UNIVERSITATEA “BABEŞ-BOLYAI” CLUJ-NAPOCA
FACULTATEA DE BIOLOGIE ŞI GEOLOGIE
DEPARTAMENTUL DE GEOLOGIE

Reconstruction of the Paleogene and Neogene marine paleoenvironments in the southernmost part of the Tarcău Nappe (East Carpathians) based on fossil foraminifera assemblages

- Ph.D. Thesis Summary -

Scientific advisor
Prof. Dr. SORIN FILIPESCU

Ph.D. student
SZABO BOTOND

CLUJ-NAPOCA
2012

UNIUNEA EUROPEANĂ
GUVERNUL ROMÂNIEI MINISTERUL MUNCII, FAMILIEI ŞI PROTECŢIEI SOCIALE AMPOSDRU
Fondul Social European POSDRU 2007-2013
Instrumente Structurale 2007-2013
MINISTERUL EDUCAŢIEI CERCETĂRII TINERETULUI ŞI SPORTULUI
OIPOSDRU
UNIVERSITATEA BABEŞ-BOLYAI CLUJ-NAPOCA

Investing in people!

Ph.D. scholarship, Project co-financed by the SECTORAL OPERATIONAL PROGRAM FOR HUMAN RESOURCES DEVELOPMENT 2007 - 2013

Priority Axis 1. "Education and training in support for growth and development of a knowledge based society"

Key area of intervention 1.5: Doctoral and post-doctoral programs in support of research.

Contract nr.: **POSDRU/88/1.5/S/60185 –** "INNOVATIVE DOCTORAL STUDIES IN A KNOWLEDGE BASED SOCIETY"

Babeş-Bolyai University, Cluj-Napoca, Romania

Keywords:

foraminifera
East Carpathians
Tarcău Nappe
Paleogene
Neogene
biostratigraphy
paleoecology
depositional environments

Contents

Acknowledgements

Before starting my scientific argumentation, I would like to express my gratitude towards the people who helped me along the way.

First of all, I want to thank my supervisor, Prof. Dr. Sorin Filipescu for his guidance and support. His constructive criticism regarding my activity and towards my personality were higly appreciated.

I want to thank Lect. Dr. Silye Lóránd for all his help and support provided trough the years, ever since he introduced me to the field of micropaleontology and foraminifera.

Many thanks and warm wishes go towards my colleagues at the Department of Geology. I am grateful for their support and friendship.

I want to thank Prof. Dr hab. Adam Gasiński, from the Jagiellonian University, for all his help during my research mobility in Krakow.

During the field work, I enjoyed the company and help of Lect. Dr. Emanoil Săsăran, and former M.Sc. students Răzvan Bercea, Székely Szabolcs Flavius and Gheorghe Iordache. Much appreciated was the help provided by Dr. Krézsek Csaba, Dr. Radu Olaru and Dr. Victor Barbu from the exploration division of OMV Petrom.

Valuable biostratigraphic data, based on calcareous nannofossil assemblages, were provided by Lect. Dr. Ramona Bălc and Răzvan Bercea.

I also want to thank my parents, Margit and István, and my brother, Isti, for their support and understanding during all these years.

Last but not least, I want to thank my wife, Márta and my son, Dávid, for all their love and support. Thank you for being so patient and understanding with me, when I was absent, working on my thesis. I love you so much, and I dedicate my Ph.D. thesis to you.

This study was financially supported through the Ph.D. scholarship **POSDRU/88/1.5/S/60185** – "INNOVATIVE DOCTORAL STUDIES IN A KNOWLEDGE BASED SOCIETY" and by the Research Project "*Complex stratigraphic and geochemic study of the Oligocene – Miocene transition in the Bizdidel Valley, Carpathian Bend Zone*" - funded by OMV Petrom, 2009-2010.

Chapter I. Introduction

Fossil foraminifera became the main subject of this thesis as we started to study the turbiditic sequences in the southwestern part of the East Carpathians, as a part of the collaboration between the OMV Petrom and the Department of Geology of the Babeş-Bolyai University. For a better stratigraphic characterization of the Oligocene – Miocene transition in the southern part of the East Carpathians, several characteristic sections exposing the Oligocene – Lower Miocene bituminous anoxic facies in the East Carpathians were chosen. The outcrops are located in the Bizdidel Valley, near the town of Pucioasa (Dâmbovița district) and the Teleajen Valley, in the vicinity of Gura Vitioarei – Vălenii de Munte localities (Prahova district).

The initial objective was to study fossil foraminifera assemblages from the Oligocene – Lower Miocene interval, but in order to make a better characterization of the depositional environments, in the Pucioasa section we studied older (Cretaceous) and younger (Pontian) sediments as well.

Although the area was studied before, the facies control over the foraminifera assemblages was poorly studied and understood so far. Therefore, the aims of the present study are the following:

1. To document and describe the recovered foraminifera assemblages, including a taxonomic analysis.
2. To reassess the biostratigraphy of the studied geological units based on micropaleontological assemblages.
3. To reconstruct the paleoenvironments in the southern part of the Eastern Carpathians during the Cretaceous to Miocene based on micropaleontological and sedimentological data.
4. To compare the micropaleontological assemblages and inferred paleoenvironments between the investigated sedimentary basins in order to gather a better image on the basinal evolution.

Chapter II. Geology of the studied area

The Carpathian folded area includes deformed remnants of the Tethyan oceanic crust and of its continental margins; it is the result of several tectonic events that took place in the Cretaceous and Miocene (Săndulescu, 1994).

The East Carpathians can be divided in the Inner and Outer zones (**Fig. 1**). The outer part of the East Carpathian folded chain consists of cover nappes (Săndulescu et al., 1981), which are sedimentary allochtonous bodies overthrust progressively above the foreland (European, Scythian and Moesian Platform) (Săndulescu, 1984).

