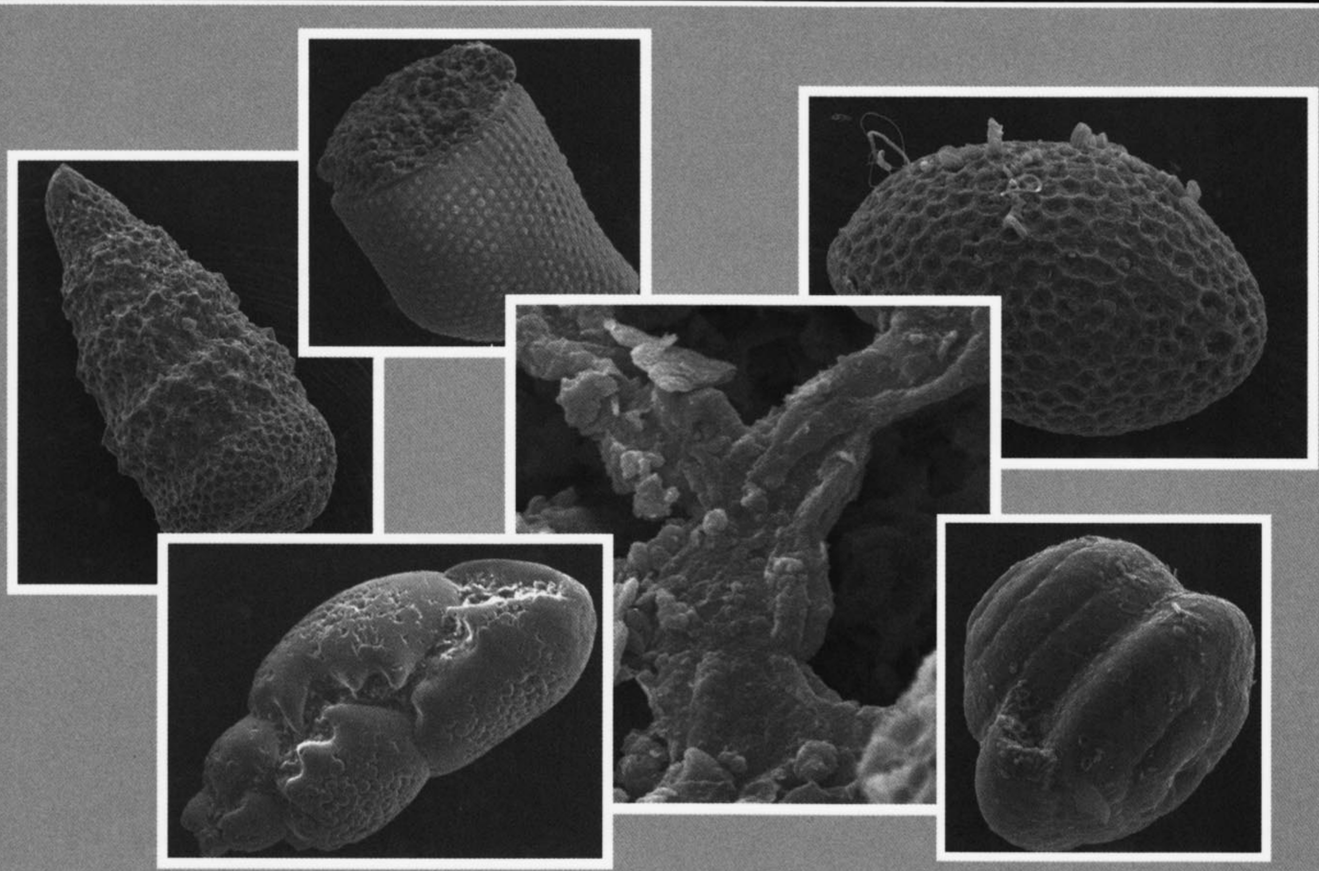
Integrating Microfossil Records from the Oceans and Epicontinental Seas



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and
Annual TMS Foram-Nannofossil Group Meeting

Kraków, June, 27–30, 2011

Topic:

"*Integrating Microfossil Records from the Oceans and Epicontinental Seas*"

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Preface

Welcome to Kraków! On behalf of the Organizing committees of the MIKRO-2011 and Annual TMS Foram-Nannofossil group meetings, we wish to welcome everyone to the historical capital of Poland. We hope that this event will serve to bring the Grzybowski Foundation and the Micropalaeontological Society closer together by fostering the sharing of ideas and collaboration in the subject of Micropalaeontology.

The Field of Micropalaeontology has a long tradition in Kraków – as early as 1905 Józef Grzybowski taught a course called "Mikropaleontologia" at the Jagiellonian University. As far as we are aware, this course commenced only two years after the word "Micropaleontology" first appeared in the title of a research article. Grzybowski trained a number of students at the Jagiellonian who continued research in the field, notably Franciszek Bieda who established the subject at the AGH University of Science & Technology, and Maria Dylążanka, who was probably the first woman scientist who graduated with a Ph.D. in the subject.

In Kraków, research & training in the subject of Micropaleontology is currently undertaken at several universities and institutions: The Jagiellonian University, the AGH University of Science & Technology, The Pedagogical University, the Academy of Sciences, and the Polish Geological Institute. All these efforts are logistically supported by the Grzybowski Foundation Library, which is located at the Geology Museum of the Jagiellonian University. The Grzybowski Library is open to the public, and is well worth a visit.

With all the various scientific and social activities planned during this year's meeting, we are certain that there will be lots of opportunities to network and to share ideas. The Field Excursion to the Silesian and Magura units in the Myślenice – Sucha Beskidzka – Zawoja areas will provide such an occasion. We are also looking forward to viewing the deep-water sediments that contain the flysch-type agglutinated foraminifera first described by Grzybowski and his students. Other activities are also planned as "satellite" events: On Friday after the MIKRO/TMS meeting the "International Committee on Foraminiferal Classification" will hold its annual discussion meeting. Short courses will be taught by Drs. Øvind Hammer and Eric Anthonissen will also take place during the meeting. Aside from the Micropaleontological events, we recommend visiting the Main Square, the old Jewish district of Kazimierz, and of course no visit to Kraków is complete without a visit to the Wawel Castle.

We take this opportunity to thank the organizors of the meeting: the Board members of the Grzybowski Foundation and the Micropalaeontological Society; as well as our sponsors. Many people worked together to make this meeting possible, and this was in many ways a very pleasant task. All the members of the Organizing Committee rallied their creative energy to make this meeting possible. We want to thank Celka Microslides for sponsoring refreshments, the AGH University of Science & Technology for letting us use their facilities; the Jagiellonian University Geology Museum for providing access to the Museum and the Grzybowski Foundation Library, and to our Secretaries who took care of registration and collected the abstracts for this volume. Many people too numerous to mention here (you know who your are…) helped with different aspects of the meeting – we wish to say a big collective "Thanks!" Let the meeting begin! We wish you a pleasant stay!

On behalf of the Grzybowski Foundation,

Organizing Committee:
Anna Waśkowska, Marta Bąk and Mike Kaminski

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Part 1. Scientific Contributions

Józef Grzybowski: the Scientist, Man, and the beginning of the Polish School of Applied Micropalaeontology

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Józef Grzybowski (1869-1922) was born in Kraków, where he studied at the Faculty of Law of the Jagiellonian University. One year before he was awarded his degree in Law, he undertook a job as a demonstrator and later, as an assistant at one of the oldest geological Faculties in Europe, established in 1886 when Prof. Władysław Szajnocha became the first chair of the Department of Geology at the Jagiellonian University.

Independently of obtaining his Masters diploma in Law, Józef Grzybowski also studied geology under the supervision of Prof. Szajnocha, and in 1894 had been awarded his second degree – an M.Sc. in Geology. During the same year, he published his first scientific article „The Microfauna of the Carpathian Sandstones from the environs of Dukla". Later on, his Ph.D. Thesis was dedicated to microfauna of the Carpathians – "Foraminifera of the Red Clays from Wadowice" and he achieved his Ph.D. degree in 1896 (his main advisor was W. Szajnocha, and the examiner was Prof. Kreutz). It was the first Ph.D. degree awarded in the micropaleontology of foraminiferids, and 13 years earlier than Joseph Cushman's Ph.D degree at Harvard University (in 1909). Grzybowski's role as a micropalaeontologist in compiling the famous historical Geological Atlas of Galicia was highly appreciated. During these years, together with W. Szajnocha, J. Grzybowski attended the Geological Congress in Russia (1897) and in 1898 he visited Munich and studied under Prof. Karl Zittel. Later on, he commenced his work in Peru, and summarised the results of his studies in monograph „Die Tertiarablagerungen des nordlischen Peru". On the basis of this monograph in 1900 J. Grzybowski was awarded his Habilitation degree (more or less equivalent of a D.Sc.) and became Associate Professor and in 1919 the Polish Head of State Józef Piłsudski nominated Grzybowski to the post of Full Professor.

Józef Grzybowski became an assistant at the Department of Geology, he started his teaching in micropaleontology. It was the first dedicated course of micropalaeontology in the World (started in 1895). Since Grzybowski's cooperation with Dr Henryk Walter-first director of the oil industry in Borysław, his main topic had focused on foraminiferids from wells drilled for the oil industry. His paper „Microscopical investigations of borehole muds of oil Fields. I. The Potok – Krosno Belt" (1897) introduced for the first time the application of agglutinated foraminiferids as correlation tools for flysch-type sediments. It should be underlined that such deposits are almost barren of other fossils, therefore, agglutinated deep-water foraminiferids were used for the first time as biostratigraphic markers. Especially, the deep-water sediments of the Polish Flysch Carpathians contain only very rare macrofauna and no calcareous microfossils due to their depositional environment below the CCD. Unfortunately, his papers were published only in Polish language in local periodicals (mainly as results summaries in the Bulletin of the Polish Academy of Knowledge in Kraków) and therefore were not distributed or known among the

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international community of micropaleontologists/stratigraphers.

His main achievement related to the practical aspects of micropalaentology of foraminiferids. Working as an expert for the oil industry in Borysław (which was the most important hydrocarbon productivity region of Galicia at that time in the Carpathians), with assistance and cooperation of Dr Henryk Walter (Councellor for Mining Affairs) he collected very unique collection of foraminiferids, typical for the deposits of the deep water turbiditic sequences of the Alpine type of sediments. It should also be mentioned that Grzybowski in his papers established the palaeobathymetric affiliation of the certain species of agglutinated foraminiferids. His conclusions have had great importance and influence on future interpretation of palaeoenvironments of deposition of the deep-water turbiditic sequences.

Józef Grzybowski's role in biostratigraphy of the deep-water, turbiditic sequences of the Alpine type basins was definitely pioneering. Later, when his work became known internationally, and especially since the Fourth International Workshop on Agglutianted Foraminifera in Kraków, 1993, his name has been included in the professional geological literature and his methods were adopted and used in the biostratigraphical studies, especially in the DSDP/ODP Project. Grzybowski's pupils (F. Bieda, M. Dylążanka, S. Geroch, and also their students) continued his pioneering work on flysch-type agglutinated foraminiferids of „Polish school of applied micropalaeontology". The scientific, educational and citizen's contributions of Józef Grzybowski was highly appreciated not only amongst fellow specialists, but also by the Jagiellonian University and the Kraków community.

In memory of his role in micropalaeontology and to continue his studies, in 1992 Mike Kaminski and M. Adam Gasinski established The Grzybowski Foundation. This international scientific foundation promotes education, research and further advancement in the field of Micropalaeontology.

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Evolution of the Outer Carpathian Basins

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ABSTRACT

The Outer Carpathians are built up of a stack of nappes and thrust-sheets showing different lithostratigraphy and tectonic structures. From the south to north these are: the Magura Nappe, Fore-Magura Group of nappes, the Dukla, Silesian, Subsilesian, and Skole nappes. The following geodynamic evolution stages can be distinguished in the Outer Carpathians: I – synrift and postrift, Middle Jurassic – Early Cretaceous; formation of passive margin and basin with attenuated crust, IIa – early collisional, Late Cretaceous–Paleocene; development of subduction zones and partial closing of the oceanic basin, development of the flysch basin, IIb – late collisional, Eocene; development of an accretionary prism closing of the oceanic basin, further development of the flysch basin, III – orogenic, Oligocene – Early Miocene; formation of nappes and foredeep, IV – postcollisional, Neogene.

Key words: paleogeography, plate tectonics, lithostratigraphy, Carpathians, Mesozoic, Cenozoic

INTRODUCTION

The Polish Outer Carpathians form the northern part of the Carpathians (Figs 1–2). The Carpathian overthrust forms the northern boundary, while the southern runs along the Poland-Slovakia state border. The Outer Carpathians are built up of a stack of nappes and thrust-sheets showing varied lithostratigraphy and tectonic structures (Książkiewicz, 1977; Ślączka *et al*., 2006; Golonka *et al*., 2011). The Outer Carpathians nappes are thrust over each other and over the North European Platform and its Miocene-Paleocene cover (Fig. 3).

During the late Oligocene and Miocene orogenesis, several nappes corresponding to the lithostratigraphic units were formed with prevalent northern direction of thrusting (Figs 2, 3). In the Western Carpathians from the south to north these are: the Magura Nappe, the Fore-Magura Group of nappes, the Dukla, Silesian, Subsilesian, and Skole nappes (Książkiewicz, 1977; Ślączka *et al*., 2006; Golonka *et al*., 2011).

The systematic arrangement of the lithostratigraphic units according to their occurrence within the original basins and other sedimentary areas are given in Tables 1-4). The following geodynamic evolution stages can be distinguished in the Outer Carpathians: I – synrift and postrift, formation of a passive margin and basin with attenuated crust, IIa – early collisional, development of subduction zones and partial closing of the oceanic basin, development of the flysch basin, IIb – late collisional, development of an accretionary prism and closing of the oceanic basin, further development of the flysch basin,

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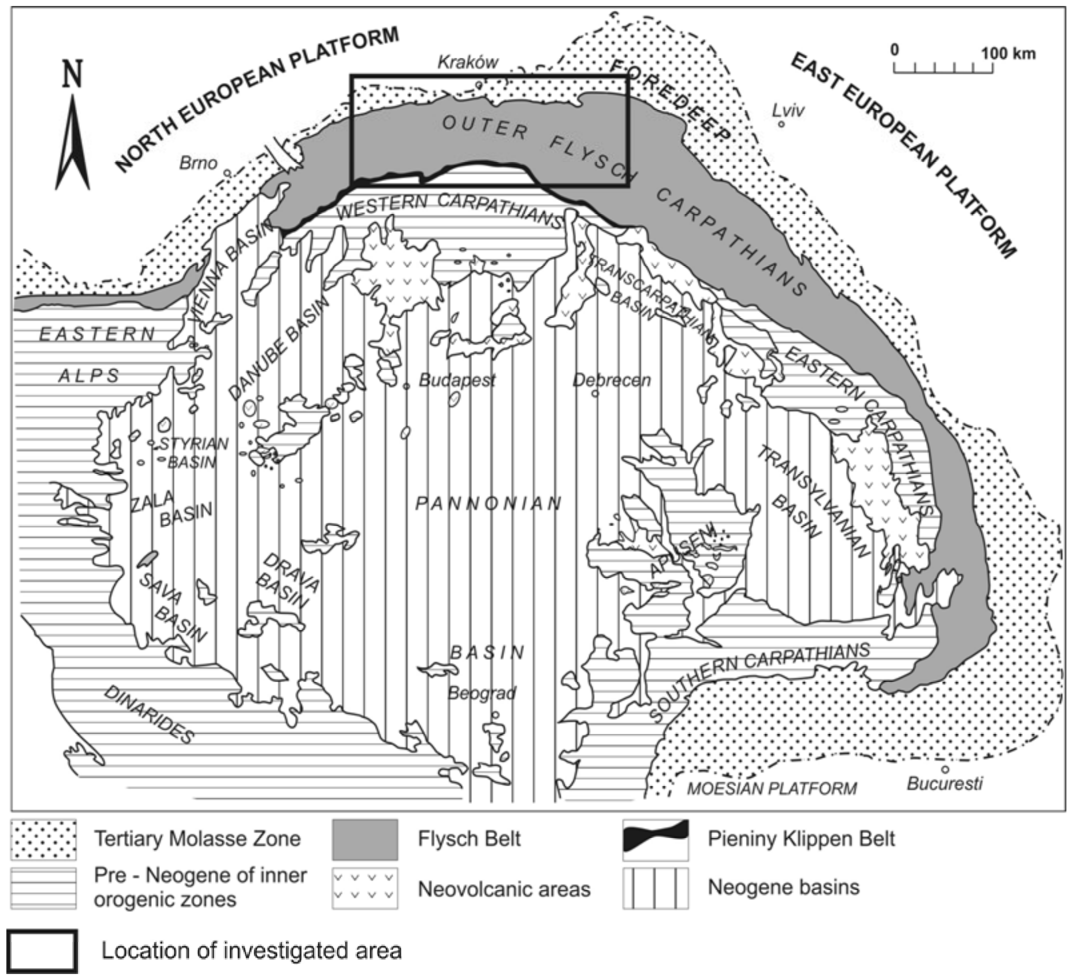


Figure 1. Map of the Carpathians with the location of the investigated area; modified from Kováč *et al.* (1998)

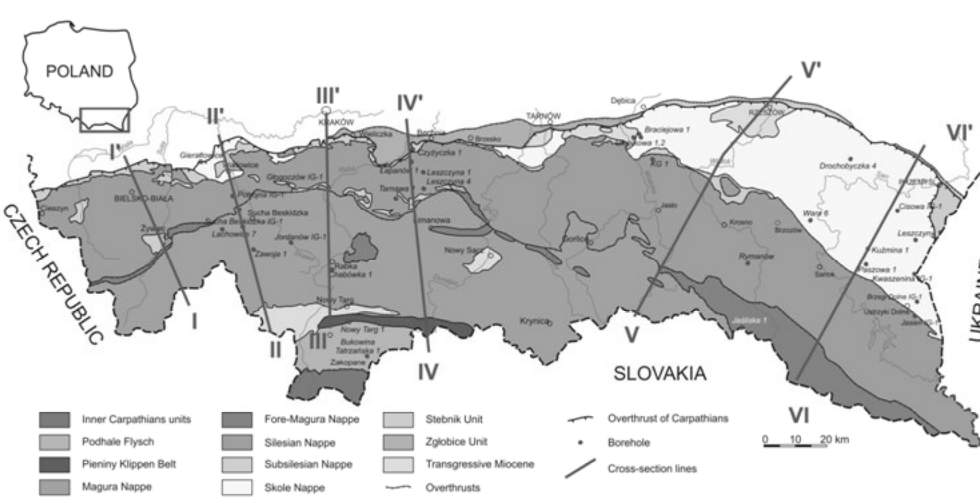


Figure 2. Map of the Polish Outer Carpathians with the location of cross-sections; modified from Żytko *et al.* (1989); Golonka *et al.* (2011).

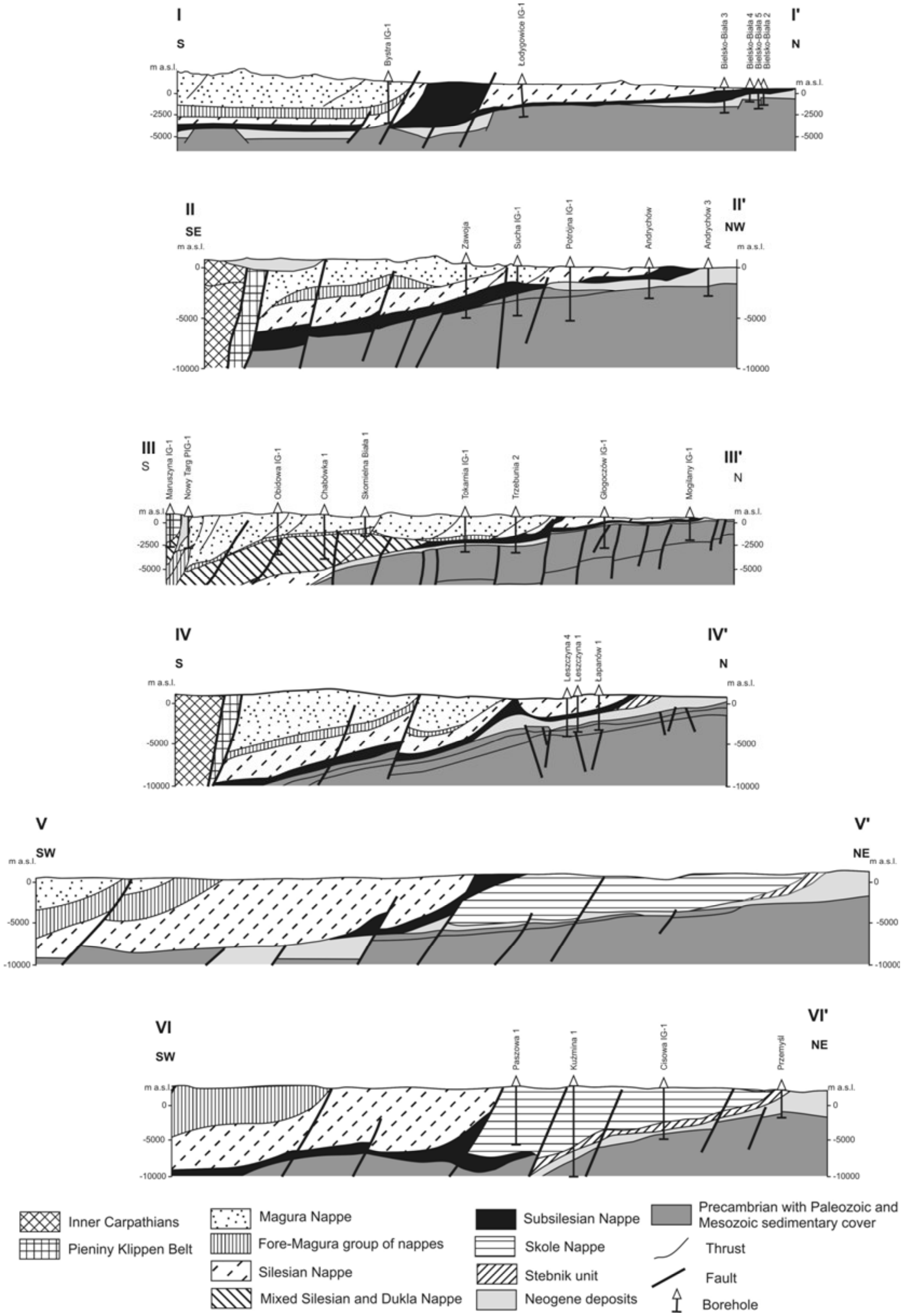


Figure 3. Cross-sections through the Outer Carpathians and their foreland; modified from Golonka *et al.* (2011). Cross-section locations on Fig. 2

III – orogenic, perhaps terrane – continental collision with the accompanying convergence of two large continents, IV – postcollisional. These stages correspond with the global sequence stratigraphy, two to five supersequences encompassing one stage (Golonka & Kiessling, 2002; Golonka *et al.*, 2008a).

METHODS

The assessment of the evolution of the Outer Carpathian basins was based on paleogeographic mapping, evaluation of existing published and archive data, plate tectonic analysis, and correlation of lithostratigraphic units with the global sequence stratigraphy scheme. The time interval maps were constructed according to the following four steps: (1) Construction of base maps using a plate tectonic model. These maps depict plate boundaries (sutures), passive margins, transforms, ridges, plate positions at specific times and the outlines of present-day coastlines. (2) Review of existing global and regional paleogeographic maps. (3) Posting of generalized facies and paleoenvironment database information on base maps. (4) Interpretation and final assembly of computer map files.

The plate tectonic model used (PLATES and PALEOMAP software) incorporates the relative motions between approximately 300 global and about 20 Circum–Carpathian plates and terranes (Golonka *et al.*, 2006). Information from several general and regional paleogeographic papers was assessed and utilized. The calculated paleolatitudes and paleolongitudes were used to generate computer maps in the Microstation design format using the equal area Molweide projection.

The arrangement of the lithostratigraphic units is related to their paleogeographic position within the original basins. It is partially based on previously published papers (Cieszkowski *et al.*, 2006, 2007; Golonka *et al.*, 2008a; Waśkowska *et al.*, 2009).

Stage I – synrift and postrift (Middle Jurassic–Early Cretaceous)

The sedimentation of the Outer Carpathian allochthonous rocks started during the Jurassic (Ślączka *et al.*, 2006). The oldest time interval comprises the Jurassic and Early Cretaceous (Table I). The rocks representing this time interval belong to Lower Zuni I, lower Zuni II, Lower Zuni III, Upper Zuni I and Upper Zuni II from the sequence stratigraphy point of view (Golonka & Kiessling, 2002; Golonka *et al.*, 2008a). The Alpine Tethys (Fig. 4), which constitutes important paleogeographic elements of the future Outer Carpathians, developed as an oceanic basin during the Jurassic as a result of the break-up of Pangea (Golonka *et al.*, 2000, 2006, 2008b). The Magura Basin constitutes the northwestern part of Alpine Tethys separated by the Czorsztyn Ridge from the Pieniny Klippen Belt Basin (Fig. 4). To the north and northeast it is limited by the North European Platform and the Silesian Ridge (Golonka *et al.*, 2008b). The ridge separated the Magura Basin and the Protosilesian Basin (Fig. 4), and is known only from exotic rocks and olistoliths occurring within the various allochthonous units of the Outer Carpathians. Shallow-water marine sedimentation prevailed on the Silesian Ridge during the late Jurassic and earliest Cretaceous. The southern part of the North European Platform, adjacent to the Alpine Tethys is known as the Peritethys. Uplifted and basinal zones were distinguished within the platform. The Baška-Inwałd Ridge and Pavlov Carbonate Platform belong to the uplifted elements, while the Bachowice and Mikulov basins represent the basinal zones (Golonka *et al.*, 2008b). The carbonate material was transported from the uplifted zones of North European Platform and Silesian Ridge toward the basins.

The sedimentary rocks of the Magura Basin include the Sokolica, Czajakowa , Czorsztyn, Pieniny, and Kapuśnica formations. These formations are represented by radiolarites and pelagic and deep-water limestones (Birkenmajer, 1977).

