and near-bottom waters;
   - hydrogen-sulfide contamination of the water-mass.

These types alternated each other in the Majkopian basin.

3. The most significant anoxic events of the second type took place in the second part of the early Rupelian (NP22, D13), beginning of the Chattian (NP24, D14) and beginning of the Miocene (NN1, D16).

4. Besides the stratigraphic position, anoxy was controlled by paleogeography: in the deepest parts of the Paratethys almost all succession presents anoxic deposits; at the same time in shallow margins of the basin anoxic facies were rare or absent.

5. It was the anoxic environments of the second type that caused the formation of unique mineral ores: manganese ones in the early Oligocene; uranium and rare- metal accumulation in the late Oligocene; oil and gas.

CHANGES IN MARINE MOLLUSCAN ASSEMBLAGES FROM THE UPPER OLIGOCENE–LOWER MIOCENE IN NW TRANSYLVANIA

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The Upper Oligocene-Lower Miocene marine molluscan faunas are known in NW Transylvania in the Buzaş (latest Rupelian-Aquitanian), Vima (latest Rupelian-Aquitanian), Coruş (Aquitanian) and Chechiş (Aquitanian-early Burdigalian) Formations.

Buzaş Formation (Dumitrescu, 1957), exclusively arenitic, consists of marly sandstones, sands and calcareous sandstones (maximum 500 m thick) deposited in an outer shelf zone. The deposits of this formation represent the expresion of a new cycle of open sea sedimentation, subsequent to the Protoparatethys isolation phase of a brackish sea - the Solenovian Sea (Rusu, 1988).

Within the Buzaş Formation the molluscan assembages constitute specific biohorizons, more or less continous, as follows (from old to new): Pycnodonte callifera Level, Turritella and Thracia Level, Amusiopecte burdigalensis Level, Callista lilacinoides Level, and Chlamys gigas Level (Fig.1). The observation of the changes in these malacologic assemblages makes possible the tackling of biogeographic and biostratigraphic problems nearby the Oligocene/Miocene boundary.

a. Pycnodonte callifera Level (Rusu, 1969), one of the most widespread, well individualized faunistically, representing a real marker level, is situated 40-60 m above the base of the formation. It includes an assemblage formed of *Pycnodonte callifera* (LMK.), *Thracia speyeri* KOEN., *T. bellardii stenochora* (ROV.), *Angulus nysti* (DESH.), *Panope angusta* NYST, *Arctica islandica rotundata* (BRAUN), *Callista beirichi* (SEMP.), *C. splendida* (MÉR.), *Pitar incrassata* (SOW.), *P. boehmi* (HÖLZL), *Isocardia subtransversa* (D'ORB.), *Pholadomya puschi* GOLDF., *Nemocardium tenuisulcatum* (NYST), *Turritella venus* D'ORB. etc. representing the first normal marine fauna immigrated into the basin after the isolation phase with endemic brackish fauna from the first part of the Kiscellian. Within this association of medium-depth sublittoral zone, the elements of a northern origin are prevailing, the boreal influences being obvious.

The age of the Pycnodonte callifera Level is considered latest Kiscellian (time equivalent on the classical scale to a basal Chattian), the biohorizon being assigned to the upper part of the Zone NP24 of calcareous nannoplanckton (Rusu et al., 1995).

b. Turritella and Thracia Level (Rusu, 1977), less outlined and paleontologically poorly characterized, is situated 100-120 m above the previous horizon. It contains a molluscan assemblage similar to the first level, slightly impoverished in species (*Pycnodonte callifera* is one of the missing species); it was named after the frequency of the *Turritella venus* and *Thracia speyeri* taxa.

Turritella and Thracia Level is assigned to the upper part of the zone NP25 (Rusu et al., 1995), corresponding to the middle part of the Eggerian or to the Upper Chattian.

c. Amusiopecten burdigalensis Level (Rusu, 1972), situated at maximum 100 m above the preceding level, is well characterized paleontologically and is of a special stratigraphic significance.