The studied area encompasses Upper Cretaceous to Miocene deposits that are outcropping in the Bizdidel Valley, near Pucioasa (Dâmbovița district) and Oligocene – Lower Miocene deposits outcropping in the Teleajen Valley, near Gura Vitioarei (Prahova district). During this interval, the epiclastic sediments were supplied by two main sources: the foreland in the east (external source), and the "cordilleras" or the already structured (mostly Cenozoic) internal units of the East Carpathians in the west (internal sources) (Săndulescu, 1994). Therefore, one of the main reasons of this study was to compare the microfossil assemblages and sedimentary paleoenvironments from distinct basins in order to get a better image on the basinal evolution.

The investigated Upper Cretaceous sediments belong to the Moldavides, more specifically to the "variegated clays" nappe (Ştefănescu, 1995), while the Oligocene – Lower Miocene deposits are developed in the Tarcău Nappe (Rusu et al., 1996).

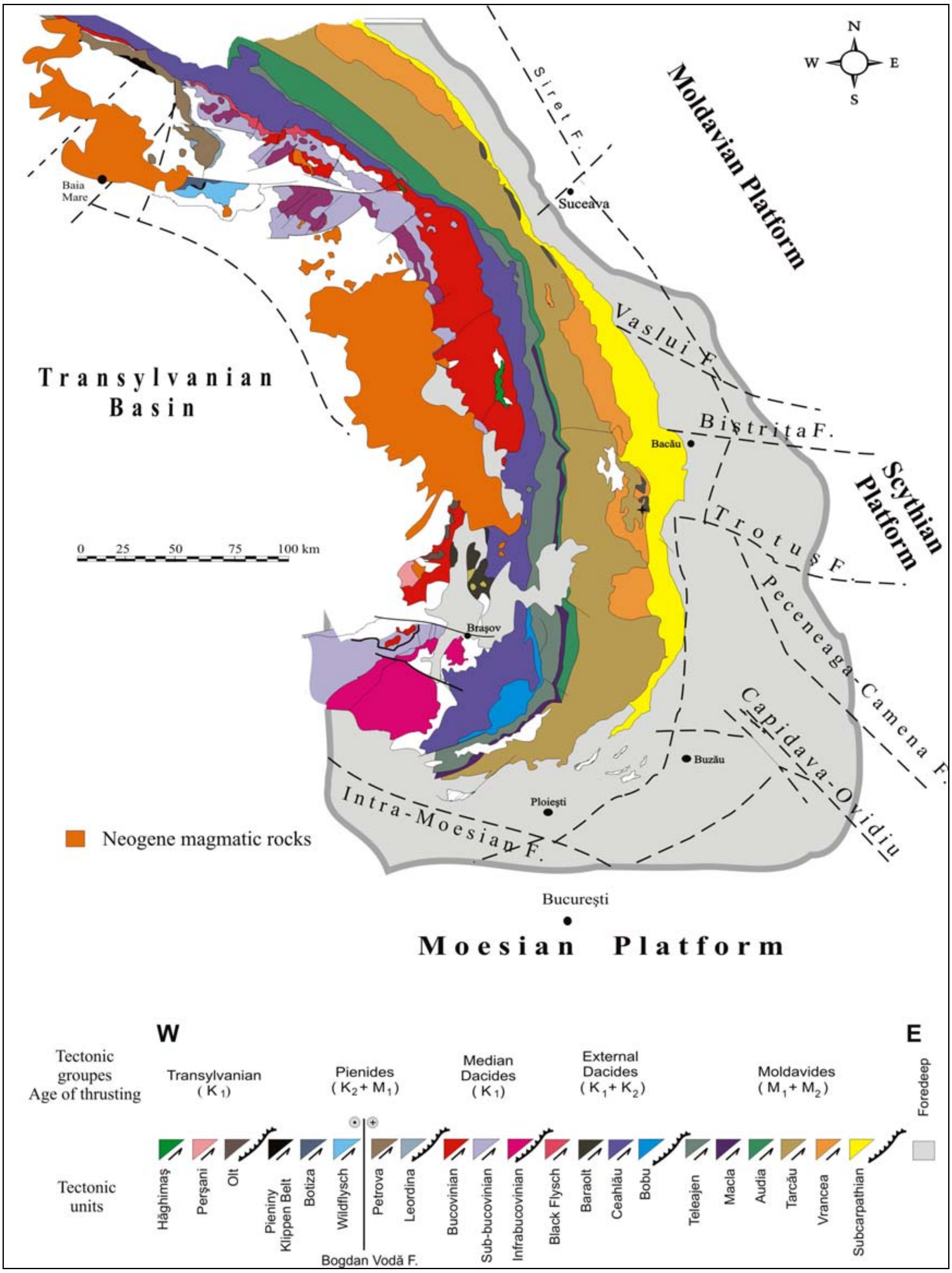

Figure 1. The geological map of the East Carpathians (after Bădescu, 2005)

Chapter III. Previous research in the studied area

The idea of a structure in overthrust nappes of the East Carpathians goes back to the beginning of the 20th century and was issued by Uhlig (1907), who worked out a comprehensive monograph of the whole Carpathian Mountain Range (1903) (*fide* Marinescu, 1972).

Mrazec and Popescu-Voiteşti (1912) support the idea of the Carpathian "Flysch Zone" being a structure of overthrust nappes, mainly based on the numerous geological investigations they carried out in the valleys of the East and South Carpathians.

Systematic geologic studies where also carried out by Mrazec and Teisseyre (1902, 1907); whilst Teisseyre, (1911) compiled the first geologic map of the Vălenii de Munte area (*fide* Preda, 1925).

Athanasiu (1907) introduced to the literature the definition of the Middle Eocene Tarcău Sandstone (*fide* Dumitrescu, 1952 and Pătruț, 1955).

The definition of the "Pucioasa beds" was given by Mrazec in 1911 (*fide* Mrazec and Popescu-Voiteşti, 1912) for the marly deposits outcropping above the Fusaru Sandstone, near the Pucioasa locality.

The Fusaru Sandstone was separated for the first time in the Carpathians by Popescu-Voiteşti in 1909 (*fide* Popescu-Voiteşti, 1911); it was named after the Fusaru Peak (731 m) in the Ialomița Valley (Dâmbovița district), from its typical outcroping area.