The Proto-Silesian Basin developed within the North European Platform as a rift and/or back-arc basin during late Jurassic times. Its basement is represented by the attenuated crust of the North European plate with perhaps incipient oceanic fragments. The upper Jurassic–lower Cretaceous rocks

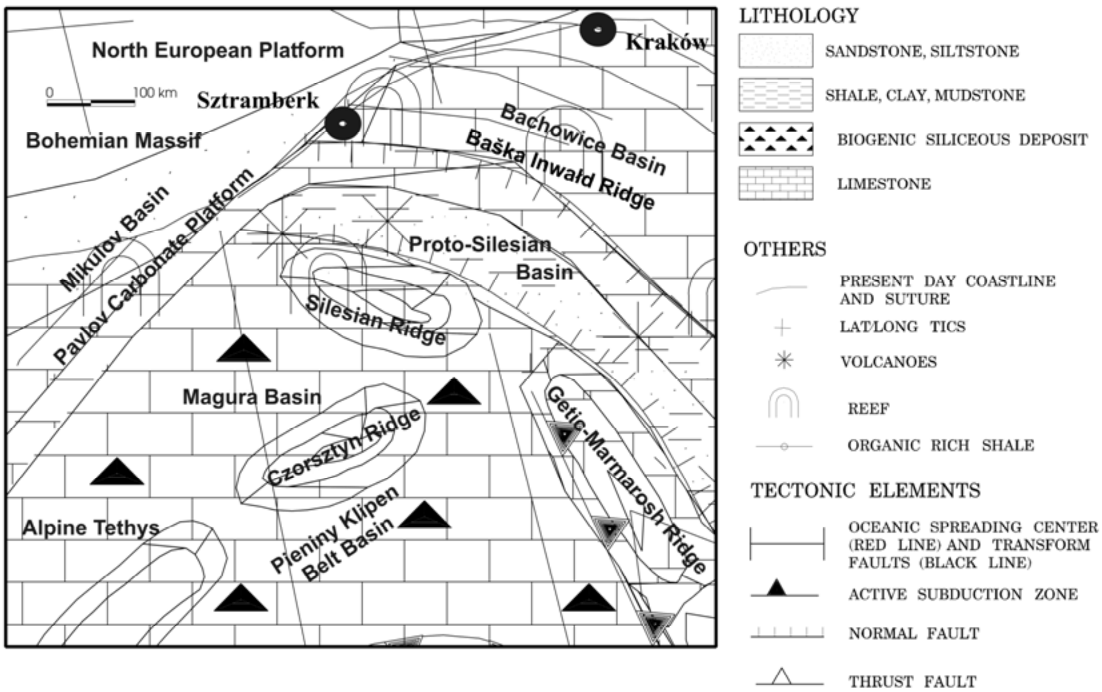


Figure 4. Paleolithofacies with main paleogeographical elements of the West Carpathians and adjacent areas during the latest Jurassic – early Cretaceous (modified from Golonka *et al*., 2008b, 2011). Plate position at 140 Ma.

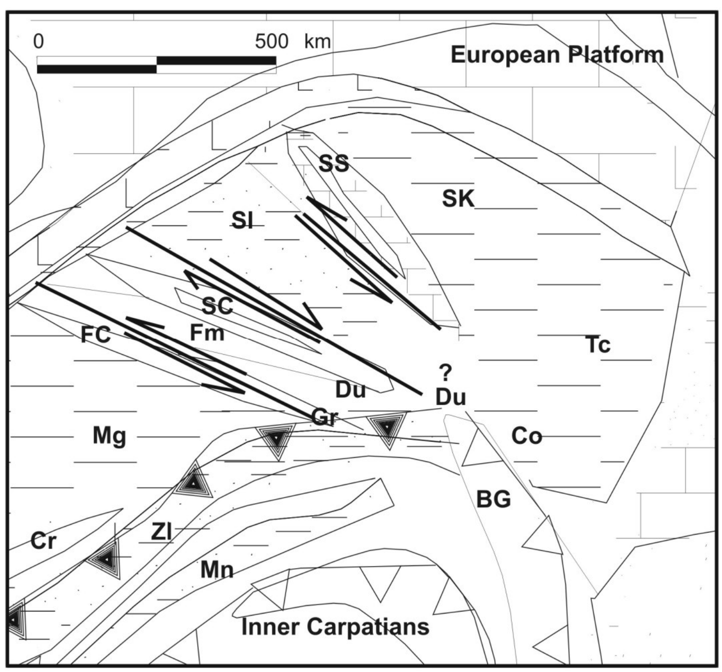


Figure 5. Paleogeography of the Outer Carpathian basins during the Late Cretaceous–Paleocene (after Golonka *et al*., 2011). Explanations as in Fig. 4. Abbreviations: BG – Bucovinian-Getic, Co – Cornohora, Porkulec, Audia, Teleajen, Cr – Czorsztyn ridge, Du – Dukla, FC – Fore-Magura ridge (cordillera), Fm – Fore-Magura basin, Gr – Grybów, Mg – Magura, Mn – Manin, Si – Silesian basin, SK – Skole, SC – Silesian ridge (cordillera), SS – Sub-Silesian ridge, Tc – Tarcau, Zl – Złatna

formed in this basin, belong recently to various tectonic units in Poland, the Czech Republic, the Ukraine, and Romania. In Poland they belong mainly to the Silesian, Subsilesian, and Skole nappes (Table 1). The basin deposition was controlled by synrift subsidence and later (Barremian–Albian) by post-rift thermal subsidence, which culminated with the Albian expansion of deep-water facies (Ślączka *et al*., 2006). The sedimentary rocks of the Silesian and Subsilesian zones include the Vendřyne, Cieszyn, Hradište (subdivided into the Cisownica and Piechówka Members), Verovice and Lhoty Formations (Golonka *et al*., 2008a). The Spas Formation with Bełwin and Kuźmina members represents the Skole zone (Waśkowska *et al*., 2009).

Table 1. Jurassic-Lower Cretaceous lithostratigraphy of the Outer Carpathian basins in Poland

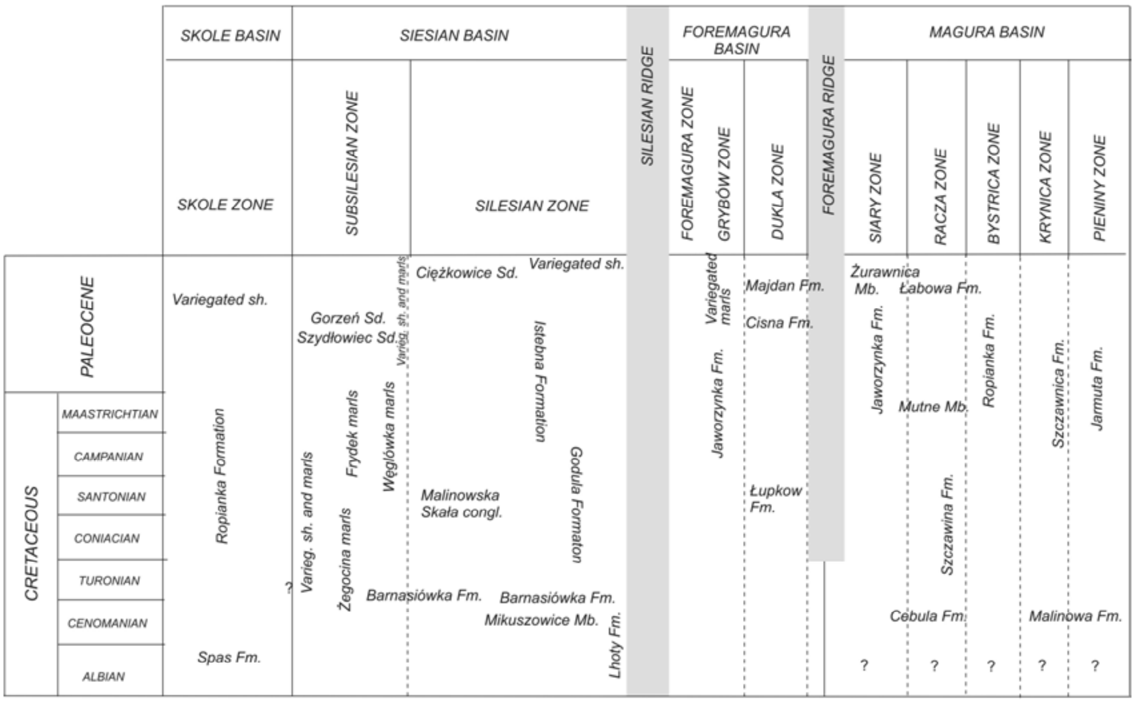
		PROTOSILESIAN BASIN (SEVERIN-MOLDAVIDIC)			MAGURA BASIN
		SKOLE ZONE	SILESIAN AND SUBSILESIAN ZONES		
Cretaceous	Albian	Spas Fm. – Kuźmina Mb.	Lhoty Fm.	SILESIAN RIDGE	Kapuśnica Fm.
	Aptian	Spas Fm.	Veřovice Fm.		
	Barremian	Spas Fm. – Bełwin Mb.	Hradiśte Fm. – Piechówka Mb.		
	Hauterivian				Pieniny Lst. Fm.
	Valanginian	?	Hradiśte Fm. – Cisownica Mb.		
	Berriasian		Cieszyn Limestone Fm.		
Jurassic	Tithonian		Vendryné Fm.		
	Kimmeridgian		?		Czorsztyn Lst. Fm.
	Oxfordian				Czajakowa Rad.Fm.
	Callovian				Sokolica Rad. Fm.
	Bathonian				

Stage IIa – early collisional (Cretaceous–Paleocene)

The Cretaceous-Paleocene collisional stage is characterized by the formation of subduction zones along the active margin, the partial closing of the oceanic basin and the development of main flysch basins. The rocks representing this time interval belong to the Upper Zuni III and Upper Zuni IV from the sequence stratigraphy point of view (Golonka & Kiessling, 2002; Cieszkowski *et al*., 2006). Compression embraced the Inner Carpathians and subduction consumed the major part of the Pieniny Klippen Belt Basin (Fig. 5). The accretionary prism had overridden the Czorsztyn Ridge. The subduction zone moved from the southern margin of the Pieniny Klippen Belt Ocean to the northern margin of the Czorsztyn Ridge (Golonka *et al*., 2000, 2006). The development of the new accretionary prism in the Magura Basin was related to the origin of the trench connected with this subduction zone. The submarine slumps and olistoliths along the southern margin of the Magura Basin were related to the uplift of this margin (Cieszkowski *et al*., 2009). New ridges were uplifted as an effect of the orogenic process. These ridges distinctly separated several subbasins, namely the Magura, Dukla-Foremagura, Silesian, and Skole (Figs 5-6). An enormous amount of clastic material was transported by various turbidity currents from uplifted areas, filling the Outer Carpathian basins. Each basin had specific types of clastic deposits, and sedimentation commenced at different times (Ślączka & Kaminski, 1998; Golonka *et al*., 2006, Ślączka *et al*., 2006).

The sedimentary rocks of the Magura Basin (Birkenmajer, 1977; Oszczypko, 1991; Oszczypko *et al.*, 2005; Cieszkowski *et al.*, 2005, 2006) includes the Malinowa, Cebula, Szczawina, Jarmuta, Ropianka, Jaworzynka and Łabowa formations (Table 2). The Foremagura Basin was formed during this time. It includes the Dukla, Foremagura, and Grybów zones. The Łupków, Cisna, Majdan, and Jaworzynka formations belong to this basin. The Silesian Basin included the Silesian zone with the Lhoty,

Table 2. Upper Cretaceous–Paleocene lithostratigraphy of the Outer Carpathian basins in Poland



Barnasiówka, Godula, and Istebna formations, the Ciężkowice sandstones and variegated shales. The Żegocina marls, Węglówka marls, Variegated Shale, Frydek marls, Gorzeń and Szydłowiecc sandstones belong to the Subsilesian zone. The Ropianka Formation and Variegated Shales represent the deposits of the Skole Zone (Bąk *et al.*, 2001; Cieszkowski *et al.*, 2006; Ślączka *et al.*, 2006).

Stage IIb – late collisional (Eocene)

The Inner Carpathians (Alcapa) terrane continued its northward or NE movement during the Eocene, leading to the development of the accretionary prism of the Outer Carpathians (Golonka *et al.*, 2000, 2006) (Fig. 7). Numerous olistostromes were formed during this time (Cieszkowski *et al.*, 2009). The rocks representing this time interval belong to the Lower Tejas I and Lower Tejas II from the sequence stratigraphy point of view (Golonka & Kiessling, 2002; Cieszkowski *et al.*, 2006).

The development of the accretionary prism caused distinctive differences between the sedimentary zones. The Siary, Rača, Bystrzyca, and Krynica zones acquired their distinguished sedimentological features within the Magura Basin. Sedimentation of thick bedded, coarse-grained turbidites (the Magura Formation) formed several submarine fans. In more distal parts, medium- and thin- bedded sandstones and shales developed, passing farther towards the north into variegated shales. These lithofacies migrated in time across the Magura Basin towards the north. The Eocene time interval (Table 3) includes the Łabowa, Beloveza, Łącko, Magura, and Beskid Makowski formations within the Magura Basin (Oszczypko, 1991; Oszczypko *et al.*, 2005; Cieszkowski *et al.*, 2005, 2006).

In more external basins (Dukla, Silesian, Skole and Subsilesian sedimentary area green and gray shales with thin- and medium-bedded sandstones with intercalations of red shales prevailed during

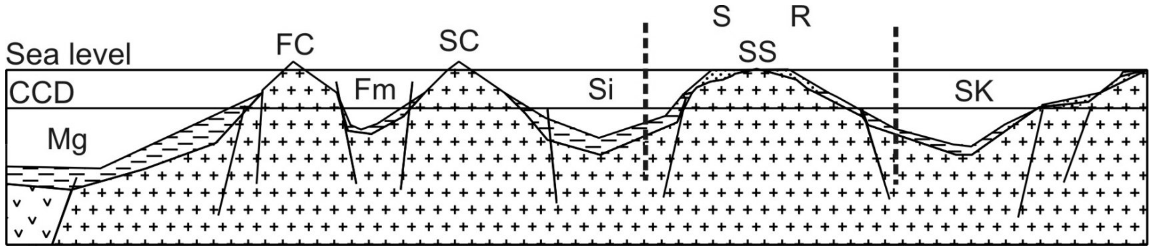


Figure 6. Palinspastic cross-section showing the Outer Carpathian basins during Paleocene (after Waśkowska *et al.*, 2009; Golonka *et al.*, 2011). Abbreviations: FC – Fore-Magura Ridge, Fm – Fore-Magura Basin, Mg – Magura Basin, Si – Silesian Basin, SK – Skole Basin, SC – Silesian Ridge, SS – Sub-Silesian Ridge, SR – Subsilesian sedimentary area

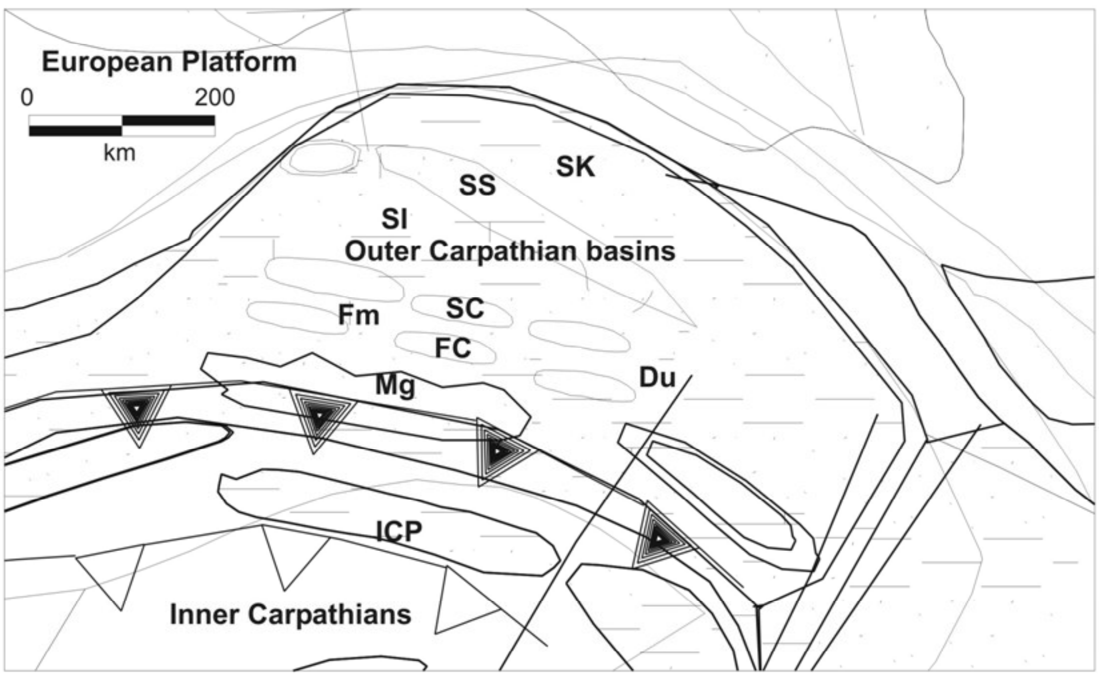


Figure 7. Paleogeography of the Outer Carpathian basins during Eocene (after Golonka *et al.*, 2006). Explanations as in Fig. 4. Abbreviations: Du – Dukla, FC – Fore-Magura ridge (cordillera), Fm – Fore-Magura basin, ICP – Inner Carpathian Paleogene, Mg – Magura, Si – Silesian basin, SK – Skole, SC – Silesian ridge (cordillera), SS – Sub-Silesian ridge

Early Eocene. The sedimentation of thick-bedded turbidites continued during the Early Eocene, in Silesian Basin only. Small turbiditic fans developed only locally. This type of sedimentation gave way during the late Eocene to green shales and yellowish *Globigerina* marls marking a period of unification of sedimentation (Golonka *et al.*, 2006; Ślączka *et al.*, 2006).

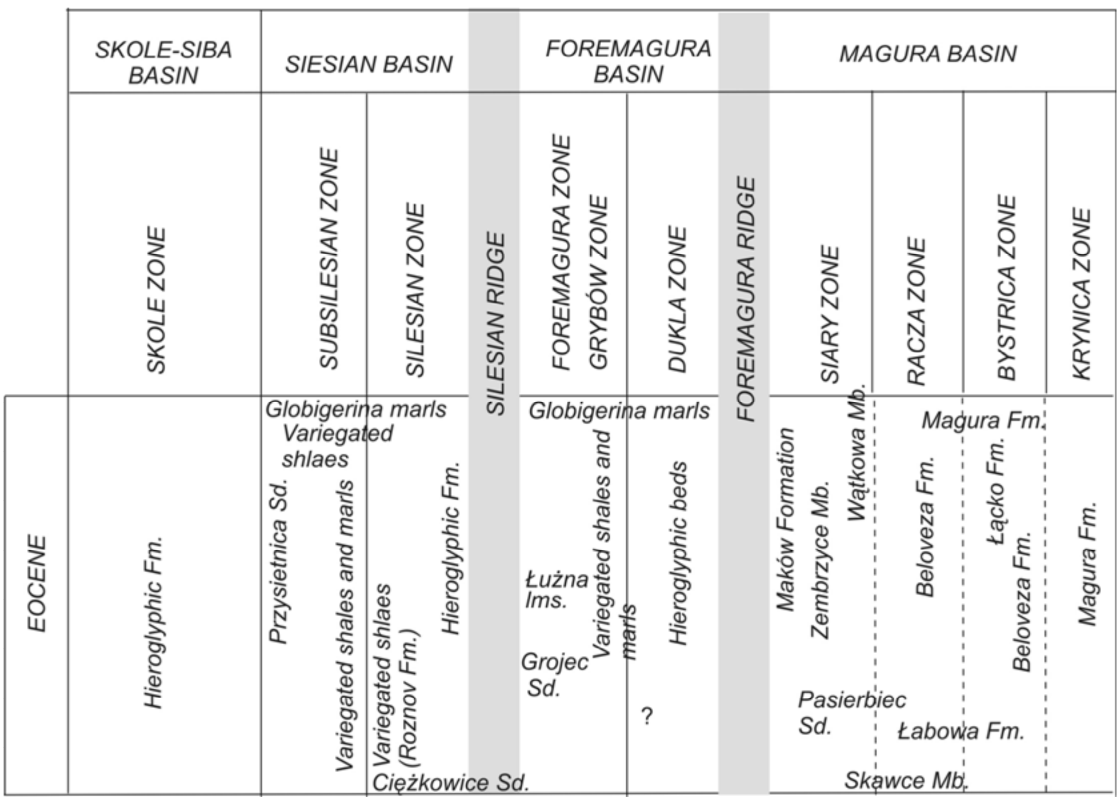
The Foremagura Basin is represented by Variegated Shales, Hieroglyphic Beds, as well as by the Łużna limestones and Grójec sandstones. The Silesian Basin includes the Hieroglyphic Formation, Variegated Shales, Przysietnica sandstones, and Globigerina Marls. The Skole-Skyba Basin contained the Hieroglyphic Formation, Variegated Shales and Globigerina Marls (Tab. 3).

Within the more outer parts of the Carpathians realm, from the Dukla to Skole basins evidence of migration of the depocenter appeared at the Eocene/Oligocene boundary (Golonka *et al*., 2006; Ślączka *et al.,* 2006) as an effect of compressional movements. As a consequence of these movements, the bottom of the basins started to deform and initial anticlines locally developed, slumps and coarse grained sediments were locally deposited, and volcanic activity increased. A deep-marine connection with Tethys Sea was closed and euxinic conditions developed (Ślączka, 1969; Ślączka & Kaminski, 1998).

Stage III – orogenic (Oligocene–Early Miocene)

The Oligocene sequences commenced with dark brown bituminous shales and cherts with locally developed sandstone submarine fans or a system of fans up to several kilometers long. The upper boundary of the bituminous shales is progressively younger towards the north, and shales pass gradually upwards into a sequence of micaceous, calcareous sandstones and grey marls that thin

Table 3. Eocene lithostratigraphy of the Outer Carpathian basins in Poland



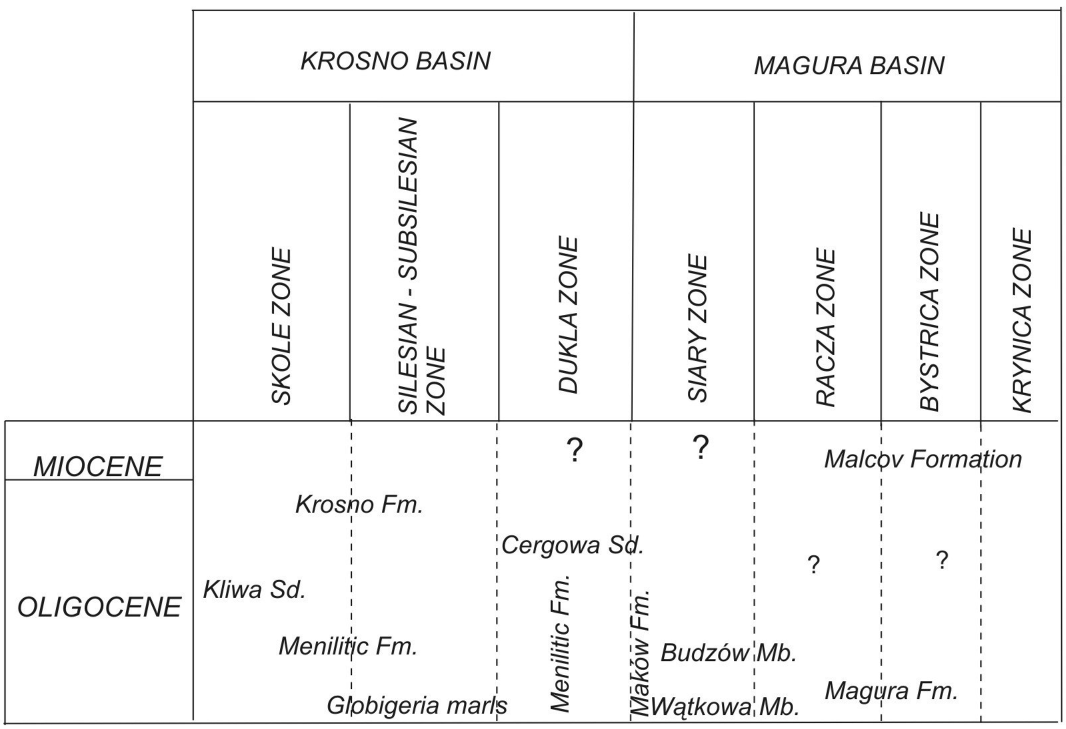
upward. The lower part of the sequence is generally represented by a complex of thick-bedded sandstones that pass upwards into a series of medium- to thin-bedded sandstones and grey marls that terminated sedimentation of the whole flysch sequence in the Outer Carpathians, and can be considered as post-flysch deposits. The boundaries between these lithofacies are diachronous across the basins, older in the south and younger in the north. Also the cessation of deposition is diachronous across the Carpathians due to migration of tectonic activity and formation of trailing imbricate folds and/or accretionary prisms generally from the south to the north. With the final phase of tectonic movement, in front of advancing nappes and/or accretional wedges (prisms), huge (up to kilometers in size) slumps (olistostromes) developed with material derived from approaching nappes (Golonka *et al*., 2006; Ślączka, 1969; Cieszkowski *et al*., 2009). During the overthrusting movements, the marginal part of the advancing nappes was uplifted, whereas in the inner part sedimentation persisted in the remnant basin (Golonka *et al.*, 2006, Ślączka *et al.*, 2006, Cieszkowski *et al.*, 2009).

The rocks representing this time interval belong to the Lower Tejas III and Upper Tejas I from the sequence stratigraphy point of view (Golonka & Kiessling, 2002, Cieszkowski *et al.*, 2006). Two basins were present during these times: the Magura and Krosno. The Magura Basin included the Magura, Beskid Makowski, and Malcov formations (Tab. IV). The Menilite and Krosno formations prevailed within the Krosno Basin. In addition, the Cergova and Kliwa sandstones were present (Oszczypko, 1991; Oszczypko *et al.*, 2005; Cieszkowski *et al.*, 2005, 2006; Ślączka *et al.*, 2006).

Stage IV-postcollisional (Neogene)

Tectonic movements caused the final folding, and the Carpathian nappes became uprooted from the basement. The allochtonous were trust over the North European platform for a distance of 50 km to more than 100 km. Overthrusting movements migrated along the Carpathians from the west towards the east. In front of the advancing Carpathians nappes the inner part of the platform, in the eastern part

Table 4. Oligocene–Lower Miocene lithostratigraphy of the Outer Carpathian basins in Poland



also with the marginal part of the flysch basin started to downwarp and a tectonic depression formed during the Early Miocene. Thick molasse deposits filled up this depression. At the end of the Burdigalian that basin became overthrusted by the Carpathians, and a new, more external basin, developed. Clastic and fine-grained sedimentation of the Carpathian and foreland provenance prevailed with a break during the late Langhian to early Serravalian, when the younger evaporate basin developed. Locally olistostromes were deposited with material derived from the Carpathians and the inner margin of the molasse basin. During Langhian and Serravallian, part of the northern Carpathians collapsed and the sea invaded the already eroded Carpathians. The foreland basin and its depocenter migrated outwardly and eastward, contemporary with the advancing Carpathian nappes. As a result, the Neogene deposits show diachrony in the foreland area. In the west sedimentation terminated already in the Langhian and in the east lasted until the Pliocene. These events mark the postcollisional stage in the Outer Carpathian (Golonka *et al*., 2006; Oszczypko *et al*., 2006; Ślączka *et al*., 2006). The rocks representing this time interval belong to the Upper Tejas II and Upper Tejas IV (Golonka & Kiessling, 2002).

CONCLUSIONS

- The first stage of the Outer Carpathian Basin evolution is related to the disassembly of Supercontinent Pangea during Jurassic to Early Cretacaeous times. It is expressed by the opening of the Alpine Tethys linked with the opening of the Atlantic Ocean.
- The opening of the Protosilesian Basin followed the opening of the Alpine Tethys.
- The Inner Carpathian Alcapa movement toward the North European plate led to the development of the accretionary wedge and partial closing of the Outer Carpathian basins.
- The collisional stages were marked by the development of thick flysch sequences with olistostromes.
- The formation of the West Carpathian thrusts was completed by the Miocene. The thrust front was still propagating eastwards in the Eastern Carpathians, marking the postcollisional stage in the Outer Carpathians.

ACKNOWLEDGEMENTS
The author is greatly indebted to Mike Kaminski (KFUPM) & Michał Krobicki (AGH), for their comments.