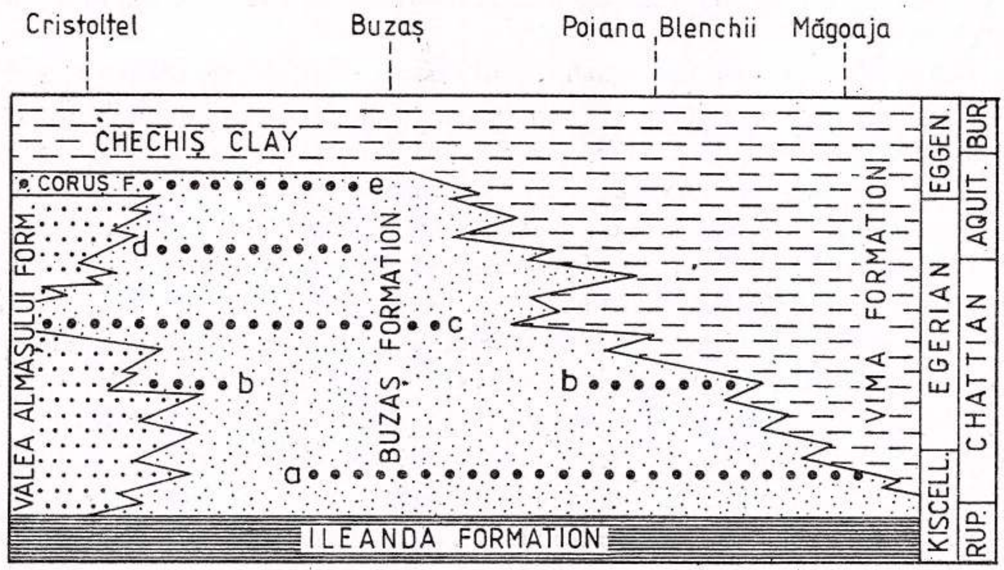

Fig. 1 – Molluscan horizons in Buzaş Formation a. Pycnodonte callifera Level; b. Turritella and Thracia Level; c. Amusiopecten burdigalensis Level; d. Callista lilacinoides Level; e. Chlamys gigas Level.

The index species, in fact the subspecies *Amusiopecten burdigalensis minor* (ROTH) - typical for the Central Paratethys, where it occurs in the Chattian and proliferates in the muddy bottom zones - is accompanied by *Cardium egerense* ROTH, *Cerastoderma edule greseri* (MAYER in WOLF), *Nuculana psammobiaeformis* ROTH, *Lutraria oblonga soror* MAYER, *Solecurtus basteroti* (DES MOUL.), *Ficus conditus* (BRGT.), *Athleta ficulina* (LMK.), *Aporrhais* cf. *callosus* ROTH., *Cassidaria nodosa buchii* etc., (Şuraru, 1969, 1970; Rusu, 1972, 1977).

At this level one can observe a renewal of the molluscan fauna which is enriched with warmer climate forms (remaining a predominantly boreal fauna); the first representatives of the Miocene occur, as well.

The faunal assemblages resemble the Hinia-Cadulus community of Eger section from Hungary (Báldi, 1973). As for the age, the Amusiopecten burdigalensis Level, which includes typical Egerian species, corresponds to the latest Chattian, the micropaleontological analyses pointing out the presence of the Zones NP25 of nannoplankton (Mészáros et al., 1975) and P22 planktonic foraminifera (Rusu, 1977).

d. Callista lilacioides Level (Rusu 1972) is situated at more than 100 above the preceding level and has a reduced spreading area by comparison with the bracketed levels. Here, the index fossil, a Miocene species typical of the Eggenburgian from the Paratethys realm, occurs beside *Turritella venus*, *Isocardia substransversa* and *Glycymeris* ex gr. *latiradiata* (SANDB. IN GÜMBEL), persistent species from the Oligocene.

In our opinion, the Oligocene-Miocene boundary could be traced in the Buzaş Formation, under this biohorizon, for which unfortunately no data based on planktonic microfossil are available.

e. Chlamys gigas Level (Rusu, 1988), situated at about 100 m above the preceding one, at the top of the Buzaş Formation (in the region where this formation is entirely developed), characterizes in fact the Coruş Formation individualized as lithostratigraphic entity in the Meseş and Gilău Areas.

Coruş Formation (Hauer and Stache, 1861), sandy and microruditic, in the mentioned areas transgressively rests over diverse older terms. It includes a diversified fauna of marine molluscs (enriched towards the sea-shore), well-known due to the fossil content since the first half of the last century (Hauer, 1847). Among the characterisitc species of this formation (or biohorizon) mention should be made of: *Chlamys gigas* (SCHLOTH.), *Ch. holgeri* (GEINITZ), *Pecten pseudobeudanti* DEP & ROM., *Laevicardium kubecki* (HAUER), *Rudicardium grande* (HÖLZL), *Discors spondyloides* (HAUER), *Glycymeris fichteli* (DESH.), *Callista lilacinoides* SCHFF., *Pitar schafferi* (KAUTS.), *Codakia haidingeri* (HÖRN.), *Anadara fichteli* (DESH.), *Thracia pubescens* (PULT.), *Turritella turris* BAST., *T. terebralis* LMK., *Protoma cathedralis quadricincta* SCHFF., *Athleta ficulina* (LMK.), *Ficus conditus* (BRGT.), *Sinum aquense* (RECLUZ), *Natica epiglotina moldensis* SCHFF. and *Typhis horridus* (BROCC.) (Hauer and Stache, 1861; Hofmann, 1887; Koch, 1900; Răileanu and Negulescu, 1964; Şuraru, 1967; Rusu, 1969). This type of litoral and shallow sublittoral fauna of indopacific origin, within which the warm water elements clearly prevail, marks a significant change in the molluscan assemblages evolution. It occurs in Transylvania with the first Miocene trangression and is characteristic of the Eggenburgian in the Paratethys (Larger Pecten Horizon), from Georgia in the east (with its Sakaraulian stage) up to Bavaria in the west (see Steiniger, Seneš et al., 1971, Popov et al., 1993).