Popescu (1952) defined for the first time the Pucioasa Formation with Fusaru Sandstone, and attributed it to the Oligocene.

Definition of the Tarcău Nappe as a plurifacial unit was given by Dumitrescu (1948, 1952). Although the sedimentary deposits forming the Tarcău Nappe are Cretaceous to Oligocene, the Eocene Tarcău Sandstone facies is the one that characterizes this unit (Dumitrescu, 1952).

With the second half of the 20th century, geologic investigations become more specific, focusing on micropaleontological, sedimentological and tectonic aspects of the East Carpathians.

Chapter IV. Material and methods

109 samples of claystones (approximately 500g/sample) were collected on four occasions (October and November of 2009, March and June of 2010) from the banks of the Bizdidel stream, a tributary of the Ialomița River. Additionally, 46 samples were collected from the Teleajen River valley on two occasions (July and October of 2010). 12 samples were supplied by the exploration division of OMV Petrom; unfortunately, none of these samples presented a micropaleontological content. The micropaleontological sampling was correlated to the sedimentological characters, with the help of Dr. Emanoil Săsăran and Răzvan Bercea, in order to obtain a more reliable image on the depositional environment.

The micropaleontological samples were processed according to standard micropaleontological methods: 1. sediment samples were dried; 2. 250 g from each sample was boiled in tap water, with one tablespoon of sodium carbonate (Na_2CO_3) added; 3. samples were washed over a 63 µm brass mesh sieve, to remove the clay content; 4. the resulted residue was dried; and if necessary, it was treated with 0,3% hydrogen peroxide (H_2O_2) to further disintegrate the clay minerals; 5. the treated material was washed again and dried.

All foraminifera > 63 µm were picked from the dried wash residue. The picked individuals were mounted on lightly glued cardboard microslides, then were sorted by species and counted.

Methods used in this study include paleoecological quantitative indices (relative and absolute abundance, generic dominance), agglutinated foraminifera biofacies, agglutinated foraminifera morphogroups, calcareous benthic morphogroups, planktonic / benthic (P/B) ratio and benthic foraminifera oxygenation index (BFOI). The benthic foraminifera assemblages were used to make estimations on paleoecological conditions. Interpretations of the fossil record depend largely on comparison with modern ecology (Murray, 2006); therefore direct comparisons between the fossil material and a selection of papers describing the ecology of modern environments was used to document paleoenvironmental changes in the studied area.

Chapter V. Results

5.1. Pucioasa section (Bizdidel Valley) (Fig. 2)

The sedimentary facies and associated micropaleontological content were analyzed as part of a project funded by OMV Petrom; therefore the results will be presented according to the report of Filipescu et al. (2010).

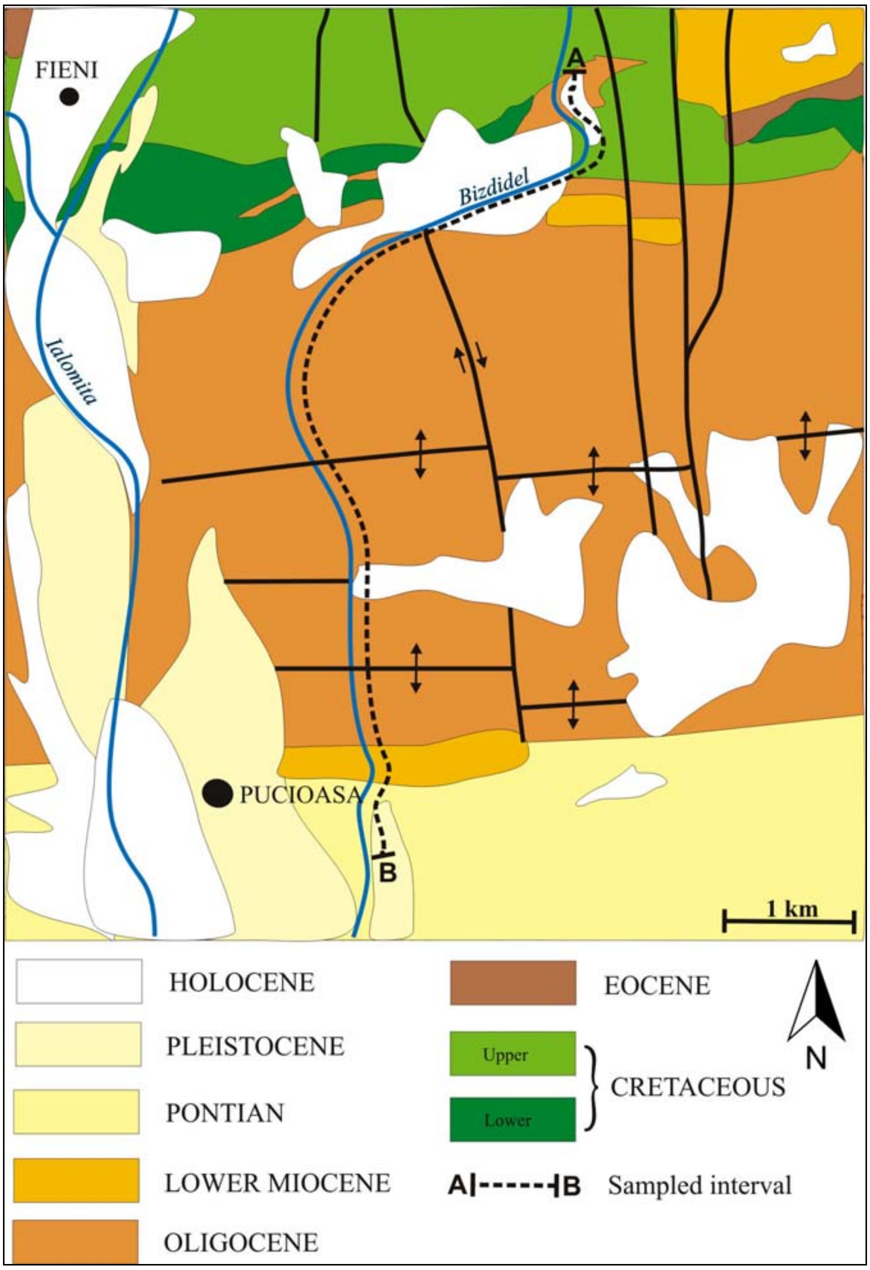

Figure 2. Geological map of Pucioasa showing the sampled interval in the Bizdidel Valley (after Ştefănescu et al., 1988)

5.1.1. Upper Cretaceous

Gray-brown clays and grey sands with high muscovite content are outcropping in the beginning of the studied section. The locally developed coarse deposits (conglomerates, microconglomerates, sandstones, and mudstones) have lenticular or sheet geometries, with erosional bases and display oblique structures, horizontal laminations and deformational structures.