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Palaeoenvironmental signal from the microfossils record in the Mikuszowice Cherts of the Silesian Nappe, Polish Outer Carpathians

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ABSTRACT

The Mikuszowice Cherts are thick-bedded, fine-grained turbidities consisting of detrital material mixed with biogenic particles which are predominantly siliceous spicules of lithistids. These deposits formed in the Silesian basin (Outer Carpathians) during the middle to late Cenomanian. It is possible that sponge spicules are the relic of mud-mounds formed by sponges and accompanied by other benthic organisms like crinoids, calcareous benthic foraminifers, and encrusting coralline algae. Iron-fixing bacteria occurring within the microfossil communities are the remnants of microbial activity, important for mud-mound formation. Sponge communities were situated on the middle to outer shelf in the marginal part of the North European Platform. Disintegrated material from the mounds was redeposited into the deep basin, as confirmed by the occurrence of hemipelagic, non-calcareous clays within the Mikuszowice Cherts, including radiolarians and deep-water agglutinated foraminifers.

The delivery of siliceous and calcareous bioclasts from a shallower part of the basin, was controlled by two groups of factors: (1) environmental parameters such as nutrient availability, water temperature, and salinity, which enabled the growth of benthic and planktonic communities, and (2) a hydrodynamic regime activating the transport of biogenic particles onto the basin floor.

Key words: Spiculite, sponges, turbidite, Outer Carpathians, Cenomanian

INTRODUCTION

The Cenomanian was a period of accumulation of spicule-bearing deposits in the Outer Carpathian basin of the Western Tethyan domain, that extended along the southern edge of the North European Platform. Locally, spicules from sponge buildups were redeposited into deep-water environments due to gravitational flows. These spicules could be one of the main components of turbidites in such regions, forming the gaize and chert layers. The middle–upper Cenomanian deposits in the Silesian and Subsilesian nappes of the Outer Carpathians, named the Mikuszowice Chert (MCh), is an example of such a facies. The siliceous sponge spicules with calcareous benthic foraminifers, radiolarians, and siliciclastic material created a series of fine-grained turbidities intercalated with deep-water, hemipelagic, non-calcareous clays.

In: Bąk, M., Kaminski, M.A. & Waśkowska, A. (eds), 2011. Integrating Microfossil Records from the Oceans and Epicontinental Seas. *Grzybowski Foundation Special Publication*, **17**, pp. 15–25.

In this paper, we present the analysis of microfossils from the MCh in the context of their palaeonvironmental interpretation of the Silesian Basin during the middle–late Cenomanian.

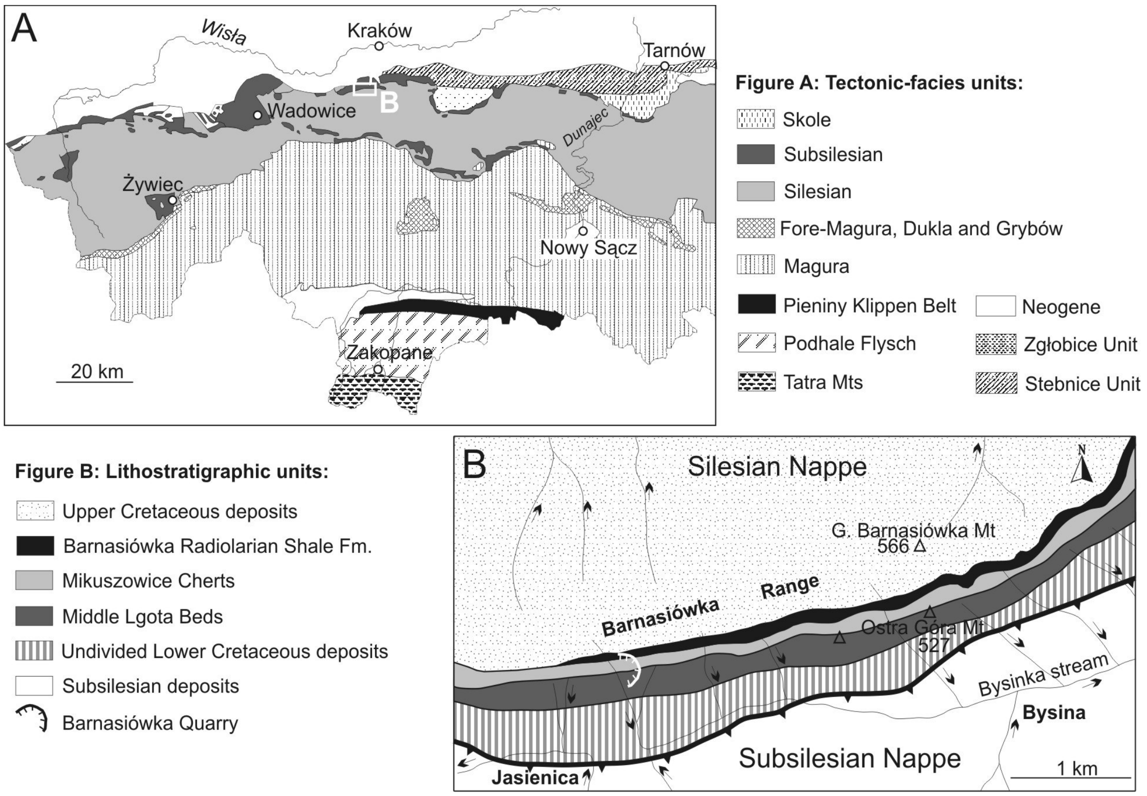

Figure 1. A – Location of the studied section on the sketch tectono-facies map of the Outer Carpathians. **B** – Detailed geological map of the studied area including the Barnasiówka-Jasienica quarry (map after Burtan, 1964, and Burtan and Szymakowska, 1964; simplified)

GEOLOGICAL SETTING AND LITHOSTRATIGRAPHY

The spicule-rich facies (Mikuszowice Cherts) lies in the central part of the Silesian Nappe of the Polish Outer Carpathians, within the Lanckorona – Żegocina tectonic zone (Fig. 1), built of Cretaceous deposits (Książkiewicz, 1962; Książkiewicz & Liszkowa, 1978). The MCh belong to the uppermost part of the Lgota Beds (middle–upper Cenomanian, Bąk *et al.*, 2005), and are overlain by the Barnasiówka Radiolarian Shale Formation (upper Cenomanian–Lower Turonian; Bąk *et al.*, 2001; Fig. 2). The characteristic feature of these sediments are bluish cherts occurring within the middle and upper parts of medium- to thick-bedded, fine-grained turbidites (Fig. 3). Most of the turbidite layers are parallel-laminated and have a gaize character. The cherts represent laminated spongiolites including numerous radiolarian skeletons.

The MCh do not create a continuous level in the Western Carpathians (Koszarski *et al.*, 1962). It occurs mostly in the northwestern part of the Silesian Nappe. Their average thickness varies between 20 and 30 m.

The presented data of the MCh came from a quarry on the Barnasiówka Ridge within the Pogórze Wielickie Foothills; ca 25 km south of Kraków. This area is located on the SW slope of one of tributaries of the Bysina stream, at an altitude of ca. 520 m (Fig. 1B). The section represents here the upper divisions of the Lgota Beds, including the MCh and their contact with the overlying Barnasiówka Radiolarian Shale Formation (Fig. 2).

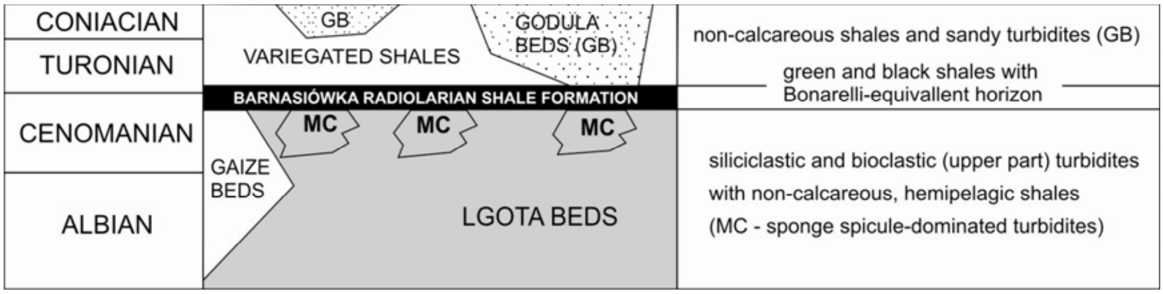

Figure 2. Generalised stratigraphy of the Albian–Coniacian of the Silesian Nappe; on the basis of Koszarski and Ślączka (1973), modified by Bąk *et al.* (2001)

METHODS

Samples for micropalaeontological analyses were collected from eight medium- to thick-bedded layers including bluish cherts and a limestone layer within the MCh and from five layers of sandstones of the underlying Middle Lgota Beds (Fig. 3). Microfossils (spicules, radiolarians, and foraminifers) were extracted from every type of deposits as siliciclastics and carbonates.

Fine-grained turbidites were analysed millimeter by millimeter to identify the microfacies and lithology. SEM photographs of the microfauna and photographs of microfacies were made using the scanning microscope HITACHI S-4700 and a Nikon SMZ1500 stereoscopic microscope with a digital camera.

Microfaunal slides with Radiolaria and Foraminifera are housed in the Institute of Geological Sciences, Jagiellonian University (collection Nr LG-1), and in the Institute of Geography, Pedagogical University (collection Nr 11Sl) respectively.

LITHOLOGY

The Mikuszowice Cherts are composed of turbidites, which are siliciclastic sediments such as greywackes, mudstones, siltstones, limestones, and also calcarenites to calcisiltites, usually silicified. The distinguishing feature is the high content of spicules of siliceous sponges (Fig. 4A, B). Other biogenic particles include planktonic and benthic foraminifers (Fig. 4C), radiolarians (Fig. 4D), and sporadic fragmented echinoid spines. Tube-like trace fossils occur on the tops of some layers. Flute casts locally occur on the soles of thick beds.

Occurrence and petrography of cherts

Cherts occur in the lower and middle parts of thick-bedded, sand-sized deposits represented the Ta–Td intervals of Bouma's turbidite sequence. Locally, they make up nearly the whole thickness of a bed (Fig. 3). The chert layers are 2 to 20 cm thick, with the longer dimension parallel to the bedding. Horizontal contacts are sharp. Relicts of the host rock are common. The cherts are parallel-laminated, similarly as the host-sediment.

The morphology of the chert layer is controlled by primary sedimentary structures and porosity of the turbidite. The cherts are mostly present within greywackes, gaizes, and spiculites, sporadically in calcarenites and calcisiltites. Most of the silica is in the form of cryptocrystalline quartz, microquartz, megaquartz, length-fast chalcedony, and rare microspheres. Microquartz usually replaced carbonate sediment, bioclasts, and is the first cement generation to fill primary intraparticle porosity. Megaquartz

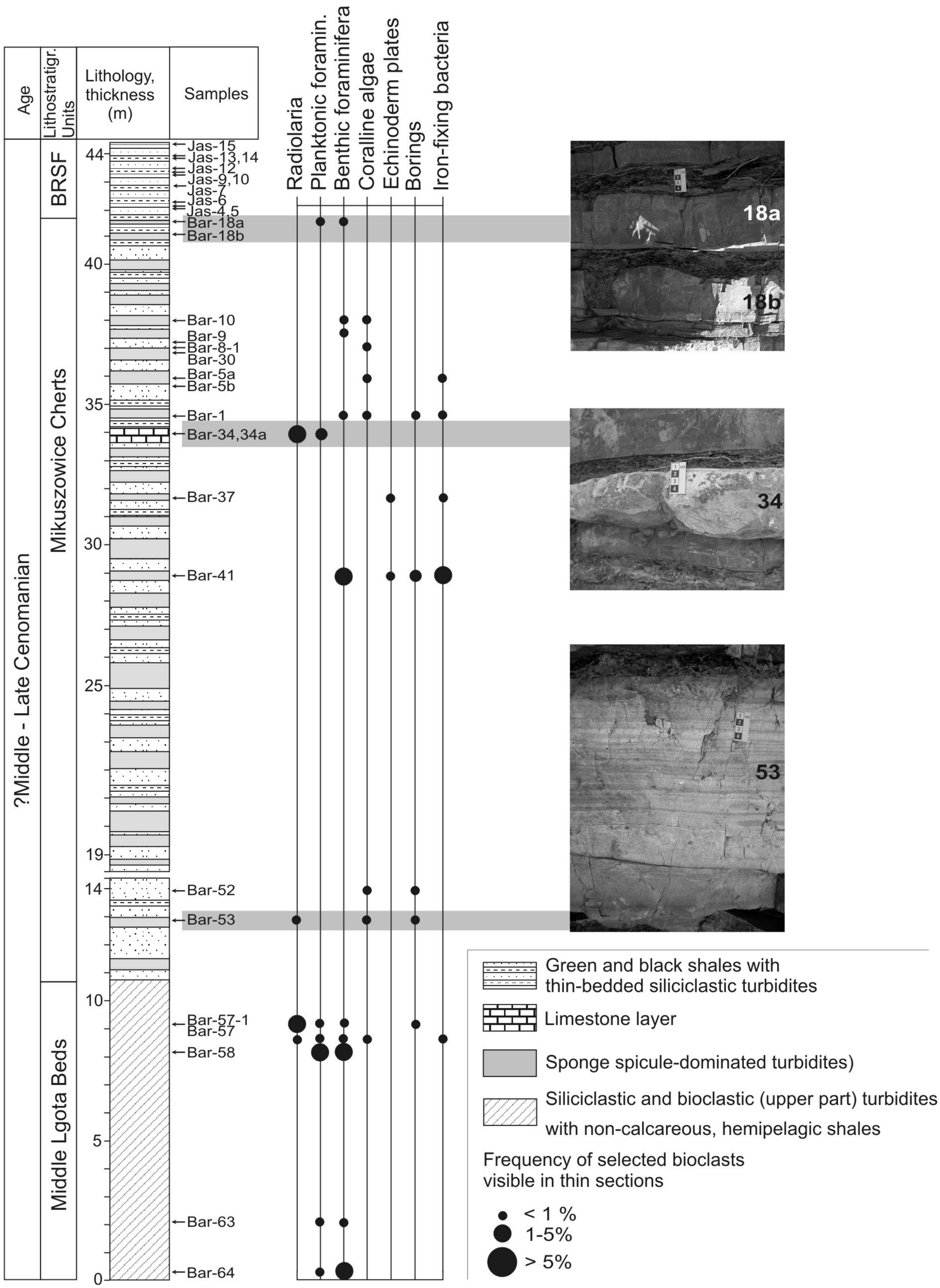

Figure 3. Stratigraphic log of the Mikuszowice Cherts and the Middle Lgota Beds at the Barnasiówka-Jasienica section, with position of the studied samples, occurrences of microfossils and photographs of the most characteristic chert beds

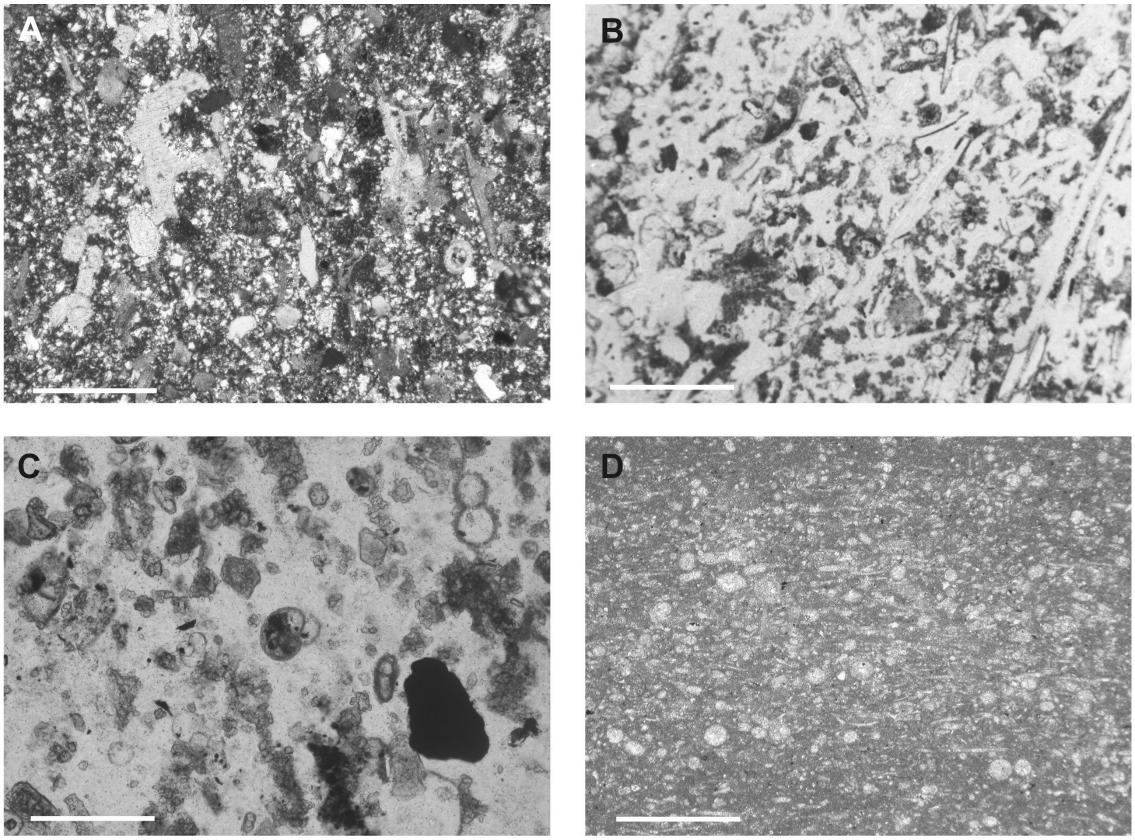

Figure 4. A – Thin section (cross-polarized light) of gaize (silicitized), formed macroscopically laminae of bluish chert. Bar-5. Scale bar 500 µm. **B** – Photomicrograph (plane polarized light) of spiculite, with minor terrigenous grains. Bar-1. Scale bar 500 µm. **C** – Photomicrograph (plane polarized light) of silicified biomicrite with foraminifers. Bar-10. Scale bar 500 µm. **D** – Thin section of limestone layer (plane polarized light), macroscopically pelitic, and non structural. Middle part is radiolarian wackstone with sponge spicule, micro-laminated. Calcite casts of radiolarians and another fossil debris are oriented parallel to the bedding. Bar-34. Scale bar 1 mm

is characterized by mosaics of crystals up to 300 micrometers in diameter. It always occurs as a late cement, after the microquartz and LF-chalcedony generations, as primary and secondary filling of radiolarian and foraminiferal chambers. It is also present as a secondary generation of pseudomorphs after rhombohedral calcite-like crystals. The fibrous variety of quartz is less common.

Length-fast chalcedony is present locally as a cement phase, mostly botryoidal, which infilled axial canals of sponge spicules, radiolarian and foraminiferal chambers. Sometimes it replaces the walls of sponge spicules and forms pseudomorphs after rhombohedral calcite crystals.

The chert also contains spherical structures that are usually rare and dispersed, associated with spicule-bearing rocks (greywacke, geize, spiculite). These microspheres have a regular size, with a diameter of 30-40 µm. Their interior consists of two parts, a central part of microcrystalline quartz, 20-30 µm in diameter, and a cortex, 10-20 µm thick, composed also of microcrystalline quartz but fibrous, radially arranged. Similar microspheres were described by Gimenez-Montsant *et al.* (1999) from chert related with shallow-water platform carbonates that contains sponge spicules. Thin sections of microspheres display internal structure similar to cross-sections of non-calcitized siliceous sponge spicules, suggesting their biogenic origin.

MICROFOSSILS

Microfossils in the MCh occur in green, hemipelagic shales, sand fraction deposits, limestone, and cherts. Shales are enriched in deep-water agglutinated foraminifera and radiolarians. The sand fraction includes mainly sponge spicules, less common are radiolarians, planktonic and calcareous benthic foraminifera, inoceramid prisms, echinoderm oscilles, and fragments of coralline red algae. Cherts display a similar composition of microfossils, however, they differ from the sand fraction deposits in the much better preservation of siliceous microfossils.

Sponge spicules

Loose spicules have been obtained by dissolving rocks in a weak hydrochloric or hydrofluoric solution (Plate 1). They are present in samples from the uppermost part of the middle Lgota Beds and the whole section of the MCh. The number of spicules exceeds 12 thousand individuals per gram of rock sample. Spicules are present only in redeposited sediments representing Bouma's Ta–Td sequences, except for the uppermost interval of pelagic sediments, in which spicules are absent.

Lithistid spicules prevail in the assemblages. The most common are desmas, especially dicranoclones. Less common are prodichotriaenes and phyllotriaenes. Various oxeas and microxeas are also very common. Hexactinellid spicules are very rare. These are loose hexactines and hexasters.

Spicules in thin sections of different lithologies represent three types of preservation: (1) recrystalized, (2) replaced by blocky calcite, and (3) replaced by isopachous, bladed calcite. Spicules recrystalized from primordial amorphous opal-A into more stabile silica phase are present predominantly in spiculite and gaize. In most of the cross-sections, the spicule interior consists of two parts: a central part (remnants of central canal) infilled by microcrystalline quartz, and an internal part, composed of microcrystalline, fibrous, radially-arranged quartz.

Spicules replaced by blocky calcite are the prevailing type of preservation of spicules in the greywackes. They consist of 20–30 percent of spicules in the gaize layers; they are rare in the spiculites and absent in the limestone layers. Different cross-sections show that calcite very faithfully replaced the whole spicule. The central canal of spicules is usually present, and infilled by the same type of sediment or cement as surrounding the spicule. These calcitized spicules possess micro-borings filled in by micrite or bacterial coatings. In silicified rocks, they are partly dissolved due to changing in pH conditions during diagenesis. The same type of replacement may suggest that this process took place very early, before the spicules were delivered into the turbidite beds. It would suggest that early dissolution of silica, previously forming the spicules, took place during initial decay and early burial of the sponges. The surrounding carbonate mud may be the source of calcite which shortly thereafter precipitated, reducing porosity after spicules.

Former descriptions of sponge spicules from the cherts of the Lgota Beds came from the Beskid Śląski Mountains (Lipnik, Straconka, Brennica; Romer, 1870; Szajnocha, 1884; Sujkowski, 1933, Alexandrowicz, 1973). The described sponge assemblages were dominated by forms of the order Tetractinellida, with accompanying forms from the orders Lithistida and Monactinellida, and sporadic spicules of the order Hexactinellida. Sujkowski (1933) noted also silicified spicules of the order Calcispongia.

Radiolaria

The radiolarians are generally poorly and moderately preserved. Only 15 percent of skeletons may be identified; the best preserved radiolarians come from the cherts. Most of the radiolarian skeletons, especially from the shales have been recrystalized, replaced by pyrite or Fe-oxides, resulting in the destruction of external and internal wall structures.

Radiolarian assemblages are moderately diverse in the middle and upper division of the Lgota Beds. Nassellarians dominate there quantitatively, comprising 50–80 percent of the total assemblage.

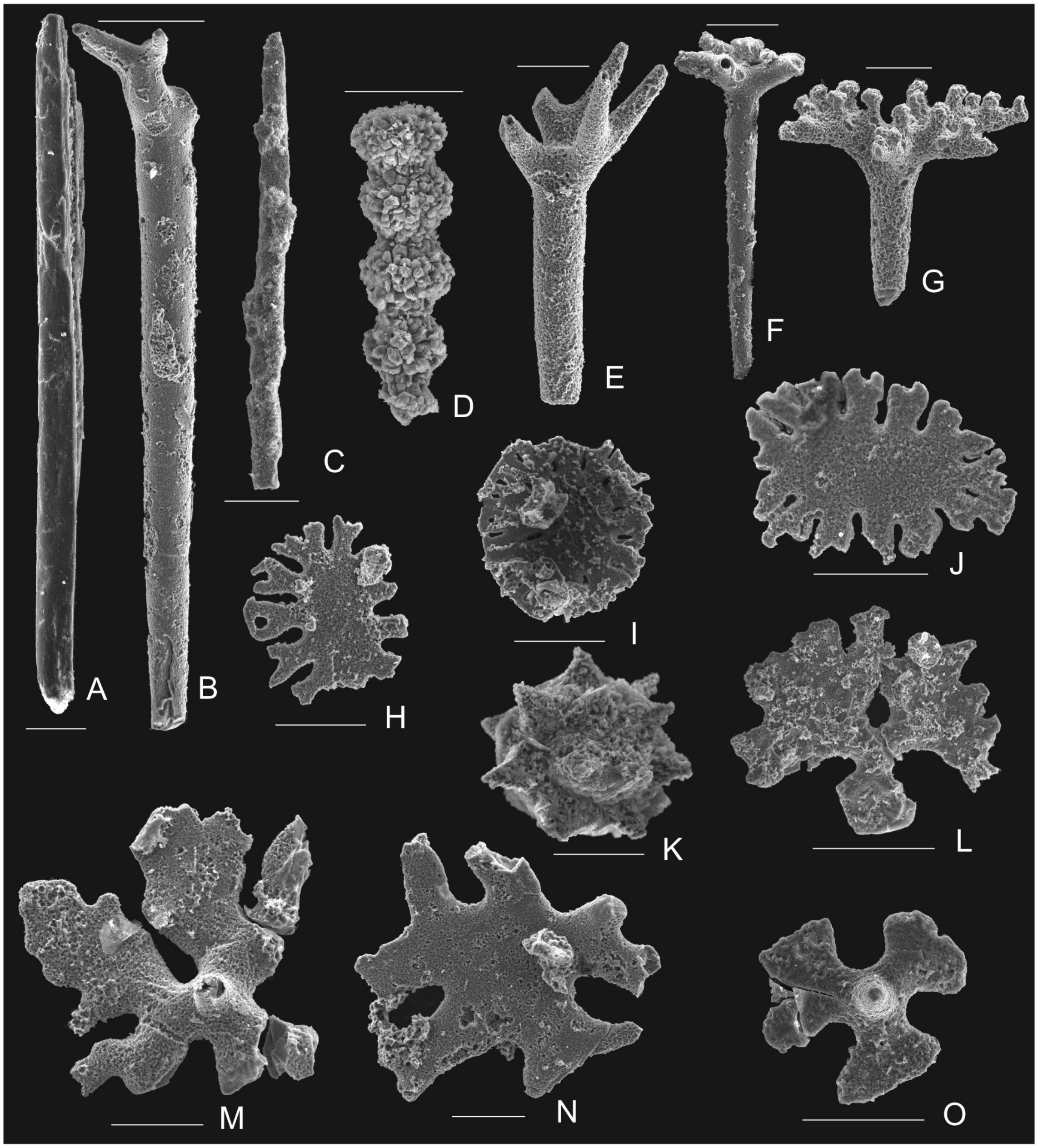

Plate 1. Selected Demosponge spicules obtained from spiculite and gaize of the Mikuszowice Cherts. **A** – Style, smooth type. **B** – Style, spiny type. **C** – Massive prodichotriaene. **D** – Massive dichotriaene. **E** – Prodichotriaene. **F** – Criccorhabd. **G** – Phyllotriaene. **H–J** – Dermal discoid spicules resamble modified phyllotriaenes. **K** – Oxyaster. **L–O** – Dermal phyllotriaenes, different shapes. Scale bars – 100 μm

Most frequent are representatives of the family Williriedellidae, which prefer eutrophic water conditions (e.g., *Holocryptocanium barbui* Dumitrica and *Cryptamphorella conara* (Foreman)). Generally, skeletons of the family Williriedellidae consist of 98 percent of the whole radiolarian assemblages in the studied series. Other nassellarians belong to families such as: Amphipyndacidae, Archaeodictyomitridae, Eucyrtidae, Stichcyrtidae and Syringocapsidae, of which the total number of specimens does not exceed 10 percent of the whole assemblage.

Spumellaria are less frequent than Nassellaria, consisting 20 to 50 percent of the total number of radiolarian specimens. Species belonging to two families: the Actinommidae and Hagiastridae prevail.