Vima Formation (Lăzărescu, 1957, emend. Rusu, 1969), predominantly pelitic, includes a molluscan fauna poor in species and idividuals, pointed out by Hofmann (1827) and reviewed by Mészáros and Marosi (1957). This fauna comes only from the Oligocene section of the Vima Formation and is constituted of representatives of the genera *Palliolum, Variamusium, Limopsis, Nuculana, Nucinella, Axinus, Thracia, Cuspidaria* etc., that populated the deep sublittoral zone and shallow bathyal zone in Transylvania. The malacologic assemblage is of a boreal origin and displays clear affinities with the Kiscell Clay from Hungary (Baldi, 1986), the former being a bit younger.

The molluscan fauna from the Vima Formation is not significant for the estimation of the Oligocene-Miocene boundary, as it is spread only within the interval of the zones NP24-NP25 of nannoplankton (Rusu et al., 1995), therefore below this boundary.

Chechiş Formation (Hofmann, 1897), predominantly pelitic like the Vima Formation (which includes in the Preluca Area), contains two types of fauna: an shallow water type fauna (on inner shelf), situated in the basal, strongly transgressive part, and an deep water type fauna (on outer shelf and continental slope) developed in the rest part of the formation. The shallow water fauna specific to sandy bottom, with large-sized *Pectens, Glycymeris, Anadara, Cubitostrea, Callista, Venus, Thracia, Turritella, Terebra, Cassidaria, Ficus, Xenophora, Strombus* (Rusu, 1967; Şuraru, 1968) is of warmer water (as proved by the presence of the genus *Strombus* of tropical climate). The deep water fauna included in the "Schilier" type clays, is characterized by the presence of the thin-shelled pectinid forms (*Amusium, Parvamusium*), *Nucula, Yoldia, Astarte, Taras, Lucinoma, Macoma, Angulus, Nassa,* etc. (Şuraru, 1968). This fauna certainly belongs to the Eggenburgian, being situated in the nannoplankton subzone NN 2b (Mărunţeanu, 1993), that is the Burdigalian.

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OLIGOCENE-MIOCENE TRANSITION IN THE SUBPARATETHYS

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Subparatethys is an interregional zone of specific intraplatform sedimentogenesis, which covers the area from the northwestern Europe to the South Fore Urals area and is directed in general parallel to marine and freshwater basins of the Central and Eastern Paratethys. This vast area is characterised by a common geological history, similar structural-facial features and physico-geographic environments. The Subparatethys comprises the system of negative intraplatform structures surrounded by the Precambrian shields and old mountain structures. These are the Polish-German Depression, Danish- Polish Depression, Baltic (Polish-Lituanian) Syneclise, Podlyasca-Brest, Pripyat, Dnieper- Donets and North-Caspian depressions. They are restricted by the Baltic Shield, Byelorussian and Voronezh anteclises, and the southern spurs of the Urals in the north, and by the mountain systems of Harz, Thuringian Forest, Sudetes, Bohemia Massif, Rudny and Swientokszyski Mountains, Lukuv-Ratno Horst, Ukrainian Shield, Azov Massif, Donets Folded Belt, Karpinsky Ridge, uplands of Mountain Mangyshlak and Central Ust-Yurt in the south. During the Oligocene the southern margin represented a system of insular massives, submarine uplands and shoals and it was a boundary barrier zone between the Subparatethys with its shallow-water intrashelf seas and the Paratethys with its considerably deeper marine basins.