In the northern part of the studied section duplications of the lithological structures were observed. The Upper Cretaceous grey sandstones and mudstones are alternating with the Eocene variegated clays.

The Cretaceous planktonic foraminifera assemblage is rich in small *Heterohelix* spp. and *Macroglobigerinelloides* spp. in addition to *Globotruncana arca* and *Rugoglobigerina rugosa*. Even if we did not record the zonal marker, according to Premoli-Silva and Verga (2004) the assemblage identified in the grey sands from the northern portion of the investigated section in Bizdidel Valley, corresponds to the late Maastrichtian ***Abathomphalus mayorensis*** **Zone**, the Interval Zone from the FO of the nominal taxon to the extinction of most Cretaceous planktonic foraminifera.

Calcareous nannoplankton is also diagnostic for the Late Cretaceous, and indicates a post Campanian age (CC18 *Broinsonia parca parca* Biozone) (Bălc in Filipescu et al., 2010).

The agglutinated foraminifera assemblages identified in the Upper Cretaceous samples resembles the “flysch-type” assemblage (**FTA**) described by Kaminski and Gradstein (2005) from bathyal slope environments. Morphogroup analysis of agglutinated foraminifera reveals oxic environments for the Upper Cretaceous in Bizdidel Valley. Based on morphogroup analysis the calcareous benthic foraminifera assemblages reveal an oxic environment for the Late Cretaceous in Bizdidel Valley.

5.1.2. Paleogene

Variegated (red-green) claystones and marlstones outcrop in the northern part of the Pucioasa section; intercalated between the Upper Cretaceous grey sandstones and mudstones. These finer sediments are strongly affected by tectonics and diagenesis: horizontal laminations, secondary coloring, and nodular structures could be observed.

The planktonic foraminifera identified in the samples **B03**, **B89**, **B99**, **B100, and B102** show clear affinities towards an Eocene age. The genus *Globigerinatheka* first appears close to the early/middle Eocene boundary (Tourmakine and Luterbacher, 1985, Sexton et al., 2006). The identified *Subbotina* species are global in low to high latitudes (Pearson et al., 2006), but an increase in abundance of high-spired subbotinids is recoded in the late Eocene (Premoli-Silva et al., 2003).

The late Eocene age is also supported by the calcareous nannoplankton assemblages indicating the NP19 Zone with *Istmolithus recurvus* (Bălc in Filipescu et al., 2010).

Morphogroup analysis of agglutinated foraminifera revealed oxygenated bottom waters, with low to moderate organic matter flux during the Eocene. The agglutinated foraminifera assemblage identified in the variegated clays resembles the "flysch-type" agglutinated foraminifera biofacies (**FTA**) described by Kaminski and Gradstein (2005). These are typical for the Paleogene turbiditic formations in the Carpathian area. The morphogroup analysis of calcareous benthic foraminifera revealed the dominance of the epifaunal morphotypes, considering the studies of Corliss and Fois (1990) this could indicate deep-water environments.

5.1.3. ? Oligocene to Miocene

The lithology changes downstream the section from variegated clays to sandy-shaly turbiditic sediments of the Pucioasa Formation. The oldest deposits of the Pucioasa Formation outcrop in the core of an anticline and are part of the Fusaru Sandstone (between samples **B42** to **B54**). They are represented by turbidites filling submarine channels and hemipelagites. The levee and overbank deposits occur at the base of the succession (samples **B45**, **B46**, and **B47**) and consist of fine to medium-grained sands with clay and silt intercalations. Approximately 300 m upstream of sample **B14**, the outcropping sediments suggest a deltaic environment (samples **B31**, **B32**, **B33**, **B54**, and **B55**). A rich organic facies (Pucioasa-type bituminous shales) was identified towards the upper part of the succession in the north (samples **B104**, **B120**, **B121**, and **B122**). Downstream, a lagoonal-evaporitic facies with gypsum and organic rich clays and bioturbated marls were identified (samples **B79**-**B83**). The silt and silty clays between samples **B66-B70** are rich in fossils, mainly bivalves and ostracods, indicating shelf environments and a Pontian age.

The dark grey laminated marls of the Pucioasa Formation revealed poor fossil foraminifera assemblages, but however characteristic for the depositional environment. Many of the calcareous foraminifera tests are partially or entirely pyritized as a consequence of poor oxygenation.

Beside the long ranging planktonic foraminifera (*Tenuitella clemenciae*, *Tenuitellinata juvenilis*, *Tenuitellinata selleyi*, *Globigerina lentiana*, *Globigerina praebulloides*, *Globigerina officinalis*, *Globigerina ouachitaensis*, and *Turborotalia quinqueloba*) that are frequent in the Central Paratethys (Rögl and Nagymarosy, 2004; Roetzel et al., 2006) several typical Lower Miocene taxa were found (*Globoquadrina dehiscens, Globigerinoides primordius,* and *Globigerinoides quadrilobatus*) (Popescu, 1999; Spezzaferri, 1994). According to Popescu and Crihan (2011) *Turborotalia quinqueloba* is frequent in Lower and Middle Miocene of the Paratethys, while *Globoquadrina dehiscens* and *Globoquadrina langhiana* occurs until the early Middle Miocene (lower Badenian) deposits in Romania.

Calcareous nannoplankton confirms the Early Miocene age by the presence of *Sphenolithus belemnos* (NN3 Zone) and *Helicosphaera ampliaperta* (NN4 Zone) (Bălc in Filipescu et al., 2010).