The number of radiolarians skeletons varies along the studied succession, depending on the type and derivation of the host-sediment. In the whole section, green hemipelagic shales include a low number of radiolarians. Only 20 specimens in 100 g of the rock-sample occur within the deposits around the boundary between the middle Lgota Beds and the MCh. Dark-grey and black shales are devoid of radiolarians. On the contrary, radiolarian skeletons, however, as destroyed redeposited particles, are numerous in the sand fraction deposits within both studied divisions of the Lgota Beds. The most abundant radiolarian skeletons have been observed in the beds of the Ta–Td intervals of the upper division. Their number even exceeds 10,000 individuals per 100 g of rock sample. However, there are significant fluctuations in their number within this type of sediment, with an increasing trend that occurs upward in the section.

Foraminifera

The study of planktonic and benthic foraminifera was made on the basis of observations in thin sections of the rocks and from their residue in fraction >64 microns. The foraminifers have been determined from green and olive non-calcareous shales, some of them came from the chert layers. The taxonomic list of foraminifers from the middle Lgota Beds and the MCh was published by Bąk *et al*. (2005).

Non-calcareous shales from the MCh contain mostly deep-water agglutinated foraminifera (DWAF), dominated by opportunistic forms of *Recurvoides* sp., *Thalmannammina neocomiensis* Geroch and *Trochammina* sp. Some shales, especially in the upper part of the MCh, include also numerous infaunal forms such as *Gerochammina* spp. These DWAF assemblages are typical of sediments from the Cretaceous flysch basins of the Western Tethys and the North Atlantic (e.g., Kuhnt & Kaminski, 1990; Kuhnt *et al*., 1992; Bąk, 2004).

Sandstones, cherts, and limestone layers of the MCh are characterized by different assemblages. More than ten species of planktonic and calcareous benthic foraminifera have been identified in residuum from the dissolved cherts. Small hedbergellids (mainly *Hedbergella delrioensis*) associated with *Globigerinelloides ultramicra*, *Hetereohelix moremani* and *Guembelitria cenomana* are the most frequent along the planktonic foraminifera (10-50 specimens per 1 cm^2; Bąk *et al.,* 2005). Calcareous benthic foraminifera are represented mostly by gavelinellids and the genus *Gyroidinoides*, with rare specimens belonging to *Cibicides*, *Praebulimina*, *Quinqueloculina* and *Dentalina*. They are less frequent than planktonic forms, ranging from a few to 30 specimens in 1 cm^2(Bąk *et al.,* 2005).

The DWAF are sporadic in the chert layers. Most probably they represent redeposited specimens, which are typical of hemipelagic assemblages, including tube-shaped forms (*Rhabdammina* sp., *Hyperammina* sp., *Bathysiphon* sp. and *Hippocrepina* sp.), and occasionally "flysch-type" forms.

An interesting fact is that large, "keeled" planktonic foraminifera (praeglobotruncanids and rotaliporids) are extremely rare in redeposited, foraminiferal assemblages. Consequently, taking into account the taxonomic composition of the benthic calcareous foraminifera in these sediments, when it is compared with the "complete" assemblages of the same age from the platform environments (cf., Gawor-Biedowa, 1972; Hart, 1980; Leckie, 1987; Hradecka, 1993), it seems that the depth of the sea floor from which the biocomponents have been redeposited was rather shallow, probably between some tens and hundreds of metres.

Iron-fixing bacteria

Iron is present and occurs as amorphous iron oxides or hydroxides in skeletal fossil fragments, primary pore space and as encrustations on skeletal walls and some intraclast surfaces. Some benthic foraminifera in thin section views of biomicrites, appear to have their original test replaced by iron oxides. On some specimens it is visible that the replacement started with the micro-boring process toward the inside the test wall. In the others, foraminiferal tests are completely replaced and covered inside by Fe-oxides. Fe oxides formed the densest layers in test cavities, which make the remnants of the wall appear much thicker than the original. Thin filaments attached to these iron coatings externally resemble iron-fixing bacteria of the *Sphaerotilus – Leptothrix* group. In some places, iron oxides are present in elongate structures, approximately less than 10 micrometer in width, and vary in length. These structures resemble *Leptothrix discophora* which are of similar size and form. Further evidence of iron-fixing bacteria are the circular forms, which may represent cross-section of bacterial sheaths, and fuzzy brown disk-like forms resembling bacterial holdfasts, surrounded usually by defibre, prolix brown flocs and aggregates. Pyrite microcrystals were associated with bacterial coccus filaments and holdfasts. The presence of the bacterial felts is not restricted only to the foraminiferal tests. They encrust echinoderm fragments and spicules of demosponges, primary siliceous, now replaced by calcite. They are present also inside the pores between grains, or partly encrust their surface. Further porosity reduction is by blocky or isopachous bladed calcite cement. The endobiotic forms were developed before cementation by calcite. These delicate structures might be preserved due to early cementation. During the early stages of calcification, micrite crystals aggregated to form plate-like clusters around the biofilm components (Perry, 1999).

PALAEOENVIRONMENTAL INTERPRETATION

The petrography of Ta–Td intervals in the thick beds of the MCh is related more or less to facies distribution in the shallower part of the basin, while the hemipelagites reflect exclusively deep-water pelagic sedimentation. In spite of turbiditic mixing and diagenetic changes, different proportions of sponge spicules, calcareous benthic foraminifers, planktonic foraminifers, radiolarians, glauconite grains, and carbonates is related to facies migration during transgressive-regressive cycles.

The spicule-bearing turbidites possess several types of sedimentary structures, developed on the soles of thick beds, indicating the north–west direction from which the spiculitic material was derived. The source of this material might have been situated on the southern ridge of the North European Platform.

The presence of sponge-rich communites within the shallower part of the basin was related to ecological factors such as sedimentation rate, bathymetry, water energy, temperature, the quantity and quality of food, and water chemistry. The lithistid dominance is the most striking feature in the frequency of sponges in the MCh. Relatively diverse lithistid sponge faunas are also known from the Early Cretaceous platform facies of Poland, Spain, southern France, England, and southern Germany (Reid, 1962; Wiedenmayer, 1980; Kaufmann *et al*., 2000). The main controlling factor in the lithistid *vs* hexactinellid sponge distribution was the predominant type of food available, as noted in geological records and present-day communities (e.g., Pisera, 1997; Krautter, 1997; Duarte *et al*., 2001). It is possible that sponge spicules replaced by blocky calcite are the relic of mud-mounds formed by sponges, accompanied by other benthic organisms like crinoids, calcareous foraminifers, and encrusting coralline algae, which are also present in the spicule-bearing beds (Fig. 3). In modern counterparts (Reitner, 1993), hard automicrites, which are important in the formation of mud-mounds precipitates within organic films or mats, largely produced by microbial activity. The remnants of such biofilms in our material might be the presence of iron-fixing bacteria developed mostly on carbonate grains. Pyrite microcrystals are also present in association with iron-fixing bacteria, near their sheaths and remnants of bacterial biofilms in the studied deposits. These might be a result of phases of oxygen depletion in mud-mounds, which appears also occasionally in modern counterparts, preventing the growth of macro-organisms.

The sponge spicules are diagenetically transformed into calcite. According to Reitner *et al*. (1995), many of the Upper Jurassic build-ups represent siliceous sponge–microbial crust mud-mounds. The majority of them (without corals – like in case of the MCh) grew in mid to upper outer ramp settings.

The occurrence of radiolarians in redeposited material signify that their source was located in the deeper part of the basin. The same concerned beds with abundant planktic foraminifers. The presence of glauconite grains, though sporadical, marks the formation of condensed facies before or simultaneously with the formation of the turbidite sequence.

The presence of radiolarians marks high productivity and thus high nutrient concentrations. The co-occurrence of radiolarian and siliceous sponges would suggest that sponges communities were situated on the middle to outer shelf, which was influenced by upwelling, also making nutrients available for the growth of sponges.

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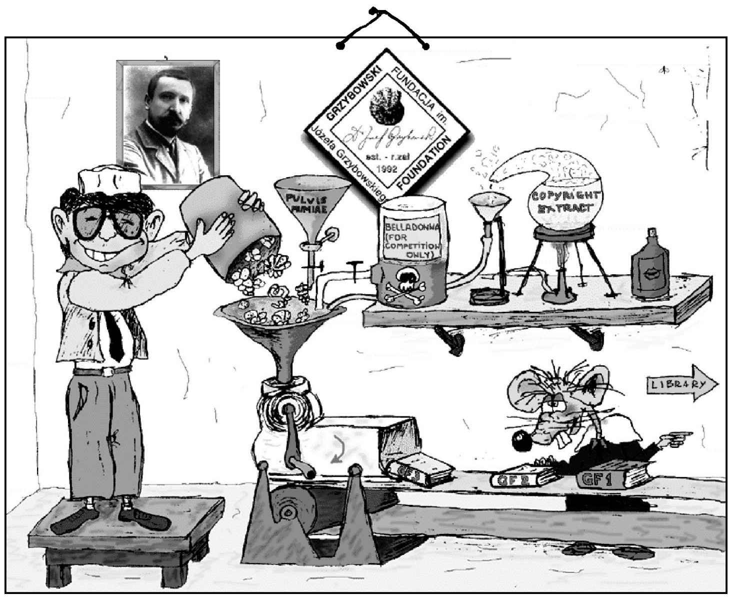

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The Beloveža Formation of the Rača Unit, Magura Nappe, in the Beskid Wysoki Mts (Polish Flysch Carpathians) north of Babia Góra Mountain – monospecific assemblages with *Praesphaerammina subgaleata* (Vašiček)

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ABSTRACT

Taxonomically poorly diversified deep water assemblages are found in the Middle/Upper and Upper Eocene deposits of the Magura Nappe. The prevalence of relatively large-size *Praesphaerammina subgaleata* (Vašiček) is typical here. Other than the principal taxon, the other foraminiferal components of assemblage are dwarfed and represent mainly infaunal species. *Haplophragmoides parvulus* Blaicher occurs among the typical Magura Basin species. The appearance of monospecific assemblages with *Praesphaerammina subgaleata* (Vašiček) resulted from poorly oxygenated environments with increased input of organic matter to the bottom of the Magura Basin. These conditions are connected with an uninterrupted supply of very fine-grained clastic material, carried by higher-energy turbidity currents during the sedimentation of the Beloveža Formation. The increased delivery of mud and silt to the sea floor during low-energy periods causes restriction of epifauna, especially in deep water basins.

Key words: Carpathians, Magura Nappe, Beloveža Formation, Eocene, *Praesphaerammina subgaleata* (Vašiček) assemblages

INTRODUCTION

Thin-bedded flysch of the Beloveža Formation was deposited during the Eocene within the central part of the Magura Basin. These deposits occur now in the Rača Unit of the Magura Nappe, the larger Outer Carpathian unit. The Eocene thin-bedded flysch was subject of numerous studies beginning in the XIX century (Waśkowska & Golonka, 2010). Paul (1869) encountered them in the Beloveža village near Bardejov in Slovakia and named them the Beloveža Beds (Schichten). He included variegated shales and thin-bedded flysch into the Beloveža Beds. Uhlig (1888) separated the thin bedded flysch of the Beloveža Beds from variegated shales. This division was accepted by Świdziński (1947) and geologists from his school (e.g., Węcławik, 1969). On the other hand, Książkiewicz (1948) used the term Hieroglyphic Beds for these thin-bedded Eocene flysch deposits. This approach was applied by geologists from the Polish Geological Institute for very similar deposits in the Beskid Wysoki area (Golonka, 1981; Książkiewicz, 1966; Sikora & Żytko, 1959). Later, Oszczypko (1991) formalized the name Beloveža Formation. His

In: Bąk, M., Kaminski, M.A. & Waśkowska, A. (eds), 2011. Integrating Microfossil Records from the Oceans and Epicontinental Seas. *Grzybowski Foundation Special Publication*, **17**, pp. 27–35.

reference section is located in Zbludza Stream and Żeleźnikowski stream in the Nowy Sącz area. The Beloveža Beds (Formation) from Paul's (1869)
type locality display striking resemblance to the typical Hieroglyphic Beds from the Rača Unit, Magura Nappe in the Beskid Wysoki Mountains north of Babia Góra Mountain. Their lithology, strati-graphic position, and location within the Magura Basin are similar (Waśkowska & Golonka, 2010).

METHODS

We have recently made an attempt to provide a systematic arrangement of the lithostratigraphic units according to their occurrence within the original basins and other sedimentary areas (Golonka & Waśkowska-Oliwa, 2007, Waśkowska & Golonka, 2010). This attempt was also accompanied by unification of these units in the whole area of West Carpathians flysch in Poland, the Czech Republic, and Slovakia (Golonka *et al*., 2008). In this approach the name Beloveža Formation was applied to thin-bedded flysch with both the Bystrica and Rača units of the Magura Nappe. We also studied the foraminifera of the Beloveža Formation in Rača Unit of the Magura Nappe in Beskid Wysoki Mountains (Polish Flysch Carpathians) north of Babia Góra Mountain.

Samples for micropaleontological research were taken from the topmost part of the Beloveža Foramation of the Rača Zone in the Magura Nape in the Mosorny Zawoja section. The samples were prepared by using standard micropaleontological methods. Approximately 500g samples of dry shaly or marly materials were put into a maceration process in the water solution of Glauber's Salt. Disintegrated samples were washed through a set of sieves (63–100 μm screen) and dried. Specimens of foraminifera were picked from the residue and then taxonomically identified.

GEOLOGICAL SETTING

The Beloveža Formation in the Beskid Wysoki Mountains

The Outer Carpathians are built up of a stack of nappes and thrust sheets consisting mainly of up to six kilometers of Jurassic to Lower Miocene thick continuous flysch sequences. These nappes are thrust over the southern part of the North European Plate. The Magura Nappe forms the innermost and largest nappe, representing the Late Oligocene to Early Miocene accretionary wedge (Fig. 1). It is thrust over the various unit of the Fore-Magura group of nappes and of the Silesian Nappe. Its substratum has also been found in several deep wells in Poland and Slovakia. In the investigated area this substratum was encountered in Zawoja 1 and Sucha Beskidzka IG-1, boreholes in Poland and Oravska Polhora 1, borehole in Slovakia. To the south, the Magura Nappe contacts with the Pieniny Klippen Belt that separates it from the Inner Carpathians (Golonka *et al.*, 2005).

On the basis of facies differentiation expressed mainly within Paleogene deposits, the Magura Nappe has been subdivided into four facies-tectonic subunits: the Oravská Magura-Krynica, Bystrica (Nowy Sącz), Rača, and Siary subunits (Golonka *et al*., 2005). The Rača and Siary subunits occur north of Babia Góra, the Rača subunit in the Zawoja area. The oldest rocks in this area belong to the Upper Cretaceous–Paleocene Ropianka Formation (Golonka, 1981; Golonka *et al.*, 2005; Golonka & Waśkowska-Oliwa, 2007; Książkiewicz, 1966, 1971a, b). This formation is represented by thin-bedded turbidites with sporadic intercalations of thick-bedded sandstones. It is covered by the 20–50 m thick Łabowa Shale Formation of variegated shales, Early to middle Eocene in age. The variegated shales pass upwards into thin-bedded turbidites of the middle Eocene Beloveža Formation represented mainly by thin to medium-bedded turbidites with packages of thick-bedded sandstones (Fig. 1). These sandstones belong to the Pasierbiec and Osielec members. The Beloveža Formation is covered by an upper Eocene–Oligocene complex of thick-bedded sandstones with intercalations of thin to medium- bedded turbidites. This complex represents the Magura Formation. The formation thickness reaches 2000 meters in the well-exposed area of Pilsko Mountain west of the Babia Góra area. The youngest unit of the Magura Nappe is

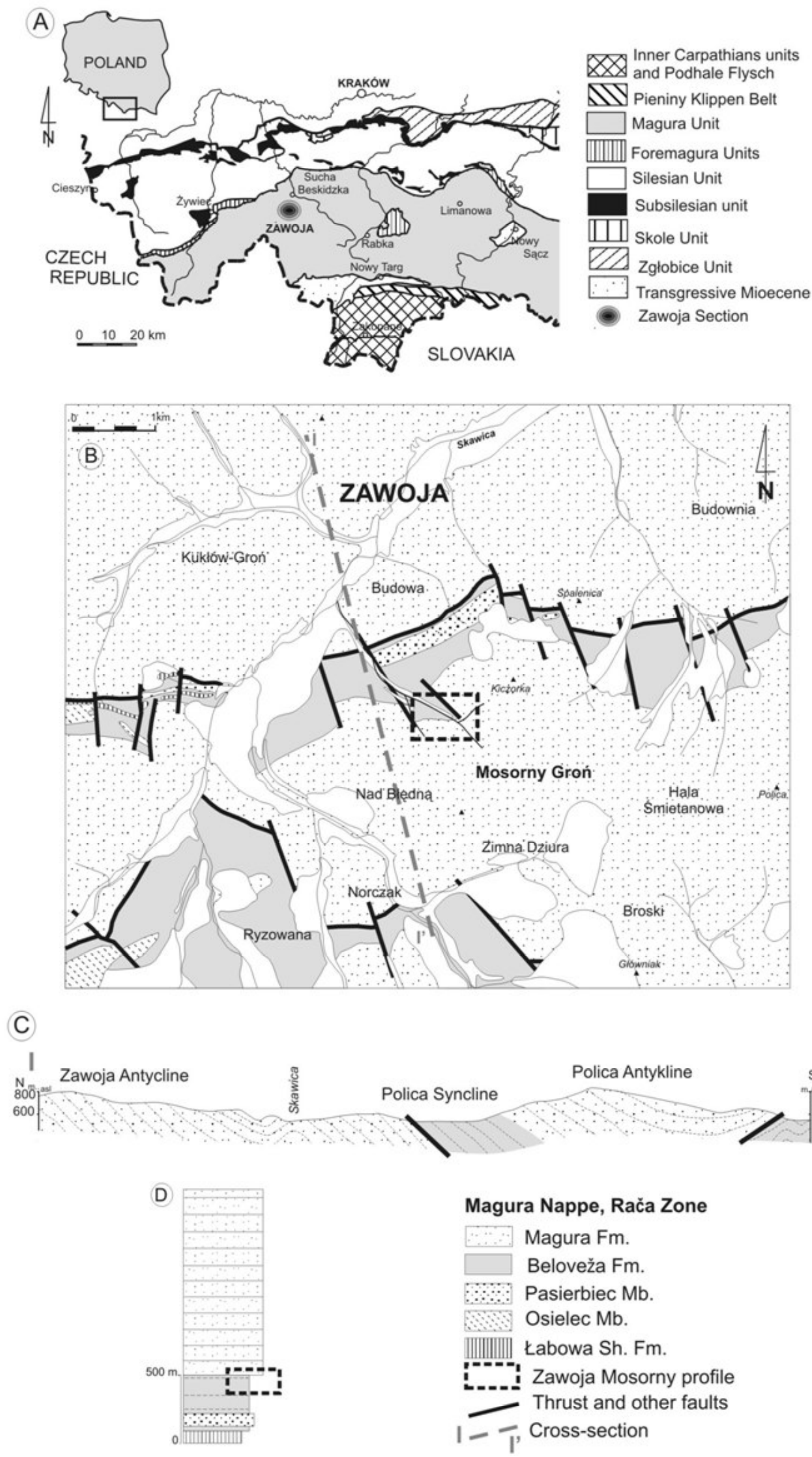

Figure 1. The geological setting of the Zawoja-Mosorny profile. **A** – Localization on the West Polish Carpathians tectonic-sketch map. **B** – The geological map of the Zawoja area (modified after Książkiewicz, 1971a). **C** – The geological cross-section of the Zawoja area (modified after Książkiewicz, 1971a). **D** – synthetic profile of the Siary Subunit, Magura Nappe in the Zawoja area

the upper Oligocene Malcov Formation (is not known from the Rača subunit in the Babia Góra area). It was encountered within the Bystrica subunit in Polhoranka valley southwest of Babia Góra Mt.

The amplitude of the Magura Nappe overthrust is at least 50 km. The thrust developed mainly within the ductile Upper Cretaceous variegated shales (Golonka *et al*., 2005; Ślączka *et al*., 2006). The northern limit of the nappe has an erosional character. The tectonic windows exposing the nappe substratum are located outside the investigated area in Sopotnia Mała westward and Mszana Dolna eastward, among others. The Silesian Nappe is elevated between Zawoja and Sucha Beskidzka, forming an out-of-sequence thrust, it does not, however, reach the surface (Golonka *et al*., 2009, 2011; Pietsch *et al.,* 2007).

Figure 2. Outcrops in Mosorny valley (Zawoja): **1** – Mosorny waterfall – contact zone of Beloveža Formation with Magura Formation; **2–4** – outcrops of Beloveža Formation in the Mosorny valley

The tectonic boundary within between the Bystrica and Rača subunits has the distinctive character of a thrust, especially in the area southwest of Babia Góra Mountain (Golonka, 1981; Golonka *et al*., 2009). The boundary between the Rača and Siary subunits, located between Zawoja and Sucha Beskiskidzka is not so well defined (Cieszkowski *et al*., 2006; Książkiewicz, 1977). Several anticlines occur within the Rača subunit north of Babia Góra. These anticlines are overturned and usually thrust northward, forming the imbricated structure of the Magura Nappe. The Upper Cretaceous–Paleocene Ropianka Formation is exposed in the large Grzechynia anticline north of Zawoja. The synclinal zones are wider than the associated anticlines. They are built of sandstones of the Magura Formation. The regionally persistent joint sets cut the folds. They are geometrically and genetically related to the folds. The normal and strike-slip faults cross-cutting the fold structure of the Magura Nappe seem to have initiated on earlier joint surfaces. The sequential development of the tectonic structures reflects successive stages of thrusting of the Outer Carpathian nappe pile onto its foredeep, accompanied by a gradual dextral rotation of regional tectonic compression trajectories during Neogene times (Aleksandrowski, 1989; Golonka *et al*., 2005).

The Beloveža Formation in the Mosorny waterfall (Zawoja) locality

The Mosorny (alternative name Mozorny) waterfall outcrop belongs to the best outcrops of the Beloveža Formation and sandstones of the Magura Formation within the Polish Outer Flysch Carpathians (Fig. 2). It is also a spectacular geotouristic object, because the profile includes a beautiful, six-meter high waterfall (Alexandrowicz & Poprawa, 2000). The waterfall is localized 500 m above the Zawoja-Mosorny hamlet, on the touristic trail Zawoja – Mosorny Groń-Polica. The object's coordinates are: latitude 49º37'49"N and longitude 19º33.54"E. A short path leads from the main trail route downhill to the Mosorny stream and the waterfall. This waterfall is carved exactly on the contact (Fig. 2) between the thin-bedded flysch of the Beloveža Formation and thick-bedded sandstones of the Magura Formation (Książkiewicz, 1966, 1971a, b). These rocks belong to the Rača subunit of the Magura Nappe. The Beloveža Formation is exposed in the Polica anticline, which is thrust northward over the Magura Formation of the Zawoja syncline (Fig. 1C) The Polica anticline runs from Koszarawa village through the Klekociny pass, Widły and Mosorne hamlets of Zawoja village on the northern slopes of the Polica Mountain (Książkiewicz, 1966, 1971a, b). It is cut by several transverse faults (Fig. 1). The Łabowa Shale Formation is exposed in the core of the Polica anticline in its western part. The older rocks of the eastern part belong to the Beloveža Formation. Southward the sandstones of the Magura Formation belonging to the Polica syncline normally overlay the Beloveža Formation. The sandstones built the Mosorny Groń and Polica mountains. The reverse morphological structure is typical for the Beskid Wysoki Mts. The anticlines build the valley and passes, while the youngest rocks of the syncline form the highest mountains in this region.

The Mosorny waterfall outcrops provide an excellent object to study the lithological characteristic of the typical Carpathian flysch. The thin-bedded sometimes medium-bedded sandstones are interbeded by grey and green-grey clayey shales and mudstones (Fig. 2). The sandstones are hard, cemented by siliceus-carbonate matrix gray in colour. They disintegrate into small blocks. The numerous hieroglyphs occur on their bottom planes. The flute casts indicate transportation of clastic material generally from the east (Książkiewicz, 1966, 1971a, b). The *Ceratophycus*, *Scolicia*, and *Cylindrites* represent, among the others, the trace fossils.

The assemblages of *Praesphaerammina subgaleata* (Vašiček) Acme

The topmost part of the Beloveža Formation in the Zawoja Mosorny waterfall profile contains poorly diversified microfaunal assemblages (Plate 1). The occurrence of *Praesphaerammina subgaleata* (Vašiček) is typical within the mainly agglutinated foraminifera. The characteristic abundance of this taxon was noted in the investigated samples with numbers reaching typically several hundred per sample, and proportions reaching 70–100% of the foraminiferal assemblage. This is the example of monospecific type of assemblages. *Praesphaerammina subgaleata* (Vašiček) was observed in middle Eocene to upper Miocene deposits (Kaminski & Gradstein, 2005). This species is typical especially for the Carpathian Middle and Upper Eocene assemblages (e.g., Bieda *et al*., 1967; Geroch *et al*., 1967; Geroch, 1960; Jednorowska, 1966, 1968, 1969; Książkiewicz, 1958, 1971, 1974; Malata, 1981; Golonka & Wójcik, 1978; Olszewska, 1996, 1997). In addition to the Carpathian region, it was noticed from offshore Louisiana (*fide*: Kaminski & Gradstein, 2005). The first occurrence of *Praesphaerammina subgaleata* (Vašiček) corresponds in the Polish Outer Carpathians with latest middle Eocene (Bubík, 2008; Olszewska *et al*., 2006) and it is placed within the Ammodiscus latus biozone (*sensu* Olszewska, 1997). *Haplophragmoides parvulus* Blaicher (a marker for the middle and Late Eocene) as well as *Haplophragmoides walteri* (Grzybowski), *Haplophragmoides kirki* Wickenden, *Haplophragmoides scitulus* (Brady), *Recurvoides* div. sp., *Paratochamminoides* div. sp., *Pseudonodosinella elongata* (Grzybowski), *Cribrostomoides subglobosus* (Cushman), *Glomospira glomerata* (Grzybowski), and numerous branched tubular forms belong to the accompanying species within assemblages of Zawoja

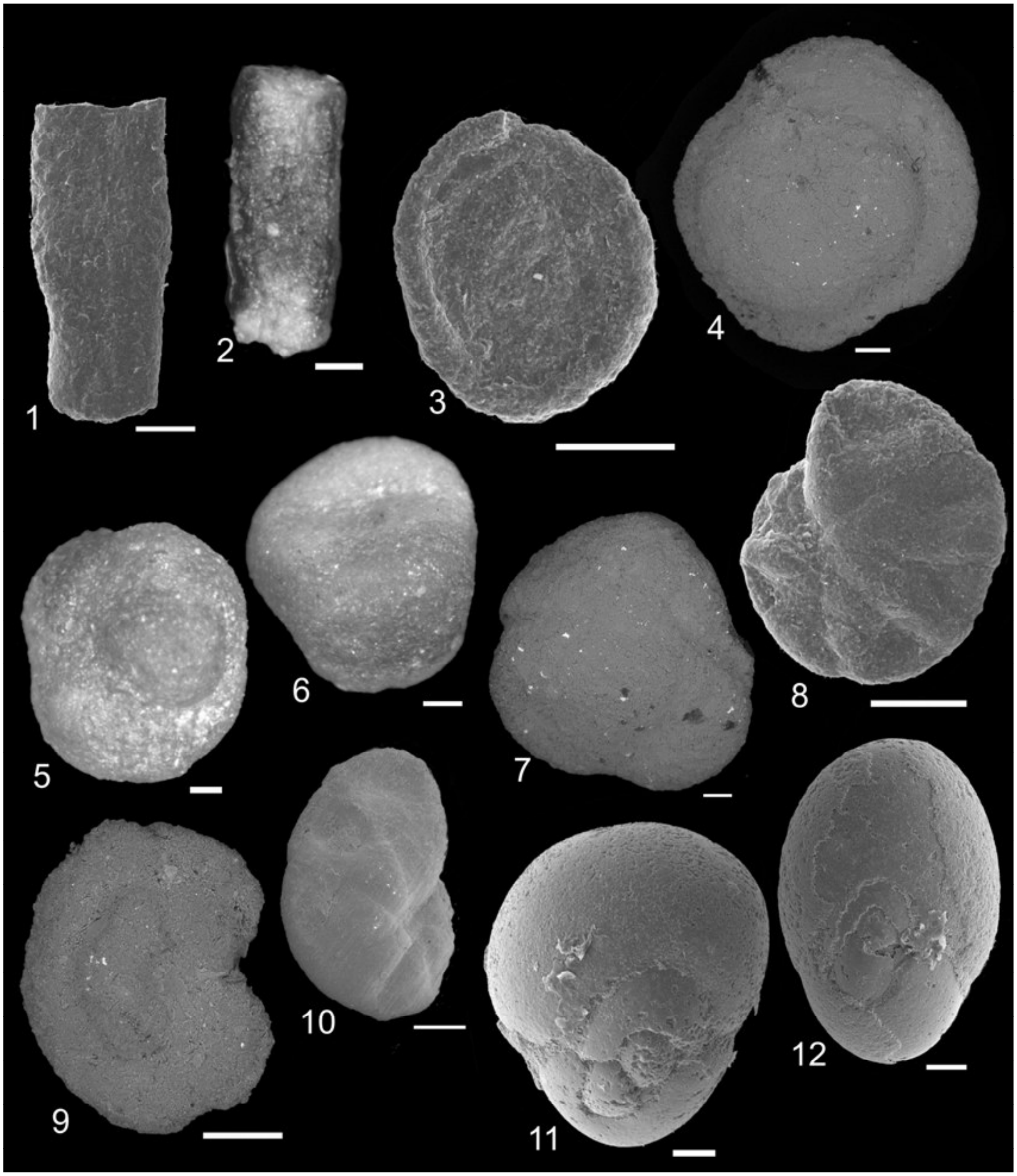

Plate 1. Foraminifera from the Beloveža Formation in the Zawoja–Mosorny section. **1, 2** – *Bathysiphon* sp., **3** – *Ammodiscus* sp., **4–7** – *Praesphaerammina subgaleata* (Vašiček), **8** – *Haplophragmoides walteri* (Grzybowski), **9** – *Paratrochamminoides dubius* (Grzybowski) **11, 12** – *Chilostomella sp*. Scale bars – 100µm

Mosorny Beloveža top profile. Pyritized specimens of *Chilostomella chilostomelloides* Vašiček (described from Magura deposits) are included in some assemblages.