The Oligocene-Miocene transition in the Subparatethys was expressed as a total change of marine sedimentogenesis by continental, predominantly aqueous one. Marine basins whith covered the vast territories of the Subparatethys in Late Oligocene were replaced by large freshwater reservoirs of the sea-lake type. Reliability of this suggestion is based on the results of the multidisciplinary studies of the Oligocene-Miocene boundary deposits of different regions of the Subparatethys such as Lower and Upper brown coal-bearing formations (Kurshskaya and Zailandskaya formations respectively) of the South Baltic or Polish-Lituanian Syneclise; the Stradubskaya and Brinevskaya (= Krupeiskaya) formations of the Podlyaska-Brest and Prypiat depressions of the southern Byelorussia, and the Berekskaya and Novopetrovskaya formations of the Dnieper-Donets Depression of the northern Ukraine. The late Oligocene age and marine genesis of the Kurshskaya, Stradubskaya and Berekskaya formations are proved by marine molluscs, sponge spicules, dinocysts and palynomorphs. The early-middle Miocene age and continental (mostly lake- boggy) genesis of the Zailandskaya, Brinevskaya, Krupeiskaya and Novopetrovskaya formations are proved by the presence of freshwater molluscs, freshwater diatoms and palynomorphs.

Marine molluscs are known only in the Berekskaya Formation. *Plagiocardium abundans* (Liv.), *Glossus subtransversus* (Orb.), *Arctica rotundata* (Braun), *Cultellus roemari* Koen., *Ensis hausmanni* Sch., *Callista reussi* (Speyen), *C. beyrichi* (Semp.), *Angulus nystii* (Desh.), *Panopea* aff. *meynardi* (Desh.), *Cyrtodaria angusta* (Nyst.), numerous *Corbula (Lenticorbula) sokolovi* (Karl.), *C.(L.) sphenioides* (Sand.) and *Cerastoderma prigorovski* (Bog.)

as well as *Polynices (Euspira) achatensis* KON., *P. (Naticina) dilatata* PHIL., *Apporhais* cf. *speciosa* SCHLOTH., etc. occur there. The above-mentioned species allow the correlation of our association of fauna with the malacofauna of the Chattian of Belgium, Lower Egerian of Hungary and Upper Oligocene of the Fore Black Sea Depression, Fore Aral Sea and Ust-Yurt etc.

According to Dr. M.Ivannik, the sponge spicules recorded from Kurshskaya, Stradubskaya and Berekskaya formations are well correlated with the sponge-assemblages of the Kerleutskaya Formation of the Crimea and of the Menelitian deposits of the Ukrainian Carpathians.

Dinoflagellates occur in all of the above-mentioned formations and, according to Dr. A.Stotland, can be regarded as an assemblage with *Chiropteridium partispinatum*.

Association of palynomorphs from these deposits is interpreted by the palynologists Dr. L.Panova, Dr. A.Mikhelis and Dr. A.Stotland as certainly late Oligocene.

Freshwater molluscs and freshwater diatoms are known only from the Novopetrovskaya Formation. Molluscs are represented by two assemblages. The unionidic assemblage was extracted from the base of the Novopetrovskaya Formation. It contains the following species: *Unio wendli dniproviensis* GOZHIK, *U.* ex.gr. *schleschi* MOD., *U.* aff. *wateleti* DESH., *U.* cf. *bacareana* DUPUY, *U. (Tumidusiana) savroni* GOZHIK., *Plicatibaphia* ex.gr. *latiplicata* NOUL., *Cyrena* cf. *brongniarti* BAST., *Viviparus* ex.gr.*pachystoma* SAND. etc. The middle part of the Novopetrovskaya Formation yields the congerian assemblage consisting of *Congeria* cf. *aquitanica* ANDRUS., *C.* cf. *basteroti* DESH., *C.* cf. *amygdaloides* DUNK., *C.* cf. *sandbergeri* ANDRUS., *C. andrussovi* RZ., *Hydrobia* sp., *Unio* sp., *Anodonta* sp., etc.

Freshwater diatoms were extrated and studied by Dr. A.Moiseeva from diatomites and diatomite-like rocks of the middle part of the Novopetrovskaya Formation. They are most similar to the Middle Miocene freshwater diatoms of the southern Czech and Hungary; extincted species *Melosira praegranulata* is a very important index of the Miocene freshwater floras in general.

As to the palynological assemblages of the lower part of the Novopetrovskaya, Brinevskaya and Zailandskaya formations, the palynologists correlate them with those of the Olginskaya and Ritsevskaya deposits of the North Caucasus and regard them as early Miocene in age.

Thus, the Oligocene-Miocene transition in different areas of the Subparatethys corresponds to the boundary between the Kurshskaya and Zailandskaya formations in Eastern Baltic; to the boundary between the Stradubskaya and Krupeiskaya (= Brinevskaya) formations of Byelorussia, and to the boundary between the Berekskaya and Novopetrovskaya formations of Ukraine.

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