The presence of tenuitellid foraminifera suggests open marine connections with the Indo-Pacific area (Filipescu and Silye, 2008; Beldean et al., 2012).

Morphogroup analysis of the agglutinated foraminifera assemblages in samples **B106**, **B105** and **B56a** (**Fig. 3**) revealed the dominance of the flattened planispiral and streptospiral morphotypes (e.g. *Ammoanita ruthvenmurrayi*, *Ammosphaeroidina pseudopanciloculata, Conglophragmium irregularis, Glomospira charoides*) classified in the **M3a** morphogroup. The agglutinated foraminifera assemblages indicate deep-water, possible bathyal environments.

Calcareous benthic foraminifera assemblages reflect dysoxic conditions; deep infaunal species, tolerant of low oxygen conditions, dominate the calcareous benthic foraminifera assemblages between samples **B33** – **B84** in the Pucioasa Formation. According to Bernhard (1986) the dominant foraminifera from Miocene anoxic assemblages include *Bolivina*, *Fursenkoina*, *Uvigerina* and *Valvulineria*. *Virgulinella* is also restricted to dysoxic environments.

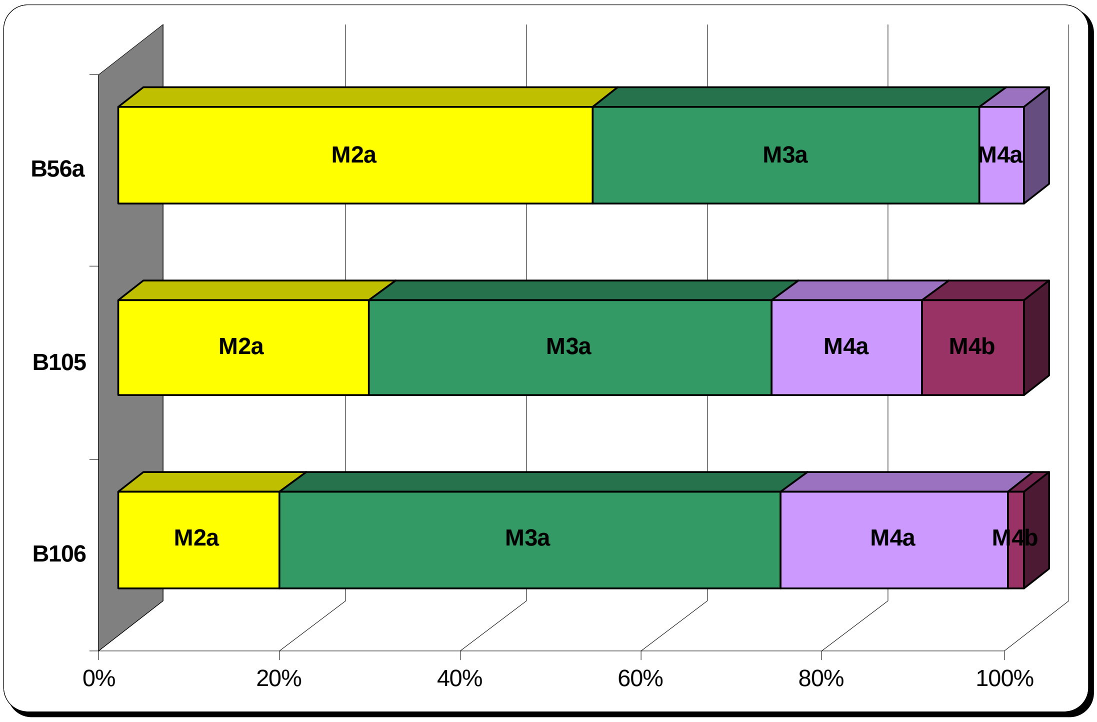

Figure 3. Relative abundance of agglutinated foraminifera morphogroups in Miocene assemblages from Bizdidel Valley

The ostracod fauna identified in the southernmost samples (that are not part of the Pucioasa Formation) indicates a late Pontian (Late Miocene) age (Wanek in Filipescu et al., 2010).

5.2. Gura Vitioarei section (Teleajen Valley)

Gura Vitioarei section (**Fig. 4**) is dominated by alternating clay and sandstone turbidity flows. A bentonised volcanic tuff layer (Vălenii de Munte Tuff), located at the lower part of the studied section is intercalated in the turbidites. Black bituminous shales marke the top of the studied sedimentary interval. Incomplete Bouma sequences, debris flows, high density flows, convolute structures in sandstones (frequent and typical for this outcrop), climbing ripples, and also deformational structures in volcanic tuff, are common in the investigated siliciclastic deposits.

The investigated fine sediments in the Gura Vitioarei section revealed very poor foraminifera assemblages. Foraminifera tests are often pyritized or poorly preserved. Siderite crystals were found in several samples. Bituminous shales are present and indicate reduced oxygen conditions.