Similar monospecific assemblages with *Praesphaerammina subgaleata* (Vašiček) were noticed in samples collected from higher part of Beloveža Formation (Hieroglyphic beds) in the Rača zone in other areas (Bieda *et al.*, 1967; Blaicher, 1961; Golonka & Wójcik, 1978; Książkiewicz, 1971; 1974; Jednorowska, 1966; 1968; 1969; Jednorowska & Węcławik, 1964, 1969; Malata, 1981, Węcławik, 1969). Type specimens of this species collected by Vašiček (1947) came from the Zlin Formation of the Rača Subunit in the Czech Republic, also the older synonym of *Praesphaerammina subgaleata* (Vašiček) described by Rzehak (1886) during the first micropaleontological research in Magura Nappe as *Trochammina placentula* was described from this formation (Bubík, 2008). Part of the Zlin Formation constitutes the equivalent of Beloveža Formation. Assemblages with numerous *Praesphaerammina subgaleata* (Vašiček) are also known from the lithological equivalents of the Beloveža Formation within Magura Nappe (Blaicher, 1958; Geroch *et al.*, 1967; Jednorowska, 1966; 1968; 1969; Malata, 1981; Olszewska & Malata, 2006; Sikora, 1970; Węcławik, 1969). They were also observed locally in Hieroglyphic beds of Silesian Nappe (Geroch, 1960; Jurkiewicz, 1967).

The stratigraphical position of assemblages with the *Praesphaerammina subgaleata* (Vašiček) Acme corresponds to the Eocene nannofosil Zone NP15 (Bubík, 2008), it is also observed in assemblages of late Eocene age where planktonic foraminifera constrain the age (Jednorowska, 1969). Assemblages with numerous *Reticulophragmium amplectens* (Grzybowski) (Jednorowska, 1968; Jednorowska & Węcławik, 1964) or assemblages with single *Ammodiscus latus* (Grzybowski) and numerous *Reophax pilulifer* Brady (Jednorowska, 1966) are listed from underlying strata in profiles.

Monospecific assemblages with *Praesphaerammina subgaleata* (Vašiček) are characterized by relatively large and properly developed specimens of the index taxon, with dwarfish specimens representing the rest of the assemblage. Infaunal forms predominate, and epifauna are rare. Poorly oxygenated environments with increased input of organic matter are favorable for the development of such type of community (Bubík, 2008; Olszewska & Malata, 2006). These conditions are connected with an uninterrupted supply of very fine-grained clastic material carried by higher-energy turbidity currents during the sedimentation of the Beloveža beds. The increased delivery of mud and silt to the basin floor during low-energy periods causes restriction of epifaunal development, especially in deep water basins.

CONCLUSIONS

- The Zawoja Mosrny section belongs to the best localities to study the Eocene sedimantation and biostratigraphy of the Magura Basin in the Outer Carpathian.
- The deep water micropaleontological assemblages occur in the Middle/Upper and Upper Eocene deposits of Beloveža Formation of the Magura Nappe.
- Monospecific assemblages with *Praesphaerammina subgaleata* (Vašiček) occur in the topmost interval of the Beloveža Formation.
- The appearance of monospecific assemblages with *Praesphaerammina subgaleata* (Vašiček) resulted from poorly oxygenated environments with an increased input of organic matter to the bottom part of Magura Basin.
- *Haplophragmmoides parvulus* Blaicher occurs among the typical Magura Basin species.

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and
TMS Foram/Nanno Group Meeting
Kraków, June, 27–30, 2011

The Zembrzyce Shale Member of the Beskid Makowski Formation in the Babica area (Siary Zone of Magura Nappe, Polish Flysch Carpathians); the *Haplophragmoides parvulus* Blaicher type locality

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ABSTRACT

The *Haplophragmmoides parvulus* Blaicher (1961) type locality is situated in Harbutowice village (Kijówka Hamlet, Harbutówka valley). The lower part of the Zembrzyce Shale Member of the Beskid Makowski Formation profile in this locality is now protected as documentary site. Unique foraminiferal assemblages (rich in calcareous foraminifera and others organic components redeposited from the shallower part of basin by turbidity currents) occurring within the lower part of the Zembrzyce Shale Formation (Siary Zone, Magura Nappe), were described by Blaicher (1961) from this locality. The typical Zembrzyce Shale Formation assemblage usually contains a taxonomically poor foraminiferal assemblage of the middle Eocene age, representing the *Ammodiscus latus* biozone. Among the cosmopolitan agglutinated forms, *Haplophragmmoides parvulus* Blaicher is common and locally numerous. The taxon is an important marker for the middle and upper Eocene biostratigraphy of the Magura Nappe.

Key words: *Haplophragmmoides parvulus*, type locality, biostratigraphy, Eocene, Magura Nappe

INTRODUCTION

Cieszkowski *et al.* (2006) proposed formal lithostratigraphic names for the Siary Zone, Magura Nappe in the Makowski Beskid Mountains southwest of Kraków. These authors distinguished the Beskid Makowski Formation with the upper Eocene Zembrzyce Shale Member, Wątkowa Sandstone Member and Budzów Shale Member. The Beskid Makowski Mountains stretch from the Żywiec area to the west of the Krzyworzeka valley to the east (Kondracki, 2009). The name is derived from Maków Podhalański, a small town located in the center of this region. The name Beskid Średni is also known in the geological literature (Książkiewicz, 1958). The name Zembrzyce Shale Member is derived from Zembrzyce town in the Skawa River valley. It was known in the older literature as the Sub-Magura Beds (Książkiewicz, 1958; 1966a, b; 1974a, b). Książkiewicz (1974a) used the terminology Sub-Magura Beds giving at the same time in a footnote the alternative name Zembrzyce Shale, containing the geographic segment according to modern lithostratigraphic nomenclature. The type locality is in the Zembrzyce area, however, recently the best outcrops of this member were found in the Harbutowice area in the marginal part of the Magura Nappe.

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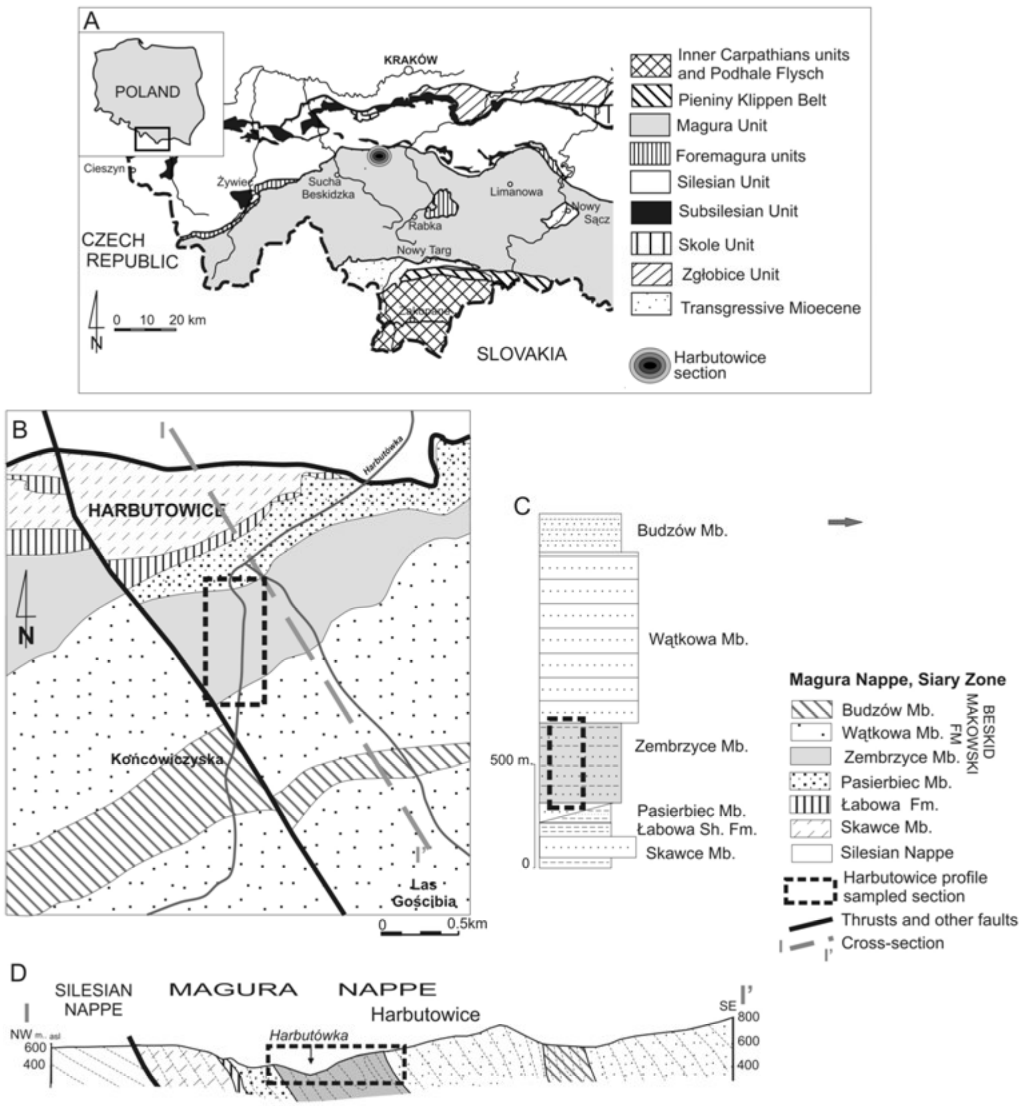

Figure 1. The geological setting of the Zembrzyce Shale Member in Harbutowice area. **A** – West Polish Carpathians tectonic-sketch map with localization Harbutowice profile; **B** – The geological map of the Harbutowice area (after Książkiewicz, 1966a, modified); **C** – Synthetic profile of the Siary Subunit, Magura Nappe in the Harbutowice area; **D** – The geological cross-section of the Harbutowice area (modified after Książkiewicz, 1966a)

METHODS

The evaluation of the *Haplophragmoides parvulus* Blaicher type locality was based on the field mapping, and micropaleontological observations. The original mapping (Książkiewicz, 1951a, b; 1953; 1966a, b; Golonka *et al.*, 1981; Wójcik & Rączkowski, 1994) were supplimented by recent field observation and updating of mapped formations using modern lithostratigraphic units (Cieszkowski *et al.*, 2006). Seventeen samples were collected for micropaleontological analysis. All these samples were located within the Zembrzyce Shale Member of Beskid Makowski Formation (*sensu* Cieszkowski *et al.*, 2006, Golonka & Waśkowska, 2007) of the Babica Mountain area, from Harbutowice section come from eight samples (Fig. 1).

The samples (500 g of dry shales or marls) were prepared by using standard micropalaeontological techniques in order to obtain microfossils. Repeated boiling and drying using Glauber's Salt disintegrated the samples which were then washed through a set of sieves (63–100 µm screen) and dried. Microfossil specimens were picked from the dry residue and were taxonomically identified and documented using light- and SEM photography.

GEOLOGICAL SETTING

The Zembrzyce Shale Member in the marginal part of the Magura Nappe

The profile of the Siary Zone in the Harbutowice area includes Paleocene and Eocene deposits (Burtan, 1993; Burtan & Szymakowska, 1964; Książkiewicz, 1951a, b, 1953; 1966a, b; Wójcik & Rączkowski, 1994). The older rocks in this area are represented by Paleocene – Eocene variegated shales of the Łabowa Shale Formation with packages of Lower Eocene, thick-bedded, coarse-grained, conglomeratic sandstones of the Skawce Sandsone Member (Fig. 1). Locally, sandstones prevail over the variegated shales and the Skawce Sandsone Member is in direct contact with the Silesian Nappe. The Łabowa Shale Formation is covered by the Piasierbiec Sandstone Member of the Beloveža Formation in the eastern part of the Harbutowice area. The Beskid Makowski Formation covers the Łabowa Shale Formation in the western part of the area. Three members of the Beskid Makowski Formation are exposed in the marginal part of the Siary Zone: the upper Eocene Zembrzyce Shale Member in the northern part, the Wątkowa Sandstone Member in the central part, and the Budzów Shale Member in the southern part of the area (Fig. 1). The next tectonic unit with the Wątkowa Sandstone Member is thrust over the youngest, Oligocene Budzów Shale Member in the southernmost part of the area (Książkiewicz, 1966a). The thick-bedded sandstones of the Wątkowa Sandstone Member form hills in the marginal part of the Magura Nappe. The Zembrzyce Shale and Budzów Shale members crop out in the valleys and passes.

The Zembrzyce Shale Member in the Harbutówka valley

Several well-exposed outcrops of the Beskid Makowski Formation, Siary Zone occur within the Harbutowice village area, located around 30 km southwest of Kraków (Miśkiewicz *et al.*, 2010; Stadnik *et al.*, 2011; Waśkowska *et al.*, 2010). A continuous profile of this formation can be observed in numerous streams running on the northern slopes of the Babica Range. This profile belongs to the northern wing of the Budzów-Zagórna Anticline (Wójcik & Rączkowski, 1994). The deposits of the Zembrzyce Shale Member are exposed in the upper part of Harbutowice village in the streambed of Harbutówka Stream as well as along the road parallel to this stream (Fig. 1). The outcrops are located near the narrow local road marked in Harbutowice by the sign "Cisy Raciborskiego". This sign indicates a local tourist attraction and nature protection monument – nearly 700-year old yews described in the 19th century by the Polish botanist Marian Raciborski (1863–1917).

The typical Zembrzyce shales are represented mainly by massive, medium to thick-bedded marly shales and mudstones with intercalations of marls, clayey shales and glauconitic sandstones. These shales are grey, green-gray, yellow-gray and beige in color. The sandstones are mainly fine- and medium-grained, sometimes coarse-grained, thin to medium and thick-bedded. The sandstone–marly shale sequences prevail in the outcrops along the Harbutówka stream (Fig. 2). Sometimes marly shales pass into clayey shale. The sequence sandstone–marly shale–clayey shale represents the full turbiditic cycle. The thin-bedded flysch packages are also locally present in the outcrops. The sandstones in these packages contain numerous hieroglyphs. The flutcasts indicate transportation of the clastic

Figure 2. Outcrops of the Zembrzyce Shale Member in Harbutówka valley

material generally from the northeast (Książkiewicz, 1966a). Thin layers of creamy bentonites occur sporadically within marly-muddy complexes. These bentonites provide evidence of Eocene volcanic activity.

The so-called documentary site (see Alexandrowicz & Poprawa, 2000) was registered in the Kijówka Hamlet, Harbutówka valley (area 0.5 ha). The level of protection of the documentary site is very similar to that of an SSSI (Site of Special Scientific Interest). The documentary sites represent the preservation form of abiotic natural objects in Poland. The fragment of the Zembrzyce Member profile is under protection because it is important for Carpathian micropaleontological research. The shales within the documentation site contain unusually rich assemblages of foraminifera with numerous calcareous species (Blaicher, 1961). It is the first such documentary site approved within the Polish Outer Carpathians.

Foraminiferal assemblages from the Zembrzyce Shale Member in the Harbutowice area

The low diversity assemblages, poor in specimens and dominated by agglutinated foraminifera, are typical for the Zembrzyce Shale Member. They represent the autochthonous fauna occupying the

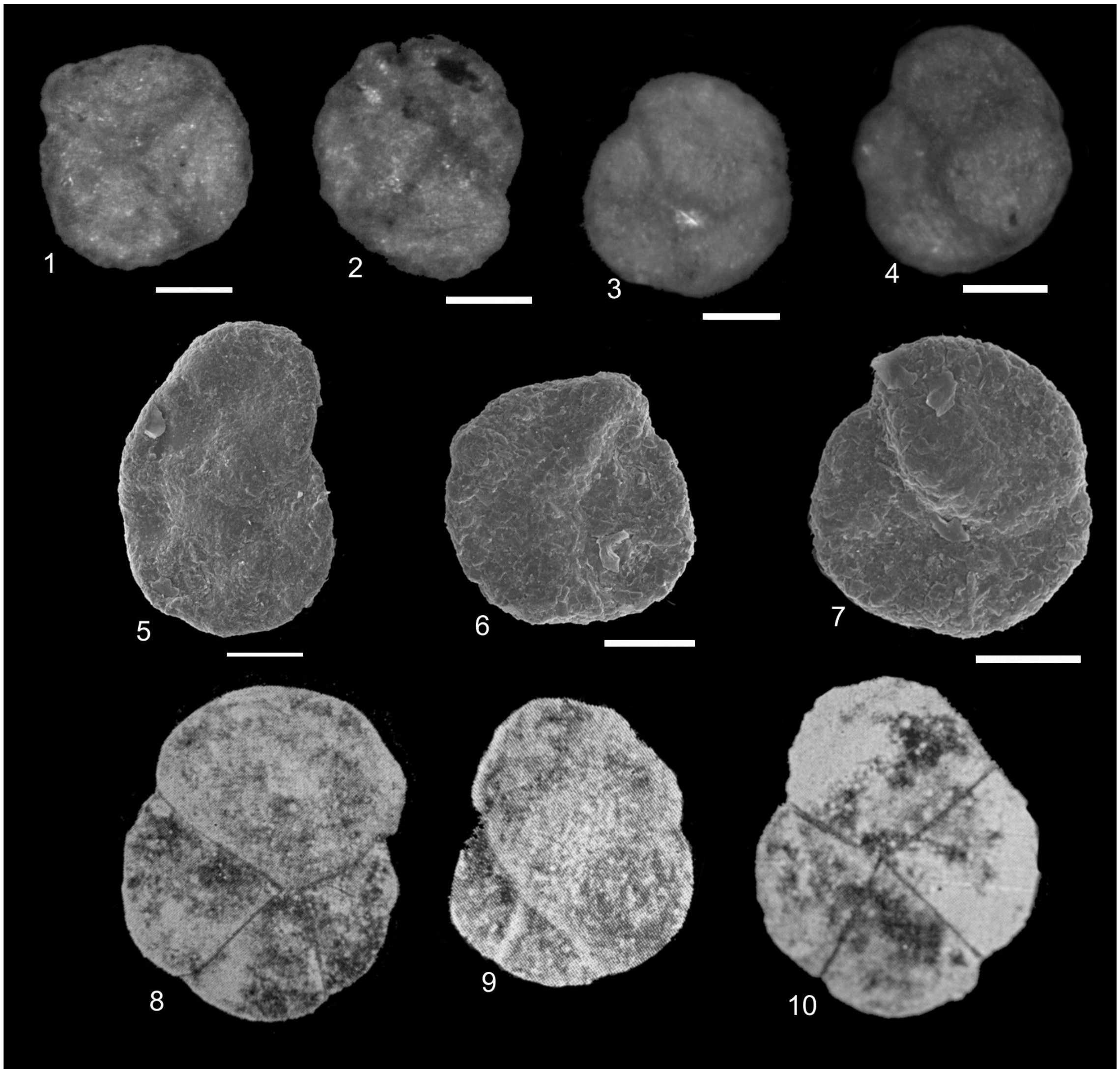

Plate 1. *Haplophragmoides parvulus* Blaicher. **1–7** – Specimens from Eocene deposits in Harbutówka valley; 8-10. Specimens documented by Blaicher (1961). Scale bar = 100μm

Magura Basin bottom. The radiolarians, fish teeth and sponges spicules represent the additional components. Assemblages with higher diversity, containing planktonic and benthonic calcareous forms are rare (e.g., Blaicher, 1961; Jednorowska, 1966, 1968, 1969). These calcareous forms are mainly redeposited from a shallower environment by turbidity currents.

Typical foraminiferal assemblages of the Zembrzyce Shale Member are dominated by cosmopolitan forms. Branched fragments of agglutinated tubes are very numerous; *Paratrochamminoides* div. sp. is also common. Among the characteristic species with biostratigraphical value, *Haplophragmoides parvulus* Blaicher, *Haplophragmoides nauticus* Kender, Kaminski & Jones, and *Praesphaerammina subgaleata* Vašiček are represented. Other important age-diagnostic forms *Ammodiscus latus* Grzybowski as well as *Reticulophragmium amplectens* (Grzybowski) are rare. *Paratrochamminoides* div. sp. (relatively high diversity within genus), *Ammodiscus cretaceus* (Reuss), *Ammodiscus peruvianus* Berry, *Cribrostomoides subglobosus* (Cushman), *Thalmannammina subturbinata* (Grzybowski), *Glomospira* div. sp. (*Glomospira glomerata* (Grzybowski) and *Glomospira* cf. *irregularis* (Jones & Parker) with locally most numerous), *Arthrodendron grandis* (Grzybowski), *Haplophragmoides* div. sp. (locally numerous *Haplophragmoides walteri* (Grzybowski)), *Haplophragmoides scitulus* (Brady), *Reophax pilulifer* Brady, *Pseudonodosinella elongata* (Grzybowski), *Psammosphaera irregularis* (Grzybowski) belong to the common foraminifera. *Eponides umbonatus* (Reuss) is the most common among calcareous benthic forms. Usually pyritized *Chilostomella* is also common.

Haplophragmoides parvulus **Blaicher, 1961 in the type locality profile**

Fifty years ago, Jadwiga Blaicher (1961) published in the *Bulletin of the Geological Institute* a paper documenting the unique and taxonomically diversified foraminiferal assemblages of the Eocene deposits of the Magura Nappe. The material for her micropaleontological investigations was collected in Harbutowice–Kijówka Hamlet and Wieprzec localities in the Siary Zone. In the Harbutowice locality, the lowermost part of the Zembrzyce Shale Member was sampled and now is selected as the documentary site.

Blaicher (1961) determined 74 species of calcareous foraminifera (benthic as well as planktonic forms) and 17 species of agglutinated forms. The larger foraminifera, bryozoa, fish teeth, ostracoda and fragments of echinodermata were documented as accompanying components. The assemblage was characterized by a mixture of autochthonous and allochthonous fauna, delivered from shallower parts of the basin. The late Eocene age was estimated by Blaicher (1961) mainly on the basis of planktonic foraminifera, and was correlated with the calcareous benthos as well as larger foraminifera ranges (Bieda, 1966).

Blaicher (1961) separated the subspecies *Haplophragmoides walteri* (Grzybowski) var. *parvulus* n. var. from the group of agglutinated foraminifera established as *Haplophragmoides walteri* (Grzybowski). The occurrence range was estimated as middle and late Eocene.

The test of *Haplophragmoides parvulus* Blaicher is flat, small, 0.5 mm and less in size, planispiral, involute, with an acute periphery, oval in outline, 4 or 4.5 chambers, sporadically 5 are located in the last whorl. Chambers are triangular in shape, their size increase rapidly. The wall is very finely agglutinated with a smooth surface. The aperture occurs at the base of the last chamber (Plate 1).

Haplophragmoides parvulus Blaicher (emend. Olszewska, 1996) is observed in flysch sediments of the Magura Nappe, within all facies zones (Olszewska, 1996; Olszewska, 1997; Malata, 1981; Olszewska & Malata, 2006). It belongs to the significant Eocene markers used in biostratigraphy, being typical for the upermost middle Eocene and upper Eocene. It occurs in rich, taxonomically diversified assemblages, and is also present within poor assemblages of agglutinated foraminifera. Its abundance is worth mentioning, in the first description report 35 specimens were analyzed, usually the number oscillates about several per sample. The number is, however, locally even higher, reaching over 100 specimens (over 30% of all foraminifera – samples from the Zawoja locality, Rača Unit). Poorly diversified assemblages with *Haplophragmoides parvulus* Blaicher were noticed frequently in sediments with higher calcium carbonate content and lower sedimentation rates (Olszewska & Malata, 2006).

CONCLUSIONS

- The Zembrzyce Shale Member of Beskid Makowski Formation profile in the Harbutowice village provides an important locality for studies of the lithology, sedimentation and biostratigraphy of the Outer Carpathian Paleogene flysch.
- The studied micropaleontological autochthonous assemblage usually contains not quite numerous, poorly diversified foraminifera of the middle Eocene age, representing the Ammodiscus latus biozone.
- *Haplophragmmoides parvulus* Blaicher represents an important marker for the Middle and Upper Eocene biostratigraphy of the Outer Carpathians Magura Nappe.

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The Żurawnica Sandstone and Skawce Sandstone members of the Łabowa Formation in the northern zone of the Magura Basin

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ABSTRACT

Two thick sandy complexes of the Żurawnica Sandstone Member (Paleocene) and Skawce Sandstone Member (Eocene) separated by variegated shales of the the Łabowa Shale Formation occur within in Sucha Beskidzka area in Siary Zone, Magura Nappe. Mainly the cosmopolitan forms with coarse-grained agglutinated tests are present in poor taxonomically diversified foraminiferal assemblages and representing autohtonic fauna of high-energy environments in the Magura Basin. These assemblages belong to recolonizators, occupying the bottom sediments after high-energy turbiditic flows. The development of foraminifera communities was limited by the dynamic delivery of clastic material. Taxomically more diversified assemblages show on longer periods with quiet sedimentation, connected with reduced clastic delivery. Large foraminifera as well as other calcareous organic components were also delivered by turbidic currents from the shallower parts of the basin. The Żurawnica Sandstone Member was deposited during Paleocene time, the Skawce Sandstone Member – during Early Eocene.