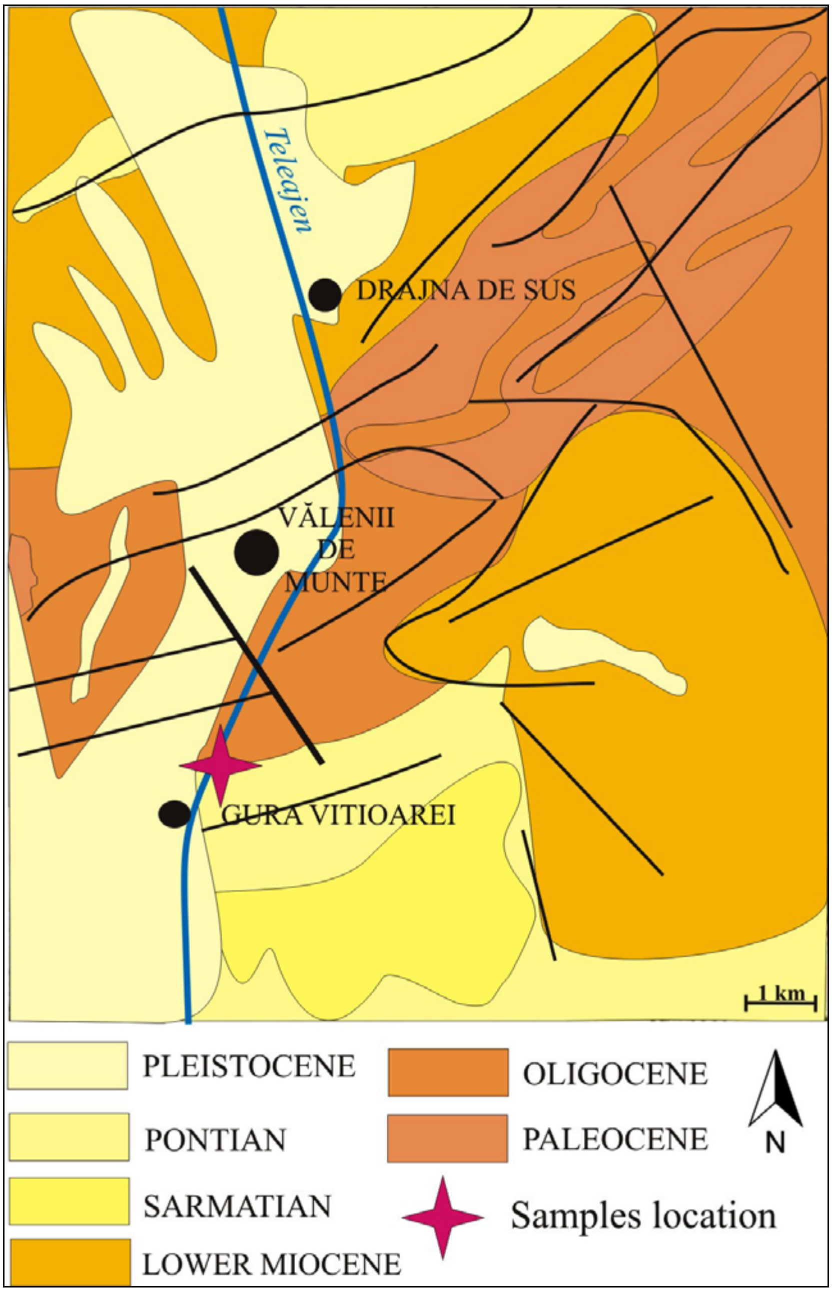

Figure 4. Geological map of Gura Vitioarei showing samples location in the Teleajen Valley (after, Murgeanu et al., 1967)

No index taxa were identified among the plantkonic foraminifera assemblages. Based on the stratigraphic ranges proposed by several authors (Popescu and Crihan, 2011; Rögl, 1994; Rögl and Nagymarosy, 2004; Spezzaferri, 1994) the identified planktonic taxa (*Globigerina ciperoensis*, *Globigerina ottnangensis*, *Globigerina steiningeri*, *Globigerinella obesa*) suggest a Lower Miocene age for most of the Gura Vitioarei section.

Based on the occurrences of *Preorbulina glomerosa glomerosa* and *Globigerinoides bisphericus* in sample **GV2b**, *Globorotalia praescitula* in sample

GV2, *Globoquadrina altispira* in sample **GV4**, *Globorotalia bykovae* in sample **GV29**, an early Badenian age cannot be excluded, even if the number of specimens is very low and the preservation is poor.

A more reliable age assumption is given by calcareous nannoplankton assemblages. Quantitative analysis shows a high abundance of *Helicosphaera ampliaperta*, also sporadic occurence of *Discoaster variabilis* and *Sphenolithus heteromorphus*, which places the studied interval in the top of Biozone NN4 (late Early Miocene to early Middle Miocene). This gives a new interpretation on the age of the investigated section.

The agglutinated foraminifera are assemblages are diagnostic for deep-water turbiditic settings. Local abundance of *Glomospira charoides* was recorded in sample **GV17.** The presence of calcareous benthic foraminifera characteristic for shallow waters (e.g. *Ammonia*, *Asterigerinata* and *Elphidium*) does not fit the depositional environment. Additionally, the tests of calcareous benthic specimens (*Bulimina*, *Uvigerina*, *Pyrgo*, and *Lenticulina*) are corroded and damaged. All these could indicate that the calcareous benthic specimens were transported from the shallower environments by the turbidity currents.

Similarities and differences were observed between the foraminifera assemblages from Pucioasa and Podu Morii formations. Similarities consist in the strongly reduced benthic assemblages, and the partially or entirely pyritized calcareous foraminifera tests, as a consequence of poor oxygenation. The Pucioasa Formation is distinguished from the Podu Morii Formation by the presence of calcareous benthic assemblages adapted to low oxygen conditions. Agglutinated foraminifera were identified in both formations; the assemblages are similar and diagnostic for deep-water turbiditic environments.

Chapter VI. Taxonomy

More than 250 species of foraminifera have been identified from the Cretaceous to Miocene sediments in the southwestern part of the Eastern Carpathians. The identified agglutinated foraminifera are arranged in taxonomic order by following the suprageneric classification of Kaminski (2004), while for the calcareous foraminifera the classification of Loeblich and Tappan (1988, 1992) was used.

Species identifications are based mainly on the work of Kaminski and Geroch, 1993, Kaminski and Gradstein, 2005, Bolli et al., 1994, Cicha et al., 1998, Popescu, 1975, Premoli-Silva et al., 2003; Premoli-Silva and Sliter, 2002; Premoli-Silva and Verga, 2004, Pearson et al., 2006, Kennett and Srinivasan, 1983.

Chapter VII. Conclusions

This study focused on the description of fossil foraminifera assemblages from the southernmost part of the Tarcău Nappe (East Carpathians) and their significance in the reconstruction of the Paleogene and Neogene marine paleoenvironments.

In the Pucioasa (Bizdidel Valley) section, micropaleontological and sedimentological data permitted the identification of three distinct paleoenvironments, in Upper Cretaceous to Miocene formations.

During the Late Cretaceous and Late Eocene deep-water settings with turbiditic complexes prevailed, with well-oxygenated bottom waters and slightly oligotrophic conditions. The paleoenvironmental situation changed in the Early Miocene, hypoxic conditions and high organic input suggest restricted environments and isolation of the basin.

In the southernmost part of the investigated section in Bizdidel Valley the ostracod assemblages, characteristic for the late Pontian (Late Miocene), revealed shallow marine paleoenvironments.

Based on biostratigraphic data and tectonic measurements duplications of the lithological structures were revealed in the northern part of the investigated section: the Upper Cretaceous grey sandstones and mudstones are alternating with the Eocene variegated clays.

Micropaleontological and sedimentological data from Gura Vitioarei (Teleajen Valley) section permitted the identification of deep water environment with turbiditic deposits in the Podu Morii Formation, with small planktonic foraminifera and reduced benthic assemblages indicating high surface productivity and dysoxic bottom conditions.

Planktonic foraminifera assemblages (supported by calcareous nannoplankton) reveals new possibilities in refining the biozonation for the southernmost part of the Tarcău Nappe. Changes in the marine paleoenvironments could be inferred as well, based on sedimentological features and benthic foraminifera assemblages.

Selective bibliography

Athanasiu, S., 1907. Raport anual. *Anuarul Institutului Geologic al României*, **1**.

Bădescu, D., 2005. Evoluția tectono-stratigrafică a Carpaților Orientali în decursul Mezozoicului şi Neozoicului. Editura Economică, Bucureşti, 311 pp.

Beldean, C., Filipescu, S. and Balc, R., 2012. Paleoenvironmental and biostratigraphic data for the Early Miocene of the North-Western Transylvanian Basin based on planktonic foraminifera. *Carpathian Journal of Earth and Environmental Sciences*, **7**(7): 171-184.

Bernhard, J.M., 1986. Characteristic assemblages and morphologies of benthic foraminifera from anoxic, organic-rich deposits: Jurassic through Holocene. *Journal of Foraminiferal Research*, **16**(3): 207-215.

Bolli, H.M., Beckmann, J.-P. and Saunders, J.B., 1994. Benthic foraminiferal biostratigraphy of the south Caribbean region. Cambridge University Press, Cambridge, 408 pp.

Cicha, I., Rögl, F., Rupp, C. and Ctyroka, J., 1998. Oligocene - Miocene foraminifera of the Central Paratethys. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, **549**: 1-325.

Corliss, B.H. and Fois, E., 1990. Morphotype Analysis of Deep-Sea Benthic Foraminifera from the Northwest Gulf of Mexico. *Palaios*, **5**: 589-605.

Dumitrescu, I., 1948. La Nappe du Grès de Tarcău la Zone marginale et la Zone néogène, entre Caşin et Putna. *Comptes Rendus des Séances de l'Institut Géologique de Roumanie*, **29**(1940-1941): 84-105.

Dumitrescu, I., 1952. Studiul geologic al regiunii dintre Oituz şi Coza. *Anuarul Comitetului Geologic*, **24**: 195-270.

Filipescu, S., Săsăran, E., Bălc, R., Szabo, B., Bercea, R., Iordache, G., Székely, S.F. and Petruța, S., 2010. Complex stratigraphic and geochemic study of the Oligocene – Miocene transition in the Bizdidel Valley. *Raport OMV Petrom*: 1-53.

Filipescu, S. and Silye, L., 2008. New Paratethyan biozones of planktonic foraminifera described from the Middle Miocene of the Transylvanian Basin. *Geologica Carpathica*, **59**(6): 537-544.

Kaminski, M.A., 2004. The Year 2000 Classification of the Agglutinated Foraminifera. *In Bubík, M. & Kaminski, M.A. (eds),. Proceedings of the Sixth International Workshop on Agglutinated Foraminifera Grzybowski Foundation Special Publication*, **8**: 237-255.

Kaminski, M.A. and Geroch, S., 1993. A revision of foraminiferal species in the Grzybowski collection. *In Kaminski, M.A., Geroch, S., and Kaminski, D.G. (eds.) The Origins of Applied Micropaleontology: The School of Jozef Grzybowski. Grzybowski Foundation Special Publication*, **1**: 239-323.

Kaminski, M.A. and Gradstein, F.M., 2005. Atlas of Paleogene Cosmopolitan deep-water Agglutinated Foraminifera. Grzybowski Foundation Special Publication 10, London, 547+vii pp.

Kennett, J.P. and Srinivasan, M.S., 1983. Neogene planktonic foraminifera: a phylogenetic atlas. Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania, 263 pp.

Loeblich, A.R. and Tappan, H., 1988. Foraminiferal Genera and Their Classification. Van Nostrand Reinhold, New York, 970 pp.

Loeblich, A.R. and Tappan, H., 1992. Present status of foraminiferal classification. *In Takayanagi, Y. and Saito, P. (Eds.), Studies in Benthic Foraminifera, Benthos'90, Sendai,1990, Tokai University Press*: 93-102.

Marinescu, I., 1972. Structural correlations between Moldavian and Wallachian Eastern Carpathians. *Geologische Rundschau*, **61**(2): 396-412.

Mrazec, L. and Popescu-Voiteşti, I., 1912. Contribution à la connaissance des nappes du Flysch carpathique en Roumanie *Comptes Rendus des Séances de l'Institut Géologique de Roumanie*, **3**: 37-58.

Mrazec, L. and Teisseyre, W., 1902. Aperçu géologique sur les formations salifères et les gisements de sel en Roumanie. *Moniteur des Intérêts Pétrolifères Roumains*, **3**: 50-56.

Mrazec, L. and Teisseyre, W., 1907. Esquisse tectonique de Roumanie/Stratigraphie des Régions Pétrolifères/Esquisse tectonique des Subcarphates. *Guide n. 1, le Congrès Internationale du Pétrole, session IIIe, Bucarest*.

Murgeanu, G., Motaş, I., Bandrabur, T., Ghenea, C. and Săndulescu, M., 1967. Geological map of RSR, scale 1:200.000, sheet 36 Ploieşti (in Romanian).

Murray, J.W., 2006. Ecology and Application of Benthic Foraminifera. Cambridge University Press, Cambridge, 426 pp.