Key words: deep water foraminifera, chanel deposits, Outer Carpathians, Magura Nappe

INTRODUCTION

The Skawce Sandstone Member of the Łabowa Shale Formation was described as a new formal lithostratigrahic unit of the Magura Series by Cieszkowski and Waśkowska-Oliwa (2001). Previously, these thick-bedded coarse sandstones occurring in the northern zone of the Magura Nappe have been not correctly termed the "Ciężkowice sandstones" (e.g., Bieda, 1966, 1968; Cieszkowski, *et al*., 1999; Golonka *et al*. 1981; Jednorowska, 1966; Książkiewicz, 1966, 1974a, b; Nowak, 1921; Oszczypko, 1992). The name "Ciężkowice sandstones" introduced by Walter and Dunikowski (1882) was first use for thick-bedded Paleogene sandstones of the Silesian Nappe, occurring at the Ciężkowice town. Grzybowski (1921) made very complete description of these beds from the type locality at Ciężkowice being considered their type section. In recent times, these sandstones have been described by Leszczyński (1981), who presented their detailed sedimentological study. Świdziński (1948) following Grzybowski (1921), proposed, that the name "Ciężkowice sandstones" should be used only for coarse, thick-bedded

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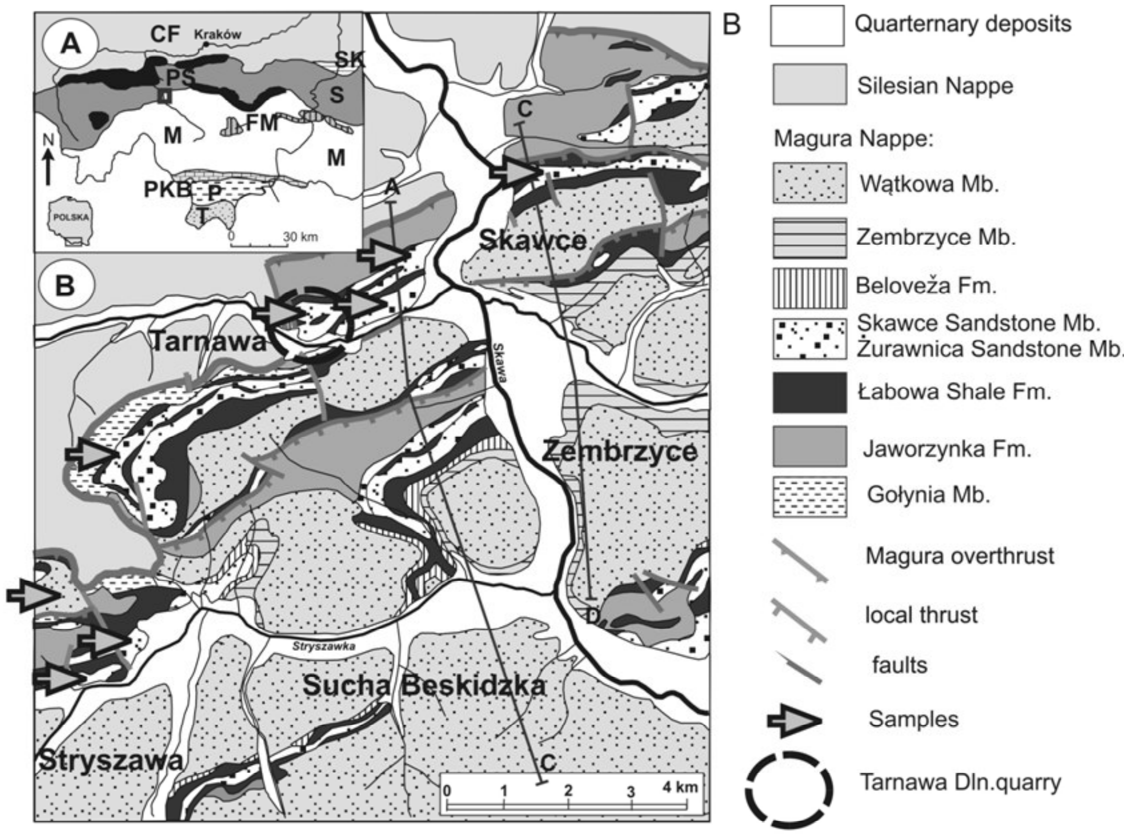

Figure 1. The geological setting of the Tarnawa Dolna quarry profile. **A** – localization on the West Polish Carpathians tectonic-sketch map; **B** – The geological map of the Sucha Beskidzka area (modified after Książkiewicz, 1974a)

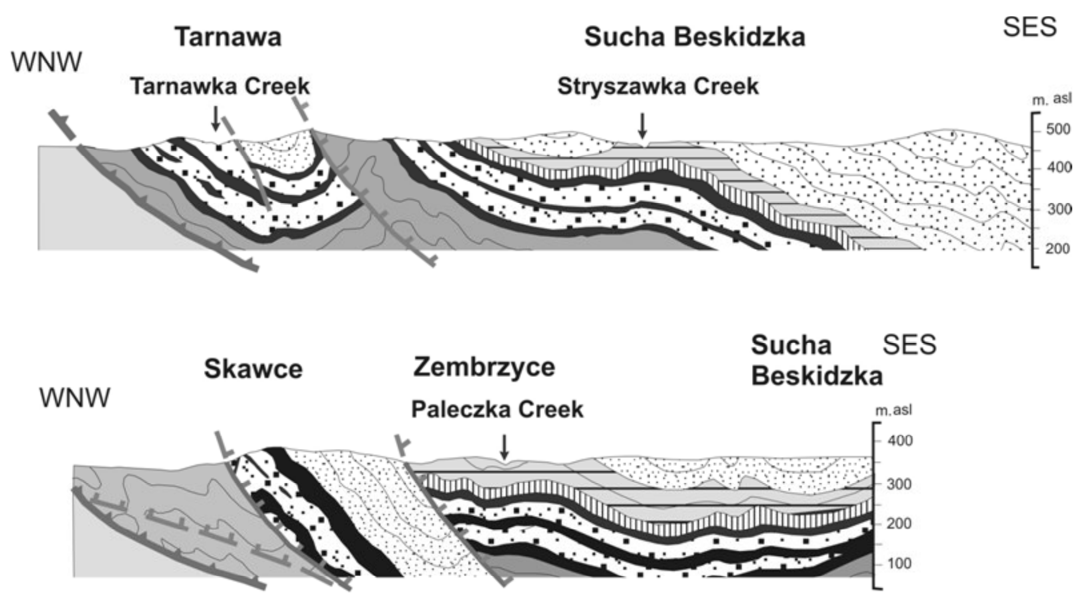

Figure 2. Geological cross-sections of the Sucha Beskidzka area (after Cieszkowski & Waśkowska-Oliwa, 2001)

Eocene sandstones from the Silesian Nappe. From the point of view of formal stratigraphy this name should not be used in the Magura Nappe as proposed by Książkiewicz (1974) because the source areas of detritic material supplied to the Magura and Silesian Basin during Late Paleocene and Early Eocene were different and represent completely different lithosomes.

Książkiewicz (1948, 1962, 1966, 1974a, b) described in details the „Ciężkowice sandstones" from the western part of the Magura Nappe, presenting in the Sucha Beskidzka area, that two sandstone levels occur. Cieszkowski and Waśkowska-Oliwa (2001) and Cieszkowski *et al.*, 2006 formalized these sandstones to the Żurawnica Sandstone Member and the Skawce Sandstone Member within the Łabowa Shale Formation (Oszczypko, 1991) developed as variegated shale. They reserved name "Skawce Sandstone Member" for the upper complex of the of thick bedded sandstones within the variegated shales of the Łabowa Shale Formation, and proposed to name the lower "Żurawnica Sandstone Member". The reference section for the Żurawnica Sandstone Member shoud be outcrops on the Żurawnica hill located between villages of Tarnawa Górna and Stryszawa.

METHODS

The studies of sandy complexes represented by the Skawce Sandstone and Żurawnica Sandstone members concentrated on lithostratigraphic, facial and paleogeographic analysis including also micropaleontological investigations. 25 samples for foraminiferal research were collected from muddy deposits within both members (localities: Skawce quarry, Skawce village, Żurawnica Mt., Stryszawka, Sucha Beskidzka sections) (Fig. 1). The material of samples (amount of 500 g of dry shales) was prepared to foraminiferal analysis by using standard micropalaeontological techniques (maceration in Glaubert's salt solution and sieved in 63 µm screen). All foraminiferal specimens were picked from residue for biostratigraphical purpose. Most samples were barren, only few of them contain foraminifera, exclusively agglutinated.

LITHOLOGY

The Żurawnica Sandstone Member (ŻSM) (thickness – up to 200m) and Skawce Sandstone Member (SSM) (thickness up to 150m) (Fig. 1, 2) are predominantly represented by thick- and very thick- bedded (up to 2,5 m) sandstone turbidites with subordinate interbeddings of thin- to medium-bedded sandstone turbidites (Fig. 3). They are occasionally separated by green or red shales. The ŻSM and SSM correspond to facies A2.2-5, B2.3, B2.4, C2.1, and C2.2 after Pickering *et al.* (1986). Thick-bedded sandstones are coarse- and very coarse-grained, often conglomeratic (Fig. 4). Fine-grained conglomerates are in some cases quite frequent. Coarser conglomerates are sporadic. The sandstones are badly sorted, coarser material is often concentrated at lower parts of the layers. Thick-bedded sandstones are massive and often amalgamated (Fig. 3). Occasional parallel or cross lamination represented by Bouma Tbc or Tbcd divisions are noticed in upper parts of the layers. Partly, these occur inverse gradation of coarse sandy or pebbly grains including shale clasts, concentrated at top of the layers. Soles of the sandstone layers are sharp, planar, with rare sole marks indicating paleotransport of detritic material from N, NW, and WNW.

Foraminiferal assemblages

Microplaeontological samples taken from shales within thick-bedded sandstones of SSM and ŻSM (Fig. 1) are lack of microfossils (15 samples) or contain poor foraminiferal record (10 samples), including low-diversified assemblages with cosmopolitan species, adopted to the high-energy environments. The forms with coarse-grained agglutinated tests and relatively big size like *Bathysiphon* (numerous), *Hyperamina elongata* Brady, *Paratrochamminoides* (numerous and diversifited): *P. subcoronatus* (Grzybowski), *P. mitratus* (Grzybowski), *Conglophragmium irregularis* (White), *Praesphaerammina gerochi* Hanzlikovà, *Placentammina placenta* (Grzybowski), *Subreophax pseudoscalaris* (Samuel), *Psammosphaera* *irregularis* (Grzybowski), *Reophax pilulifer* Brady, *Recurvoides* div. sp., and *Trochamminoides grzybowskii* Kaminski & Geroch are present there. Such unified composition of assemblages is typical of discussed deposits.

Dynamic delivery of coarse-grained clastic material to the sedimentary basin restricted development of the bottom foraminiferal microfauna. These poor assemblages represent the recolonizators, which occupied bottom sediments after turbidite deposition. More numerous and diversified assemblages showing longer periods with quiet sedimentation are there rare.

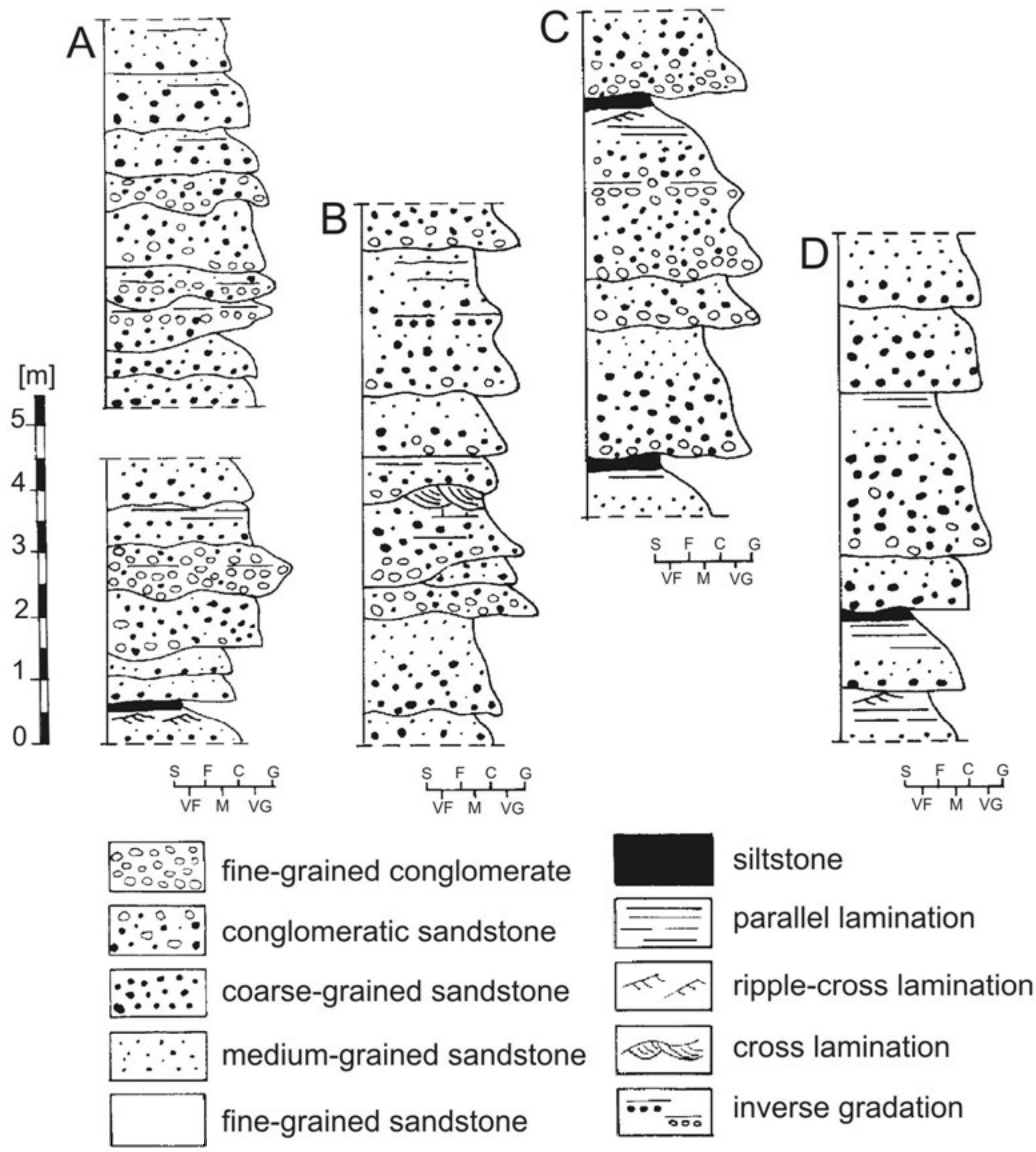

Figure 3. Sedimentary logs of the Skawce Member

The stratigraphic position of SSM and ŻSM was firstly estimated indirectly on the base of their position in the litostratigraphic sections. The Paleocene age of ŻSM was directly confirmed by occurrence of *Rzehakina fissistomata* (Grzybowski), *Rzehakina epigona* (Rzehak), *Hormosina velascoensis* (Cushman), *Caudammina ovula* (Grzybowski), and *Annectina grzybowskii* (Jurkiewicz) (Książkiewicz, 1974 b; Fig. 5). Such taxonomical composition is typical for *Rzehakina fissistomata* Zone (zone *sensu* Olszewska, 1997). The study (type locality – Żurawnica Mt., Kozie Skały) suggest that the ŻSM corresponds to the Upper Paleocene. This is suggested by an occurrence within mentioned above assemblage the *Haplophragmoides* cf. *mjatliukae* Maslakova (which is more frequent in middle and upper part of *Rzehakina fissistomata* zone) and *Annectina* cf. *biedai* Gradstein & Kaminski (in Carpathian with first occurrence in Late Paleocene).

The SSM includes single specimens of *Saccamminoides carpathicus* Geroch (index taxa for Early Eocene interval biozone) and *Reticulophragmium amplectens* (Grzybowski) (Fig. 5). In the Outer Carpathians these species are characteristic of the uppermost part of the Early Eocene (e.g., Morgiel & Olszewska, 1981; Geroch & Nowak, 1984; Olszewska, 1996, 1997; Waśkowska, 2011). Moreover the large foraminifera as *Nummulites planulatus* Lamarck, *Nummulites exilis* Douville, *Nummulites*

Figure 4. Outcrops of Skawce Sandstone Member in Tarnawa Dolna quarry: **1** – General view. **2, 3** – Thick- and medium-bedded sandstone. **4** – *Zoophycos*. **5** – Calcareous clasts in the conglomerates

globulosus Leymerie and *Discocyclina douvillei* (Schlumberger) occur in the sandstone layers SSM (Bieda, 1959; Książkiewicz, 1974b). Large foraminifera are here allochtonic fauna, and they were delivered from shallow parts of the Magura Basin. Sandstones and conglomerates of SSM occur also

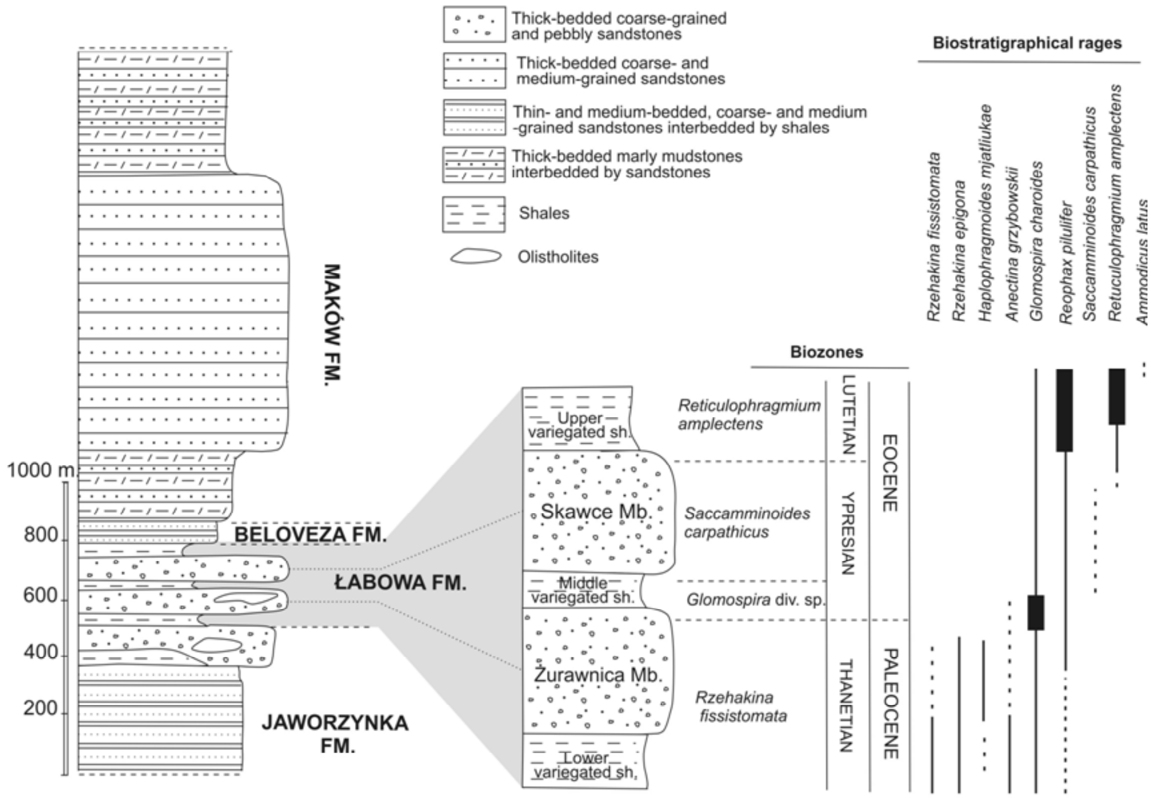

Figure 5. Litho- and biostratigraphy of the Łabowa Shale Formation in the Sucha Beskidzka area

calcareous fossils with remnants of bryozoans and algae with *Lithothamnium pieces* and rhodoids completed *ex situ*.

The sandstones of the SSM and ŻSM represent deep-water coarse-grained thick-bedded turbidite sedimentation. Their deposition took place in the northern part of the Magura Basin.

Sandstones of SSM include also trace fossils described from these sediments Scolicia, Granularia and Taphrhelminthopsis (Książkiewicz, 1974b). The authors observed other trace fossils like Thalassinoides, Ophiomorpha and Zoophycos was also found.

CONCLUSIONS

Two thick-bedded sandy complexes belonging to the Żurawnica and Skawce Sandstone members of Łabowa Shale Formation create the Paleocene–Early Eocene part of the Magura Nappe (the Siary Zone) in the Sucha Beskidzka area. Foraminiferal assemblages from these sediments represent the *Rzehakina fissistomata* Zone (Żurawnica Sandstone Member) and *Saccamminoides carpathicus* Zone (Skawce Sandstone Member). The poor deep water agglutinated foraminiferal assemblages occurring mainly cosmopolitan forms coarse-grained are characteristic for these deposits, which are interpreted as channel sediments. They represent typical assemblages adapted to the higher-energy environments, which existed on the bottom of the Magura Basin during longer brakes of dynamic delivery of clastic material transported by turbidity currents.

ACKNOWLEDGEMENTS

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Deep-water agglutinated foraminifera in Paleogene hemipelagic sediments of the Magura Basin in the Sucha Beskidzka area – variegated shales of the Łabowa Shale Formation

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ABSTRACT

Sedimentation of the variegated shales of the Łabowa Shale Formation in the Siary Zone of the Magura Basin commenced during the late Paleocene and lasted up to the middle Eocene. Quiet sedimentation of shales, mostly from a free fall suspension regime below the CCD, was favorable for the development of agglutinated foraminiferal communities. The Paleocene shales contain characteristic rich assemblages of the *Rzehakina fissistomata* Zone, followed by poor *Recurvoides* and *Glomospira* assemblages of the latest Paleocene and earliest Eocene connected with the LPTM crisis interval. These are followed by post-crisis *Karrerulina* assemblages, as well as assemblages of the *Saccamminoides carpathicus* Zone (Early Eocene) and the *Reticulophragmium amplectens* Zone (middle Eocene). Numerous very thin bentonite layers in the upper variegated shales subdivision of the Łabowa Shale Formation are found. The foraminiferal assemblages from these bentonite intercalations show low taxonomic diversity with numerous juvenile forms and increased numbers of *Glomospira charoides* (Jones & Parker).

Key words: Magura Basin, Łabowa Shale Formation, hemipelagic sedimentation, Late Paleocene–middle Eocene, agglutinated foraminifera

INTRODUCTION

The Łabowa Shale Formation is found within the middle and northern facies-tectonic zones of the Magura Nappe (Bystrica, Rača and Siary zones) in the Northern Outer Carpathians in Poland, Slovakia, and the Czech Republic (Fig. 1). The name "Łabowa beds" was firstly used by Węcławik (1986) with reference to the Paleocene–Eocene variegated shales of the Magura Series – the sedimentary succession of the Magura Nappe. This division was previously described as the "variegated Eocene" (e.g., Kozikowski, 1953) or "variegated shales" (Książkiewicz, 1948, 1951, 1953, 1958, 1962, 1966a, b, 1974a, b; Bieda *et al.*, 1967; Sikora & Żytko, 1959; Unrug, 1968, Węcławik, 1969; Sikora, 1970; Oszczypko, 1973;

In: Bąk, M., Kaminski, M.A. & Waśkowska, A. (eds), 2011. Integrating Microfossil Records from the Oceans and Epicontinental Seas. *Grzybowski Foundation Special Publication*, **17**, pp. 53–63.

Burtan, 1973a, b; Golonka & Wójcik, 1976, 1978; Cieszkowski, 1992a, b and Kender *et al.*, 2005). In the Czech and Slovak republics the "variegated shales" have been included into the Beloveža Formation (Beloveža beds) as the lower part of this division (e.g., Pesl, 1963; Andrusov, 1965; Leško, & Samuel, 1968; Roth, 1967; Eliaš *et al.*, 1990, Pivko, 2002).

The Łabowa Shale Formation was named by Oszczypko (1991) in his paper presenting the new formal stratigraphy of the Paleogene sedimentary succession of the Bystrica Subunit (Zone) of the Magura Nappe. This lithostatigraphic division of the Magura Series consists of the Paleocene – Eocene variegated shales underlain by the Upper Cretaceous–Paleocene flysch deposits of the Ropianka Formation (Inoceramian beds) or Jaworzynka Formation (biotite facies of the Inoceramian beds), and overlain by the Lower and middle Eocene thin-bedded flysch of the Beloveža Formation. The author has chosen the type section of the discussed formation in Łabowa village in the Beskid Sądecki mountain range. There along the Uhryński Creek one of the best exposures of the Paleogene variegated shales of the Magura Nappe is located. The profile at Żeleźnikowski Stream in Żeleźnikowa village in the Beskid Sądecki has been proposed as the reference section. Others were chosen at Zbludza Stream flowing southward from the Beskid Wyspowy and Zasadne Stream flowing northeastward from the Gorce mountain range, both flowing into the Kamenica Gorczańska River in Kamienica village. Though Oszczypko (1991) focused on the sedimentary succesion of the Bystrica Subunit, in his paper he stated that the Łabowa Formation is widespread in the whole of the Magura Nappe with the only exception being the Krynica Subunit (Zone).