Pătruț, I., 1955. Geologia şi Tectonica reginunii Vălenii de Munte-Cosminele-Buştenari. *Anuarul Comitetului Geologic*, **28**: 7-98.

Pearson, P.N., Olsson, R.K., Huber, B.T., Hemleben, C. and Berggren, W.A., 2006. Atlas of Eocene Planktonic Foraminifera. *Cushman Foundation Special Publication* **41**, 514 pp.

Popescu-Voiteşti, I., 1911. Contribution à l'étude stratigraphique du Nummulitique de la Dépression Gétique. *Anuarul Institutului Geologic al României*, **3**(1909-1910).

Popescu, G., 1952. Zona Flişului paleogen între Valea Buzăului şi Valea Vărbilăului. *Dări de Seamă ale Şedințelor Institutului Geologic al României*, **36**(1948-1949): 113-125.

Popescu, G., 1975. Études des foraminifères du Miocène inférieur et moyen du nord-ouest de la Transylvanie. *Mémoires de l'Institut de Géologie et de Géophysique*, **23**: 1-121.

Popescu, G., 1999. Lower and Middle Miocene agglutinated foraminifera from the Carpathian area. *Acta Palaeontologica Romaniae*, **2**: 407-425.

Popescu, G. and Crihan, I.-M., 2011. Middle Miocene Globigerinas of Romania. *Acta Palaeontologica Romaniae*, **7**: 291-313.

Preda, D.M., 1925. Geologia şi tectonica părții de răsărit a Județului Prahova. *Anuarul Institutului Geologic al României*, **10**(1921-1924): 1-60.

Premoli-Silva, I., Rettori, R. and Verga, D., 2003. Practical Manual of Paleocene and Eocene planktonic Foraminifera. In Rettori, R., Verga, D., (Eds.), International School on Planktonic Foraminifera, 2° Course: Paleocene and Eocene. Dipartimento di Scienze della Terra, Universita di Perugia, 152 pp.

Premoli-Silva, I. and Sliter, W.V., 2002. Practical manual of Cretaceous planktonic foraminifera. In Premoli Silva, I., Rettori, R., (Eds.), International School on Planktonic Foraminifera 1° Course: Cretaceous. Dipartimento di Scienze della Terra, Universita di Perugia, 462 pp.

Premoli-Silva, I. and Verga, D., 2004. Practical Manual of Cretaceous Planktonic Foraminifera. In Premoli Silva, I., Rettori, R., (Eds.), International School on Planktonic Foraminifera 3° Course: Cretaceous. Tipografia Pontefelcino, Perugia, 283 pp.

Roetzel, R., Ćorić, S., Galović, I. and Rögl, F., 2006. Early Miocene (Ottnangian) coastal upwelling conditions along the southeastern scarp of the Bohemian Massif (Parisdorf, Lower Austria, Central Paratethys). *Beiträge zur Paläontologie*, **30**: 387-413.

Rögl, F., 1994. Globigerina ciperoensis (Foraminiferida) in the Oligocene and Miocene of the Central Paratethys. *Annalen des Naturhistorischen Museums Wien*, **96A**: 133-159.

Rögl, F. and Nagymarosy, A., 2004. Biostratigraphy and correlation of the Lower Miocene Michelstetten and Ernstbrunn sections in the Waschberg Unit, Austria (Upper Egerian to Eggenburgian, Central Paratethys). *Courier Forschungsinstitut Senckenberg*, **246**: 129-151.

Rusu, A., Popescu, G. and Melinte, M., 1996. Oligocene- Miocene transition and main geological events in Romania, IGCP Project No. 326 Field Symposium Excursion Guide. *Romanian Journal of Paleontology*, **76**(1).

Săndulescu, M., 1984. Geotectonica României. Editura Technică, Bucureşti, 336 pp.

Săndulescu, M., 1994. Overview on Romanian Geology. *Romanian Journal of Tectonics and Regional Geology*, **75**(2): 3-15.

Săndulescu, M., Ştefănescu, M., Butac, A., Pătruţ, I. and Zaharescu, P., 1981. Genetical and Structural Relations between Flysch and Molasse (The East Carpathians Model): Guide to Excursion A5, Carpatho-Balkan Geological Association XII[th] Congress, Bucharest - Romania 1981. *Giudebook Series of the Geological Institute of Romania*, **19**: 3-96.

Sexton, P.F., Wilson, P.A. and Pearson, P.N., 2006. Palaeoecology of late middle Eocene planktic foraminifera and evolutionary implications. *Marine Micropaleontology*, **60**: 1-16.

Spezzaferri, S., 1994. Planktonic foraminiferal biostratigraphy and taxonomy of the Oligocene and lower Miocene in the oceanic record. An overview. *Palaeontographia Italica*, **81**: 1-187.

Ştefănescu, M., 1995. Stratigraphy and structure of Cretaceous and Paleogene flysch deposits between Prahova and Ialomiţa valleys. *Romanian Journal of Tectonics and Regional Geology*, **76** (Supplement): 1-49.

Ştefănescu, M., Ghenea, C., Papaianopol, I., Ghenea, A., Mihăilescu, N., Ivan, V., Munteanu, T., Ştefănescu, M. and Munteanu, E., 1988. Geological map of RSR, scale 1:50.000, sheet 128d Pucioasa (in Romanian).

Teisseyre, W., 1911. Harta geologică a regiunii Vălenii de Munte, 1:50.000, Bucureşti.

Tourmakine, M. and Luterbacher, H., 1985. Paleocene and Eocene planktic foraminifera. In: H.M. Bolli, J.B. Saunders and K. Perch-Nielsen (Editors), Plankton Stratigraphy. Cambridge University Press, Cambridge, 87-154 pp.

Uhlig, V., 1903. Bau und Bild der Karpaten. In Diener C. et al (eds.) *Bau und Bild Österreichs*. Tempsky, Wien; Freytag, Leipzig, 651-911 pp.

Uhlig, V., 1907. Über die Tektonik der Karpaten. *Sitzungsberichte der Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse, Wien*, **116**(1): 871-982.