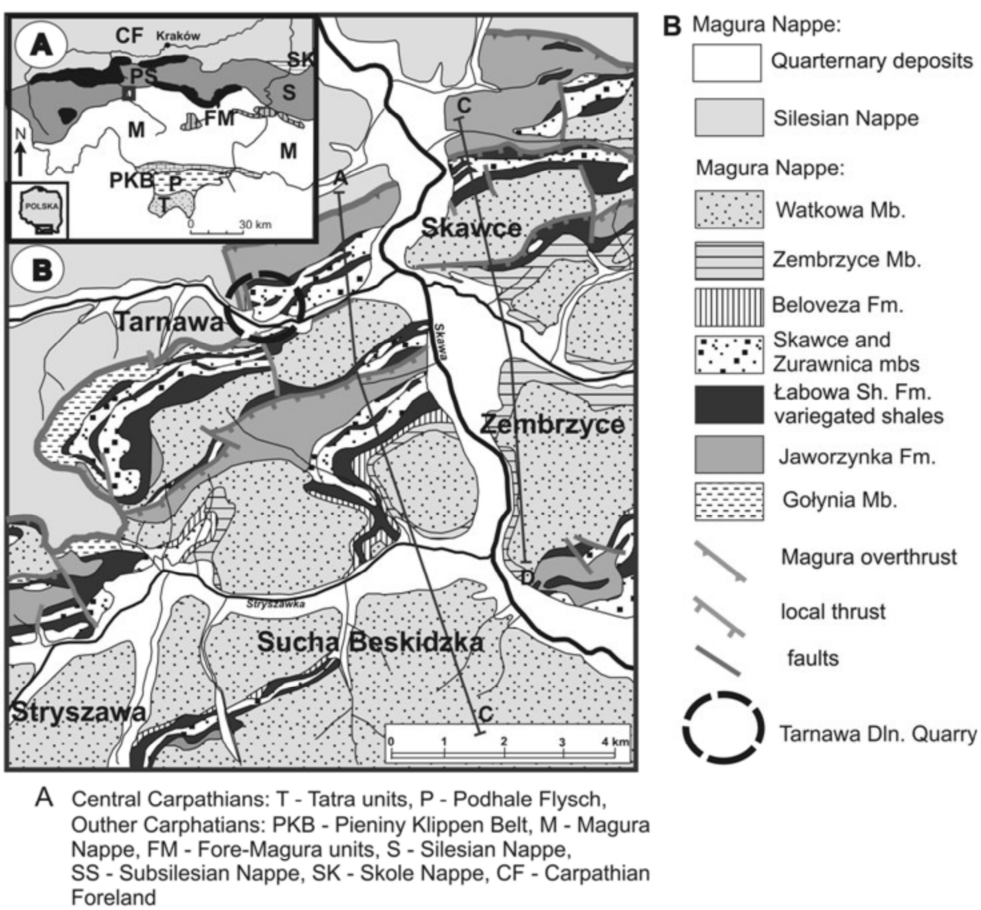

Figure 1. The geological setting of the Tarnawa Dolna quarry profile. **A** – Localization on the West Polish Carpathians tectonic-sketch map. **B** – The geological map of the Sucha Beskidzka area (modified after Książkiewicz, 1974a)

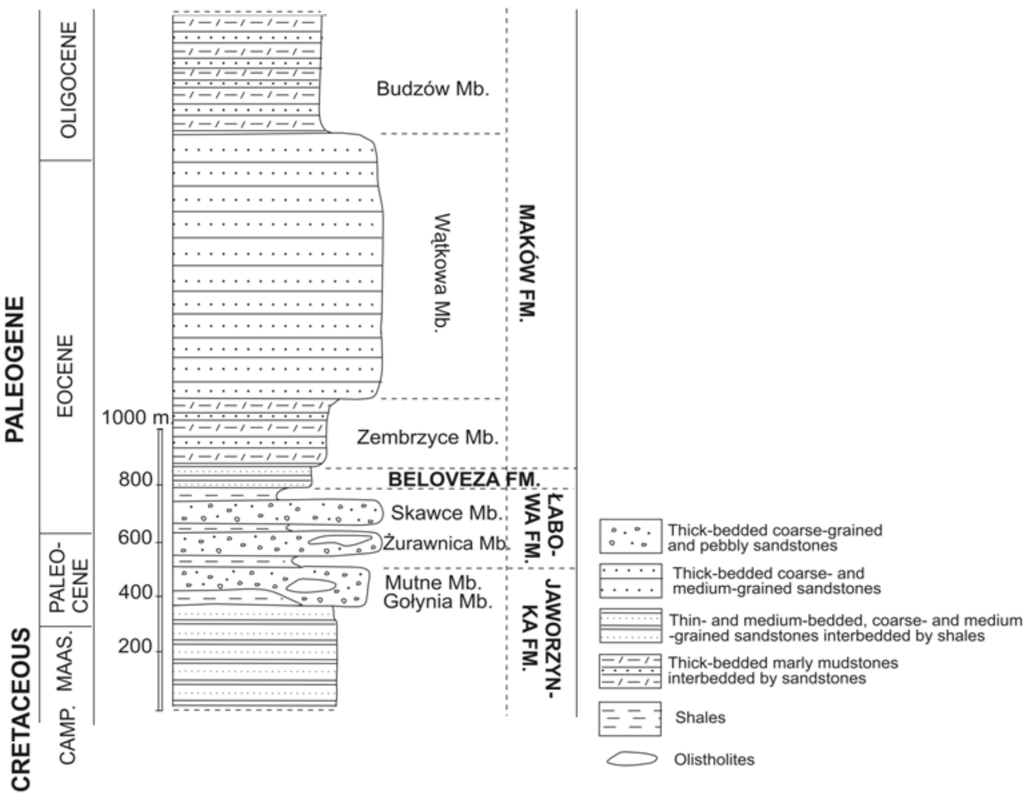

Figure 2. Lithostratigraphic log of the Siary Zone (Magura Nappe) in the Sucha Beskidzka area

Following Oszczypko (1991), the name "Łabowa Shale Formation" has been used in later publications (e.g., Oszczypko, 1992a, b; Oszczypko *et al*., 1999, 2005; Cieszkowski *et al*., 1999; Waśkowska-Oliwa & Malata, 1999; Waśkowska-Oliwa, 2000; Cieszkowski & Waśkowska-Oliwa, 2001). Cieszkowski & Waśkowska-Oliwa (2001) first used the formal name of the discussed lithostratigraphic division to describe the variegated shales from the Siary Subunnit of the Magura Nappe in the Sucha Beskidzka area. They proposed to consider outcrops of the Łabowa Shale Formation exposed in Sucha Beskidzka along the Stryszawka Creek as a further type section. Cieszkowski & Waśkowska-Oliwa (2001) concentrated especially on two of the thick-bedded sandstone levels interbedding the variegated shales and proposed to divide them as a new formal division with the rank of lithostratigraphic members of the Łabowa Shale Formation. The lower level was named the Żurawnica Sandstone Member, and the upper the Skawce Sandstone Member (cf. also: Cieszkowski *et al*., 2006, Cieszkowski & Waśkowska, this volume).

Lithological development of the Łabowa Shale Formation.

In its type area, the Łabowa Shale Formation is represented by clayey, red and cherry-red, noncalcareous, massive shales with intercalations of gray-bluish shales, with very thin-bedded silt-mud couplets, occasionally with very thin sandstone turbidites showing Bouma's Tcd subdivisions (Oszczypko, 1991). In the Sucha Beskidzka area a very similar development of shale complexes of this formation have been noticed, but here thick-bedded sandstone members occur (Fig. 2). In the lower part of the formation, below the Żurawnica Sandstone Member red clayey massive shales dominate. In the middle part between the discussed members and in the upper part above the Skawce Sandstone Member red shales are

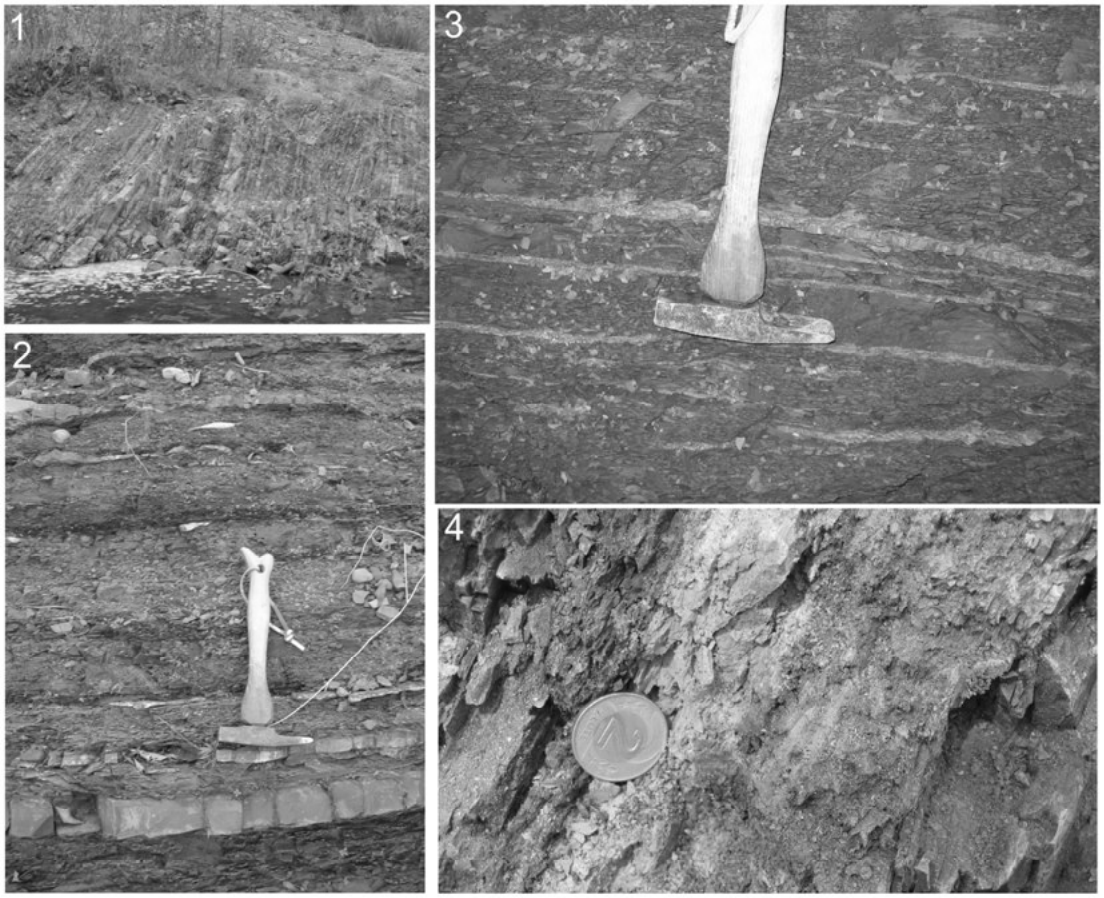

Figure 3. Outcrops of the Łabowa Shale Member – upper part in the Stryszawka section. **1** – General view. **2** – variegated (red, green and gray) shales with sandy intercalations. **3** – Cherry shales with very thin-bedded sandstones. 4 – Zone with bentonite intercalation

intercalated with a different frequency with thin layers of green shales and occasionally by thin- or very thin thin-bedded green quartz-glauconitic sandstones representing the turbidite Tcd subdivisions. Within the Łabowa Shale Formation occasional very thin intercalations of benthonites as well as manganiferous mineralizations have been recorded. In the surroundings of Sucha Beskidzka, this formation is underlain by the Ropianka Formation and overlain by the Beloveža Formation, but often directly by the Zembrzyce Shale Member (Submagura Shales) of the Maków Formation (Cieszkowski & Waśkowska-Oliwa, 2001; Cieszkowski *et al.*, 2006).

Sedimentation of the variegated shales of the Łabowa Shale Formation took place below the CCD, in quiet, hemipelagic conditions comparable to those of an abyssal plane. Occasional activity of low-density turbidite currents took place. Only in the northern part of the Magura Basin in the Siary Zone, an increasing flux of high-density turbidity currents formed two levels of thick-bedded sandstones-the Żurawnica and Skawce sandstone members-that formed a channel-lobe sedimentary system (Cieszkowski & Waśkowska, this volume).

The upper variegated shales of Łabowa Formation

Recently, outcrops of the Łabowa Formation in Sucha Beskidzka formed in the bed and banks of the Stryszawka River (Fig. 3). They are located in the central part of the Sucha Beskidzka, north of the railway station and in the eastern part between the hamlets Kotlinki and Głuszki. The second are especially well exposed. During last several years, lowering of the erosional base of the river caused removal of aluvial gravels filling the river bed and the deposits of the Magura Series were exposed. Below the bridge in Głuszki at a distance of 0,5 km downriver it is possible to observe variegated shales of the upper part of the Łabowa Formation, folded and cut by a sequence of meso-scale faults. Red clayey massive shales pass up the section into red intercalated by green. Within the massive red shales lamina 1–5 mm thick of bentonites and manganese mineralisations occur. Manganese oxides occur in shales especially in places with intense tectonic fracture density. Traces of malachite have also been noticed. Occasional intercalations of thin- or very thin thin-bedded green quartz-glauconitic sandstones representing turbidite Tcd subdivisions are more frequent in the upper part of the section. In uppermost part of the formation, couplets of several thin-bedded sandstone layers intercalated by gray-green shales developed as a Hieroglyphic bed-like facies are observed.

Upsection, the Łabowa Shale Formation passes into the Beloveža Formation, middle–late Eocene in age, represented by light gray, thin- and medium-bedded, fine grained calcareous sandstones with parallel and cross laminated Bouma (Tbcd and Tcd) sequences, intercalated by gray-bluish marly shales. Thin or medium bedded intercalations of soft, light-gray marls and occasional thin layers of calciturbidites also occur. In one place thick-bedded sandstones of the Skawce Sandstone Member arrive from below the red shales. The contact between the red shales and the sandstones is not normal, but tectonic. The sandstones formed a kind of horst delimited by a few faults.

METHODS

The Łabowa Shale Formation has been studied in detail by the authors during the field investigation carried out in the Sucha Beskidzka area in the last several years. The area was mapped and the sampling for different analyses including also foraminifera. The material for biostratigraphical analysis (in number of 30 samples) was taken from variegated shales from Skawce, Sucha Beskidzka PKP, Grygle, Żurawnica and Błądzonka sections. Usually a few samples were picked from each locality in different parts of the outcropping section of the Łabowa Shale Formation, documenting the lower, middle and upper levels of the variegated shales. Additionally, the upper shales were sampled in more detail, especially the part of the sections containing bentonite intercalations in the Stryszawka section (10 samples from section is described above). The mudstones or muddy siltstone samples (about 0,5 kg) were prepared using standard micropaleontological methods (maceration in Glauber's salt solution, sieving over a 63 µm sieve, picking foraminiferal specimens from residue).

RESULTS

Foraminifera of the Łabowa Shale Formation from Sucha Beskidzka area

The Paleocene–Eocene time interval in the Magura Basin is associated with the sedimentation of variegated shales of the Łabowa Shale Formation (Oszczypko, 1991). The origin of this type of sedimentation is first seen in the Siary Zone, in northern marginal part of the Magura Basin. Later this sedimentation steeply covered other parts of the basin floor. The quiet sedimentation, mostly from free-fall suspension, was favorable for development of foraminiferal communities. Therefore, the Łabowa Shale Formation is known as a micropaleontologically well-documented lithostratigraphic subdivision (e.g., Bieda *et al*., 1967; Geroch *et al*., 1967; Jednorowska, 1966, 1968; Kender *et al*., 2005; Książkiewicz, 1974b; Jurkiewicz, 1967; Malata, 1981; Malata *et al*., 1996). Usually well-preserved, abundant specimens and taxonomically diversified assemblages are known from this deposits. Foraminiferal assemblages contain mainly agglutinated foraminifera, typical for deep water environments below the CCD (Cieszkowski & Waśkowska-Oliwa, 2001; Malata, 2000; Olszewska & Malata, 2006; Waśkowska-Oliwa, 2000), recognized as an autochtonous microfauna.

Deposits of the Late Paleocene–middle Eocene time interval include a complete foraminiferal record. In the lower variegated shale subdivision below the Żurawnica Sandstone Member, this is registered by

Paleocene assemblages with *Rzehakina fissistomata* (Grzybowski) and *Annectina grzybowskii* (Jurkiewicz). Assemblages of the middle variegated shale division are diverse and in stratigraphic order contain assemblages with numerous *Recurvoides*, followed by *Glomospira* and *Karrerulina*, and finally assemblages with *Saccamminoides carpathicus* Geroch. Such a succession of assemblages is connected with uppermost Paleocene to Early Eocene time interval. The Late Paleocene Thermal Maximum (LPTM) had a distinct affect on the composition of the deep water foraminiferal communities (Kennett & Stott, 1991; Miller *et al.*, 1987; Pak & Miller, 1992; Thomas, 1998; Thomas & Shackleton, 1996; Tjalsma & Lohman, 1983; Galeotti *et al.*, 2004). Foraminiferal communities reacted to changes in the deep-water environment caused by the mass extinction of benthic foraminifera. As a consequence, 16 species disappeared in the Magura Basin (Olszewska & Malata, 2006), and post LPTM-crisis assemblages are undifferentiated and dominated by *Glomospira charoides* (Jones & Parker). This oportunistic assemblage gives way to a more varied assemblage with numerous *Karrerulina conversa* (Grzybowski) and *Karrerulina coniformis* (Grzybowski) indicating more favorable life conditions (Bąk, 2004). The assemblages with numerous *Reticulophragmium amplectens* (Grzybowski) and *Reophax pilulifer* Brady are characteristic for the sub division of variegated shales placed in section above the Skawce Sandstone Member and indicate the middle Eocene age of shaly sedimentation. Westward in the Myślenice area, a single *Ammodiscus latus* Grzybowski was found in this upper division of variegated shales.

Foraminiferal record of the Łabowa Shale Formation (upper subdivision) in Stryszawka creek-*reference section*

The uppermost variegated shale subdivision of the Łabowa Formation is well exposed in the banks of Stryszwka creek in Stryszawa village. The foraminiferal assemblages from this locality are typical for the *Reticulophragmium amplectens* biozone (zones after Olszewska, 1997) and contain only agglutinated cosmopolitan deep-water forms. The index taxon is numerous and occurs together with *Ammodiscus* div. sp., *Ammolagena clavata* (Jones & Parker), *Bathysiphon* spp., *Glomospira* div. sp., *Karrerulina conversa* (Grzybowski), *Recurvoides* div. sp. and *Thalmannammina subturbinata* (Grzybowski), *Reophax pilulifer* Brady, and numerous *Pseudonodosinella elongata* (Grzybowski), *Paratrochamminoides* div. sp. (*P. subcoronatus* (Grzybowski)-common), *Rhabdammina*, *Haplophragmoides walteri* (Grzybowski), *Placentammina placenta* (Grzybowski), *Haplophragmoides kirki* Wickenden, *Cribrostomoides subglobosus* (Cushman), *Subreophax pseudoscalaris* (Samuel), *Karrerulina coniformis* (Grzybowski), and *Eggerella propinqua* (Brady). As additional components radiolaria and single fish teeth were found there. Rich and diversified assemblages developed in Magura Basin during slow deposition. The sedimentation rate is estimated to be on the order of 15-20m/mln years (Oszczypko & Oszczypko-Clowes, 2006).

In the Łabowa Shale Formation (upper shale subdivision) numerous epifaunal species *Ammolagena clavata* (Jones & Parker) attached to foraminiferal tests were found. Specimens of *Ammolagena clavata* are observed with foraminifera belonging to epifaunal *Rhabdammina*, *Ammodicus*, and *Paratochamminoides*, as well as it is attaching to some infaunal tests e.g., *Reticulophragmium*, *Reophax*, *Recurvoides* and *Karrerulina*. Probably *Ammolagena clavata* settled on infaunal tests (dead foraminifera) exposed on the surface of sediment (Kaminski *et al.*, 2009), during conditions of minimal delivery of sedimentary material depositing on the basin floor.

The low sedimentation rate was favourable for the deposition of bentonites, and intercalations of thin bentonite layers are observed within the variegated shales of the Łabowa Formation. These are connected with volcanic activity that produced volcanic ash falling to the sea floor in Eocene times. The upper variegated shales sub division contains the most numerous bentonite layers. Deposition of bentonite in the deep water of basin is reflected by very low supply of clastic material, consequently pyroclastics were not diluted by terrigenous material. Reduced foraminiferal assemblages were

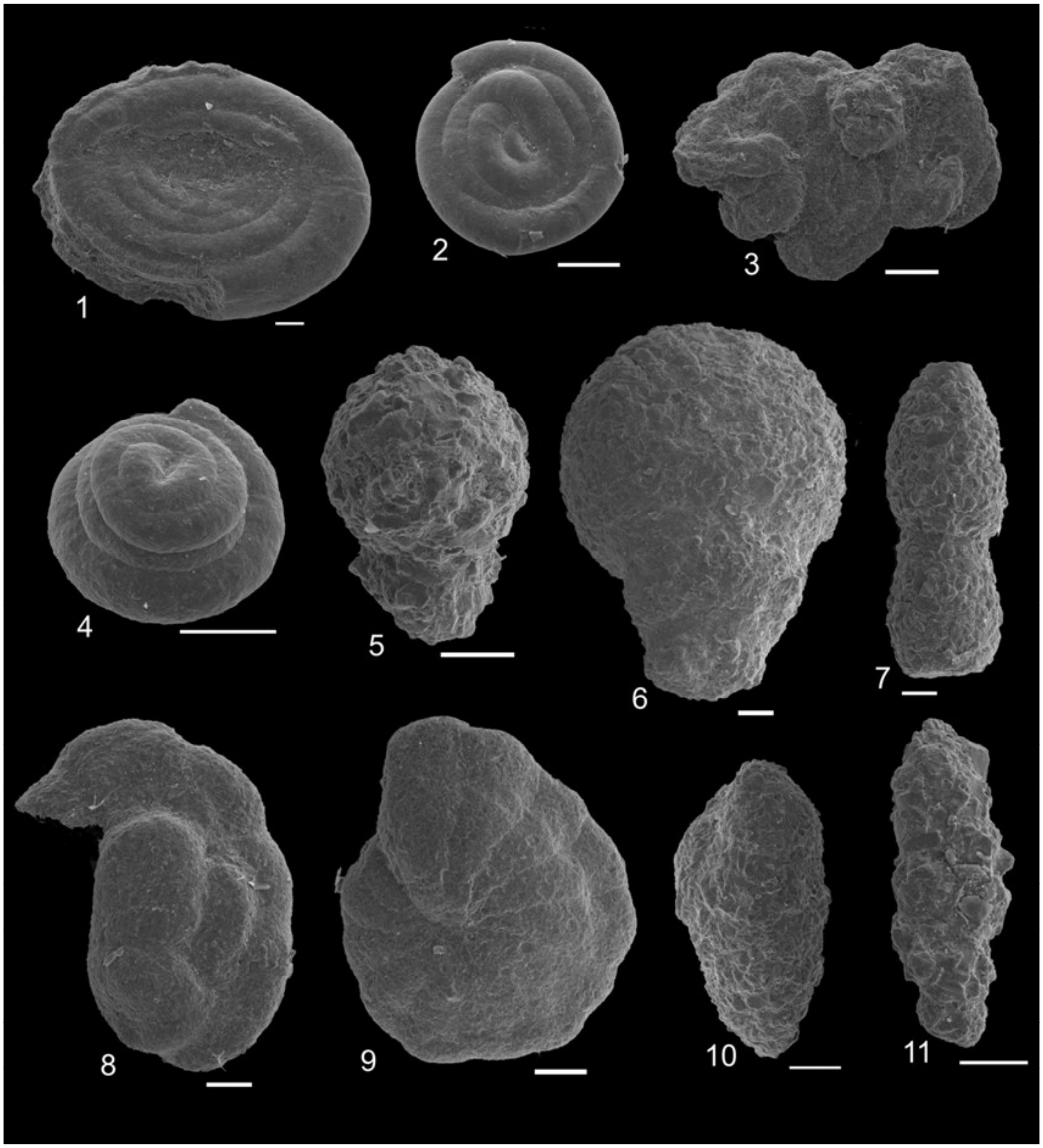

Plate 1. Foraminifera from the Łabowa Shale Formation (upper subdivision) in the Stryszawka section. **1** – *Ammodiscus cretaceus* (Reuss). **2** – *Glomospira gordialis* (Jones & Parker). **3** – *Glomospira glomerata* (Grzybowski). **4** – *Glomospira charoides* (Jones & Parker). **5** – *Reophax duplex* Grybowski. **6** – *Reophax pilulifer* Brady. **7** – *Pseudonodosinella elongata* (Grzybowski). **8** – *Paratrochamminoides heteromorphus* (Grzybowski). **9** – *Reticulophragmium amplectens* (Grzybowski). **10** – *Karrerulina coniformis* (Grzybowski). **11** – *Karrerulina conversa* (Grzybowski). Scale bar – 100µm

observed in samples taken from benthonite layers. Usually dwarfed foraminifera with low taxonomic diversity and numerous juvenile forms (especially many specimens of *Reticulophragmium amplectens* (Grzybowski)), with an increased number of *Glomospira charoides* (Jones & Parker) were observed. This type of assemblage is known as a crisis assemblage, reflecting local short-term environmental changes, and were observed in Lower Eocene bentonites of the Subsilesian Sedimentary Zone in the Outer Carpathians (Waśkowska, 2011).

In mudstone intercalations, a low diversity assemblage (represented by a few species only) is observed, with dominant *Reticulophragmium amplectens* (Grzybowski) and *Reophax pilulifer* Brady, occasionally rich *Karrerulina conversa* (Grzybowski). Generally the infaunal group dominates. Typical for this assemblage is the occurrence rather large-size specimens with coarse-grained tests and a lack of fragile foraminifera. This community reflects variable sedimentary conditions during the Łabowa Shale deposition and represents episodes with an increased supply of clastic material to the floor of the Magura Basin during the middle Eocene. Then, the barren samples with no microfauna correspond with intervals when the sea floor was not recolonized after a catastrophic higher energy turbidic flow. In the uppermost part of the Łabowa Formation the thin-bedded sandstone intercalations occur more frequently (Waśkowska-Oliwa, 2000).

CONCLUSIONS

In the Sucha Beskidzka area, the Łabowa Shale Formation is interbedded by two relatively thick sandy complexes. They subdivide the section of variegated shales to three levels: lower, middle and upper. The sedimentation of the Łabowa Shale Formation lasted from the late Paleocene (Rzehakina fissistomata zone – uppermost part) up to the middle Eocene (Reticulophragmium amplectens zone). The results of the global LPTM event are recorded in the middle variegated shales, though the sequence of *Recurvoides*, *Glomospira*, *Karrerulina* associations and assemblages are characteristic for Saccamminoides carpathicus zone. Low sedimentation rate during the deposition of the Łabowa Formation is reflected in sedimentary features of the sediments, especially in bentonites. It is likewise reflected in the very rich and taxonomically diversified foraminiferal assemblages and particularly numerous specimens of *Ammolagena clavata* Jones & Parker attached to the infaunal tests of other foraminifera. Detail sampling shows that environmental conditions during the Łabowa Shale Formation sedimentation were variable. Foraminiferal communities existing on the floor of the Magura Basin were subjected to numerous crises. Each episode (e.g., connected with the deposition of dilute pyroclastic material or a smalll amount of sandy material) modified the taxonomical structure of the assemblages.

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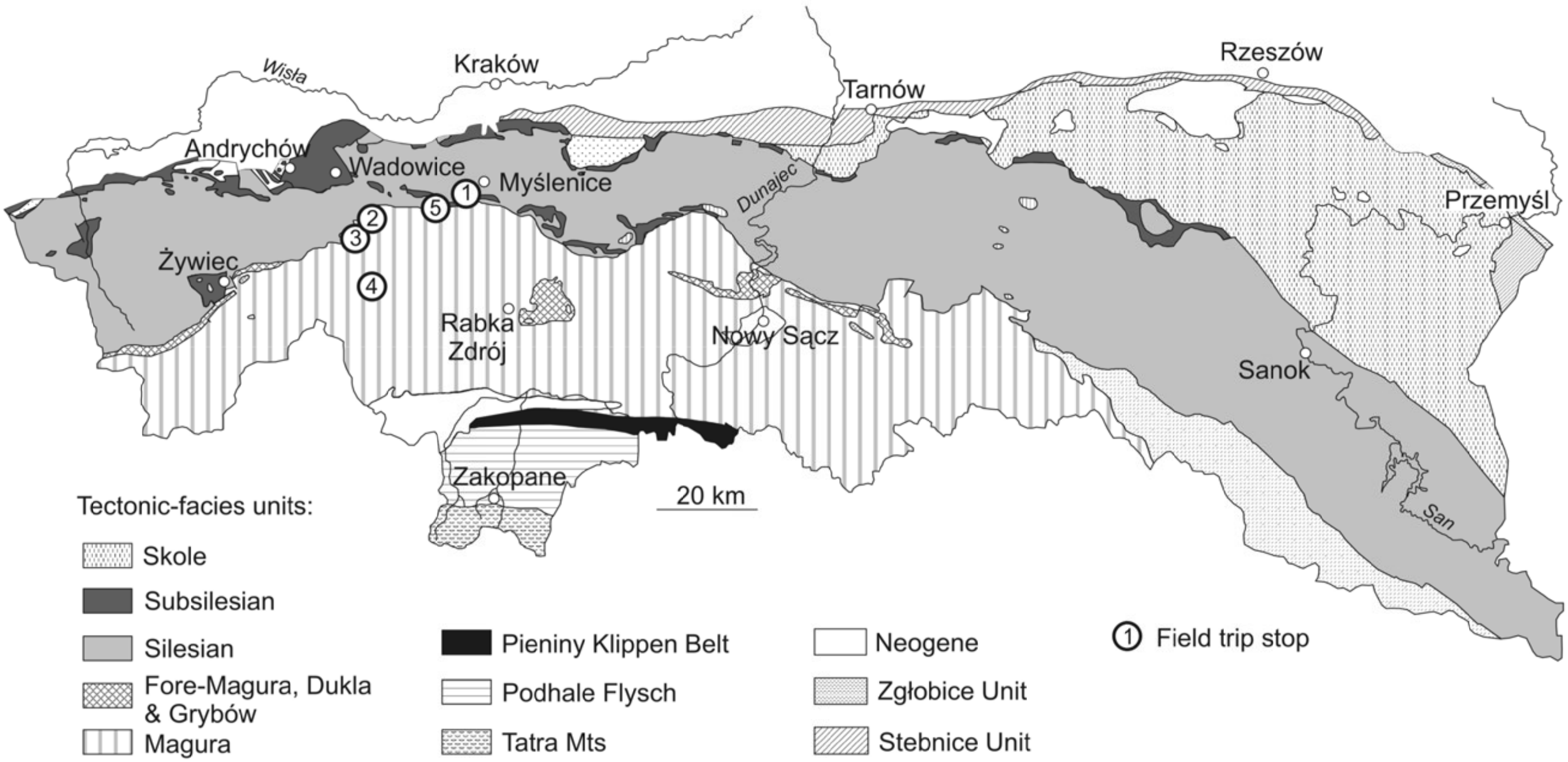

Location of the field trip stops. 1 - Barnasiówka, 2 - Tarnawa Dolna, 3 - Sucha Beskidzka - Lachówka, 4. Zawoja - Mosorny, 5. Harbutowice-Kijówka. Geological map after Żytko *et. al.* (1988), simplified

Part 2. Abstracts

Eighth Micropalaeontological Workshop "MIKRO-2011"

and

TMS Foraminiferal-Nannofossil Group Annual Meeting

First results from a planktic foraminiferal reconstruction of paleomonsoon events in the Northeastern Arabian Sea during the last 25 kyr

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The Asian monsoon circulation consists of the Indian and East Asian subsystems. The Indian subsystem is characterized by strong seasonally reversing winds from the ocean to land (SW-monsoon) and vice versa (NE-monsoon). In order to reconstruct the paleoclimatic history of the monsoons, planktic foraminiferal have been studied in sedimentary archives of the northern Arabian Sea. The monsoonal winds cause seasonal upwelling in this region and the intensity of this upwelling has shown rapid response to monsoon changes in the past. The present investigation is based on samples from SO 90-93KL located on the top of the northern Murray Ridge, the core recovered in 7.5 m the last 25 kyr, allowing the study of the response of the Monsoon system on centennial time scale. Here, we present the first results from foraminiferal census counts in different size fractions as monsoon proxies to trace paleomonsoon intensity changes as well as surface water productivity, caused by changes in the intensity of summer monsoon-induced upwelling or winter deep mixing. The present results show distinct peaks in pteropod corresponding preservation during the cold Heinrich events 1 and 2. Moreover, the relative abundance of *Globigerina bulloides* as a summer monsoon indicator shows a strong increase at about 2000 years ago. Also the high relative abundance of *Globigerina falconensis* observed during the last 2 kyr, at 12 kyr (Younger Dryas) and at 21 kyr suggests increased winter deep mixing linked to the winter monsoon during these intervals.

A new Cretaceous planktic foraminifera from the Jorband section, North Iran, with spines and double keel

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In northern flanks of Alborz Mountains, on the southern side of Caspian Sea, the upper part of late Cretaceous strata are mostly formed from milky to light grey marl and marly limestone. These successions are characterized by calcareous foraminiferal assemblages dominated by the family Globotruncanidae. The paleoenvironment of the studied area shows that the sedimentation took place in a deep open marine basin during the Campanian-Maastrichtian. In order to develop a biostratigraphic scheme and to reconstruct the environmental history, 91 samples were studied in both thin sections and washed coarse fractions (in sieve fraction >63 µm). In total 111 species of planktic and bentic foraminifera are recognized including a remarkable new form of planktic foraminifera with spine-like elongations of chambers and a double keel. The most distinct feature of this taxon is the existence of spine-like chamber elongations on each chamber with two spaced keels, separated by an imperforate pustulose, wide carinal band. This taxon thus combines the diagnostic features of both *Globotruncana* and *Radotruncana*. The species described here from outcrops of the Central Alborz Mountains was widely distributed in the late Campanian (Radotruncana calcarata Zone) warm water and survived in the cooler conditions that prevailed during the Maastrichtian (Racemiguembelina fructicosa Zone).

Tying the regional neritic biostratigraphy of the North Sea to the oceanic record: an improved microfossil zonation for the Neogene of the Nordic seas

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The main foundation for biostratigraphic age interpretations of North Sea foraminiferal zonations has been via extra-basinal correlation to high-resolution ocean drilling sites, in particular to the northeastern Atlantic sites (King, 1989, Gradstein & Backstrom, 1996). Since the publication of these zonations a significant amount of new ocean drilling data has become available, pointing to the need for a critical update to the existing biochronology. A total of thirty-three ocean drilling sites (DSDP and ODP) together with outcrop and industrial well data were used to construct a regional biostratigraphic framework for the Nordic seas. This study incorporates a holistic philosophy to calibrating bioevents, applying an ecostratigraphic approach to link the neritic microfossil record with that of the deep ocean. The result is an improved multi-group microfossil biozonation for the Neogene of the Nordic seas set within the context of the global oxygen isotope record and regional stratigraphic hiatuses.

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Time Scale Creator Workshop: How to quickly create stratigraphic charts, explore Earth history and even build your own datapacks

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Time Scale Creator, a free JAVA package, enables you to explore and create charts of any portion of the geologic time scale from an extensive suite of global and regional events in Earth History.

The internal database suite encompasses over 20,000 biologic, geomagnetic, sea-level, stable isotope, and other events. All ages are currently standardized to Geologic Time Scale 2004, and to the Concise Geologic Time Scale compilation of the International Commission on Stratigraphy and its Subcommission on Stratigraphic Information.

Participants should try to bring their own laptop computers to the workshop as there will be limited extra equipment. Participants are welcome to collaborate on the exercises and so share available computers. For further details see www.tscreator.com.

Quantifying changes in the Agulhas leakage fauna back to the last glacial: does the present resemble the past?

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Indian–Atlantic transport of heat and salt South of Africa is considered an important part of the thermohaline circulation. This inter-ocean exchange, commonly referred to as Agulhas Leakage, takes place in the form of eddies which pinch off the Agulhas Current during retroflection. Based on modern plankton tow observations, a characteristic tropical-subtropical Indian Ocean planktic foraminiferal fauna has been identified and used to reconstruct the history of Agulhas Leakage over geological timescales in the Cape Basin (Peeters *et al.*, 2004; Martínez-Méndez *et al.*, 2010). In these reconstructions it is assumed the Agulhas Leakage Fauna (ALF) did not change over geological time. To test this assumption, i.e. the Agulhas Leakage Fauna did not change over Glacial Interglacial time scales, we have analysed the fossil fauna from a sediment core located upstream beneath the Agulhas Current and within the Indian Ocean. Defining variation in the past Agulhas Fauna will aid in the interpretation of palaeo-oceanographic studies for the region. On the poster we will show the results of our efforts in better constraining the past Agulhas Fauna in the upstream 'source region'. We will discuss whether or not the 'modern analog' approach in reconstructing past changes in the Leakage can be considered correct.

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Biostratigraphy and paleoecology of Lower Cretaceous bathyal deposits in the Papuan Basin, Papua New Guinea

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The island of New Guinea lies on the northern margin of the Australian continental plate. Therefore the sedimentary basins of PNG reflect the changes of the depositional settings of this continental margin. During the Early Cretaceous, a thick sequence, of hemipelagic marine sediments were deposited over the northern passive margin of the Australian plate. Due to the accretion of several island arcs and the orogenesis, which started in the Middle Oligocene, those sediments are today exposed in the New Guinea Mobile Belt. The Lower Cretaceous Chim Formation, a succession of dark grey mudstone/siltstone with calcite nodules and occasional volcanoclasitics, crops out in the Wahgi Valley at the northern flank of the Kubor Anticline. The Cretaceous succession of the New Guinea Mobile Belt was first dated to an Aptian to Turonian age. The first detailed account of mid-Cretaceous Foraminifera was presented by Haig

(1981); before that, only brief mention had been made of foraminifera in the Wahgi Valley. All the age determinations are based on isolated samples and, as a consequence, neither the stratigraphic continuity nor the paleoenvironmental development during the deposition of the Chim Formation, are fully understood. By analyzing the foraminifera content of 34 samples from the Chim Formation collected over 3 transects, we show that the whole 3,5 km Thickness of the formation in our study area is of Albian age. This is shown by the presence of several planktonic and benthic index foraminifera (e.g., *Ticinella raynaudi*, *Ticinella madecassiana*, *Berthelina cenomanica*), whose occurrence range is restricted to the late Albian. Previously conducted studies suggested an Albian/Cenomanian boundary extended through the sample area, which we now can refute. Furthermore multivariate statistical analyses of the foraminiferal counts and sediment properties revealed the presence of a major cycle, reflected by the recurrent succession three bio- and lithofacies.

Two of the biofacies mirror the lithological properties of the formation. The third faunal zonation appears within the one zone resembling the massive part of the formation, so that a common environmental cause can be assumed. An interpretation of the foraminifera fauna and the sediment properties suggests a transition from a more open marine environment towards a more restricted basin environment, culminating in an extreme environment with a low foraminifera diversity and elevated values of total organic carbon, which we, preliminary, correlate to the Oceanic Anoxic Event 1d.

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Palynostratigraphic investigation from the Upper Cretaceous Iharkút vertebrate fossil site (Csehbánya Formation, Bakony Mts., Hungary) – problems with regional correlation

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The primary aim of this study was to give the most precise age determination of the dinosaur bone bearing layers of the fluviatile sediments of the Csehbánya Formation The bone bed layers yielded a well preserved, diverse angiosperm dominated vegetation with the predominance of the Normapolles complex. According to previously used palynostratigraphic scales (Góczán & Siegl-Farkas, 1990) the bone bed type layers were deposited during the Oculopollis zaklinskaiae – Tetrcolporopollenites globosus Dominance zone, in the Upper Santonian according to the correlation of the palynozones with CC16 Lucianorhabdus cayeuxii Tethyan nannozone (Siegl-Farkas & Wagreich, 1996). These palynostratigraphic scales consisted of dominance and assemblage zones based on the co-occurrence of several Normapolles pollen and a few other taxa (e.g., *T. globosus* or *Trilobosporites*). The correlation of these results with other playnostratigraphic scales was somewhat problematic because of the differences between the ranges of Normapolles species in Europe and because of the inconsistency in the systematics of few Normapolles genera, especially the *Oculopollis* group. The age determining *Oculopollis zaklinskaie* species is mentioned only by restricted number of authors. *Tetracolporopollenites globosus* occurs only in Hungarian and Austrian sediments. *O. zaklinskaie* is dominant in Santonian strata but with significant differences in substage level even between similar Gosau type areas (e.g., Gosau Basin, Austria and present studied area). In Hungarian strata the dominance of this species was typical for the Upper Santonian, controversially it occurred in significant amount in the Lower Santonian strata of the Gosau Basin (Hradecká *et al*., 1999) and in Northern Bulgaria (Pavlishina, 1999). This inconsistency can be

explained several ways: for instance some forms have longer time range what makes impossible their use as index fossil. Another explanation could be that at the studied areas the paleoenvironmental changes were not synchronic, and the Normapolles bearing plants were able to migrate between the localities according to their ecological niche. Another possible explanation is the archipelago effect. This effect can also cause distinct vegetation accompanied by a distinct palynoflora in the hypothesised archipelago area of the Tethyan Realm.
The questions of the regional palynostratigraphy made the Upper Santonian age of the bone bed layers doubtful. The age might be somewhat older according to the occurrence of the species *O. zaklinskaie* in the lower Santonian as well. The previously used palynostratigraphic scale by Góczán & Siegl-Farkas (1990) enables correlation only on a local level.

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On some aspects of the detailed dinocyst stratigraphy of the "black flysch" (Pieniny Klippen Belt of Poland)

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The palynologically studied samples come from three sections from unnamed creeks at Czorsztyn Dam Lake at Podubocze near Czorsztyn where the dark calcareous shales with the sandstones intercalations crop out. These deposits have been studied by Birkenmajer (1957) who used the term "flysch Aalenian" for all these strata (replaced later by the Szlachtowa Formation of Birkenmajer, 1977) and attributed them to the upper Toarcian and/or lowermost Aalenian. Recently, the organic-walled dinoflagellate cysts from this section have been studied by Gedl (2008) who recognized two dinoflagellate cyst assemblages: an upper Toarcian assemblage and a lower Bajocian assemblage. The shales studied by us yielded abundant dinoflagellate cysts including *Dissiliodinium giganteum* and *D lichenoides* commonly occurring in almost all samples and indicative of the lower Bajocian. Other cysts recognized, either show a wider stratigraphical range, or are evidently redeposited from older deposits (*Rhaetogonyaulax rhaetica* of Triassic age, *Wittnadinium minutum* of Early Jurassic age, *Parvocysta nasuta* of Toarcian to earliest Aalenian age). Some of the studied samples are markedly enriched in cysts of the genus *Nannoceratopsis*, such as *N. gracilis* - a species known from the upper Pliensbachian to Bathonian. All the samples

demonstrating postulated enrichment have been examined with blue light excitation to estimate the autofluorescence of organic particles. This method is used to various forms of the organic matter in many aspects. For coal petrologists this method used is to assess the proportions of the primary liptinitic macerals versus diagenetic macerals (Radke *et al*., 1980), whereas spectral measurements of the organic matter fluorescence provide a quantitative proxy of thermal maturation for standard comparisons (van Gijzel, 1981). Fluorescence color is often understood as a function of maturity, but significant variation can just also reflect the degree of synsedimentary or diagenetic oxidative alteration (Tyson, 1995). Studied samples yield two kinds of *Nannoceratopsis gracilis* specimens that markedly differ in fluorescence colors: the first demonstrating dark orange colors and second characterized by bright yellow colors. The bright yellow colors are shown by the lower Bajocian marker species of *Dissiliodinium giganteum* and *D lichenoides* and this probably reflects the state of preservation of the younger - less diagenetically changed organic walled dinocysts.
The specimens of *Nannoceratopsis* with dark orange colors found in the same samples are possibly redeposited similarly as mentioned above Triassic and Early Jurassic cysts.

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Response of coccolithophorid assemblages to rapid cooling events in the seasonal upwelling zone off NW Africa during the past 70 kyrs

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It is well known that abrupt massive discharges of Laurentide-derived icebergs-the so-called Heinrich Events (HEs)-influenced the northern Atlantic Ocean during the last glacial period. Similar events have been observed worldwide and are thought to be a remote response to the HEs, the signal being transported either through hydrological means and/or through atmospheric tele-connections. However, the origin of these events is still a matter of debate.
Here we explore low-latitude Heinrich events equivalents (HEEs) in a gravity core recovered from the tropical western African margin off Cap Verde. The 70-ka-long record of sediment core GeoB9601-3 (14,27°N/ 17,59°W, 1920m water depth, 7.4m core length) is characterized by generally high terrigenous sedimentation and shows abrupt increases of total dust during the mentioned events. The alkenone-

derived SST record indicates the presence of cooler surface waters during the HHEs (except of HHE3), as well as during the Last Glacial Maximum and the Younger Dryas. In addition, the coccolith assemblage obviously appears to be influenced by these events – the total numbers of coccoliths drastically decreased and the composition of the dominant species changed during these stadials. While *Emiliania huxleyi* together with the deep-dwelling and oligotrophic *Florisphaera profunda* dominated throughout most of the glacial, the %-abundances of *F. profunda* and the cool-adapted *G. muellerae* as well as increased during the HHEs. The reduction in absolute numbers most probably results from the dilution by the enormously high input of dust. The changes in the coccolith assemblage composition (together with planktic foraminifera), however, indicate cooler and productive surface water mass conditions, implying that seasonal upwelling may be strengthened during the HHEs.
In summary, our data indicate that abrupt and relatively short-term changes in the sea-surface conditions occurred off northwest African during the last glacial. A cooling of the surface waters, accompanied by shifts in the composition of the coccolith assemblages, can probably been linked with arid conditions on the adjacent northwest African continent most probably induced by substantial coolings of the subpolar North Atlantic.

Radiolarian response on environmental perturbation across 1.8 Ma interval including the Cenomanian–Turonian Oceanic Anoxic Event

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The 184 radiolarian species from deep-water settings in the Umbria-Marche and the Outer Carpathian basins of the Western Tethys were used for interpretation of environmental changes during the late Cenomanian through the Early Turonian time interval. The selected species represented various feeding preferences and ecological strategies. An increase of radiolarian total number in the sediments related to the Bonarelli Level (BL) displays a positive correlation with an increase of phosphorus (P) content, and with a significant decrease in radiolarian diversity. However, most of radiolarian species avoided levels with high phosphorus content, in contrast to some species as *Holocryptocanium barbui* and *Cryptamphorella conara*, increased significantly in number of specimens there. On the contrary, diversified radiolarian assemblages appeared at levels, directly preceded by a notable phosphorus increase, marking a period when the water system was saturated in relation to nitrogen.
The radiolarian abundance in the sediments was strongly related to their preservation during sinking in the water column and at the water/sediment interface, increasing significantly at levels, marked by high pellet production. Thus, pelletization played an important role in the transport of radiolarian skeletons and their further preservation, irrespective to conditions of their growth.
The Cenomanian–Turonian Oceanic Anoxic Event did not result in great radiolarian extinction and turnovers. The radiolarian radiation preceded the OAE2 onset by over 330 kyr. The extinction, directly connected with the OAE2 started *ca* 240 kyr before the end of the organic-rich sedimentation, coinciding with the onset of enhanced sedimentation of diatom frustules, recorded in the siliceous part of the Bonarelli Level. Since this period, a step-wise radiolarian extinction continued through the Early Turonian. Many of the radiolarian species previously considered as terminating during the Bonarelli Interval (BI), in fact outlived up to "post-Bonarelli" times, having their last occurrence above the BI or even in the Early Turonian. In the case of the radiolarian fauna, the Bonarelli period caused the

disappearance of many Lazarus taxa, which returned in almost their initial state during 940 kyr after the BI.

Microfossils and trace fossils in sediments after the OAE 2 in the Polish Outer Carpathians

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Facies succession together with foraminiferal, radiolarian, trace fossil and geochemical records in the Outer Carpathian sections reflect changing oceanographic conditions across the Cenomanian–Turonian boundary in the deep-water basins of the northern part of the Western Tethys. An organic-rich sedimentation (equivallent of the Bonarelli Level), related to the OAE 2 was replaced by manganese-rich sediments and oxidized red and green strongly siliceous and manganiferous shales. Stable isotope data of organic carbon from four sections in the Outer Carpathians (Bąk, 2007a, b) and their comparison to the orbital time scale across the Cenomanian–Turonian boundary (proposed by Sageman *et al*., 2006), show that the beginning of sedimentation of the oxydized facies in the Outer Carpathian region took place ca. 200 kyr before the C–T boundary.

The base of the oxydized sediments, directly overlying the Bonarelli Level is an Fe-Mn layer (a few cm thick) including rhodochrosite nodules, followed by variegated, strongly siliceous, manganiferous shales (0.5-0.7 m thick) and a second Fe-Mn interval with rhodochrosite nodules (up to 2 cm thick). These sediments represents an interval of extremely low sedimentation rate and even hiatuses, documented additionally by thin ferrous crusts within the variegated sediments (Bąk, 2006, 2007a, b).

Common components among microfossils within the variegated siliceous manganiferous shales are radiolarians, which are concentrated in 0.5-3 mm laminae, occurring in intervals 0.5-3 cm thick. Radiolarians skeletons occur also within the Fe-Mn nodules. Radiolarian assemblage in the oxydized sediments contains oligotrophic species. Numerous diatoms and coccospheres confirm that conditions in photic zone of water-column were preferable for nitrogen-fixing community. Fecal pellets occur commonly in all types of deposits. Benthic foraminifers are extremely rare except for a one green shale layer with a few 1 mm thick red shale laminae (2–6 cm above the top of the Fe–Mn horizon) including small conical-shaped agglutinated forms. Single small (<0.2 mm) benthic agglutinated foraminifers have been also found in another two red shale layers higher in the section, including gerochamminids, *Trochammina* sp. and *Uvigerinammina* sp. Macroscopically all variegated shales are massive, without any bioturbation structures. However, the clay minerals chaotic arrangement points to cryptobioturbation of this sediment (Uchman *et al*., 2008).

The authors suggest that the restriction of the benthic micro- and macrofossil population during the interval after the OAE 2 was caused by limitation in nutrient supply due to changes in water-column productivity in relation to the Bonarelli equivalent interval, and extremely low sedimentation rate. Unfavorable characteristics of bottom water and type of substrate could also deteriorate microfossils and trace fossil preservation.

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Micropaleontological and sedimentological features of the Early–Middle Miocene transition in north-western Transylvanian Basin

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The Early/Middle Miocene boundary can be studied in the northwestern Transylvanian Basin, at the transition between the Lower Miocene deep-sea turbidites (Tischler, 2005, Filipescu & Beldean, 2008, Beldean *et al*., 2011) and coarse-grained fan delta sediments grouped together in the Hida Formation, and the Middle Miocene hemipelagites and volcanic tuffs of the Dej Formation (Popescu, 1970). Previous studies considered that the Early/Middle Miocene boundary should be traced by a conglomerate (Popescu, 1975).

Three sections (Pâglişa, Dej, and Ciceu-Giurgeşti) have been investigated in the northwestern Transylvanian Basin in order to identify the Early–Middle Miocene transition based on foraminifera. At Pâglişa, the sediments are mainly represented by fan delta deposits with high sediment input (intercalations of microconglomerates, clays and sandstones). Micropaleontological assemblages are poorly represented, except for a few samples where planktonic *Streptochilus pristinum* and benthic *Bolivina* and *Bulimina* are present. The lower part of the Dej section (Râpa Dracului) starts with sandstones and mudstones followed by coarse-grained debritic flows and by the Dej Tuff at the top. Planktonic *Streptochilus* has been identified in the lower part of the section, followed by typical Badenian assemblages with *Praeorbulina* and *Orbulina*. A similar situation was observed at Ciceu-Giurgeşti, with the *Streptochilus*-*Bolivina* assemblage followed by *Praeorbulina* and finally *Orbulina* zones.

According to the standard stratigraphic definition, in Paratethys the Lower/Middle Miocene boundary must be traced at the beginning of the Badenian transgression, respectively at the first occurrence of the foraminiferal genus *Praeorbulina*. Our recent observations in the Transylvanian Basin (see also Beldean *et al*., 2010) showed that the early stage of the transgression should be assimilated to the *Streptochilus-Bolivina* abundance Zone, followed by an important bloom of *Praeorbulina* during the main phase of the transgression. The biostratigraphic data have been recently calibrated with radio-isotopic measurements for the upper part of the sections (de Leeuw, 2011).

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Morphogroup analysis on deep-sea agglutinated foraminifera from the northern part of the Tarcău Nappe (Eastern Carpathians, Romania)

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Agglutinated foraminifera from several sections from the northern part of the Tarcău Nappe (Eastern Carpathians, Romania) were examined in order to obtain data on the paleoenvironmental settings. All identified micropaleontological assemblages are dominated by agglutinated foraminifera, which are sometimes associated with calcareous benthic and planktonic taxa. The agglutinated assemblage consists mainly of "flysch-type" assemblages (Kaminski *et al.*, 1988). Based on test shape differentiation proposed by Nagy (1992), Nagy *et al.* (1995) and Van der Akker *et al.* (2000), the foraminiferal agglutinated species have been split into three morphogroups. The deposits from Straja have been placed into the lower Eocene *Glomospira* spp. Assemblage Zone. At Palma, the index taxon *Rzehakina fissistomata* (Grzybowski) has been identified and for this reason we placed these deposits in the Paleocene *Rzehakina fissistomata* Zone (Olszewska, 1997). The presence of these particular assemblages provides good reasons for correlations to the similar Paleocene–Eocene assemblages from the Polish Carpathians.

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Middle–Late Pleistocene calcareous nannofossils as preservation and primary productivity proxies in the North West Pacific Ocean (Shatsky Rise)

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Calcareous nannoplankton is one of the major producers of pelagic carbonates in the recent oceans and contributes significantly to the primary productivity influencing the global climate system. In fact being a phytoplanktonic group, it is able to convert CO_2 into organic matter (biological pump) but, at the same time, to promote the $CaCO_3$ bulk through the production of biogenic calcite (carbonate pump). To better understand the complex interactions between phytoplankton and climate system, the relationship among preservation of fossil assemblages, palaeoproductivity and glacial-interglacial cycles is now intensively studied. This work, based on a quantitative micropalaeontological approach, aims to evaluate the calcareous nannofossil preservation and the primary productivity in the North West Pacific Ocean during the Middle–Late Pleistocene. The studied material was recovered from the site ODP198-1209B located at 2387 m depth at the southern margin of the Shatsky Rise, an oceanic plateau east to Japan. The Pleistocene calcareous nannofossil content is here studied in detail for the first time. A total of 109 samples were collected from the top of the core to 11 mbsf (meter below sea floor) with a sampling rate of ca 10 cm and analysed in their nannofossil content under a polarized light microscope at 1000X magnification. The studied interval records the last 0.785 Ma, inferred from magneto-biostratigraphic data, with an estimated time averaging of about 7 kyr. Additional Scanning Electron Microscope (SEM) analyses were carried out on random samples in order to check the absolute abundance of some proxy species (like *Emiliania huxleyi* and *Florisphaera profunda*) for preservation and primary productivity. The nannofossil associations are abundant, well preserved and diversified. The nannofossil dissolution is evaluated using several indices proposed in literature that take into account the ratio between dissolution-resistant and more delicate taxa. These indices are: the dissolution curve of *Calcidiscus leptoporus* (Matsuoka, 1990), the NDI index (Marino *et al.*, 2009), the CEX index (Dittert *et al.*, 1999) and the CEX'index (Boeckel & Baumann, 2004). The Fragmentation Index (FI) from planktic foraminifera, is also evaluated only for 4 meters of the record. The *C. leptoporus* dissolution curve, the NDI and the FI suggest good preservation throughout the succession, confirming the qualitative observations made during the counting and their usefulness for the dissolution evaluation. The *C. leptoporus* curve and the NDI show a correlation value of 0.97 and both, in turn, correlate for a value of about -0.68 the FI. The resulting CEX and CEX', on the contrary, show low correlation values with the other indices maybe for an underestimation of the small specimens of *E. huxleyi* to the light microscope, suggesting a probable major usefulness for SEM collected data-base. The primary productivity, evaluated trough the N' (Lopez-Otalvaro *et al.*, 2008) and the PP (Beaufort *et al.*, 1997) indices both based on the relative abundance of *F. profunda*, records several fluctuations throughout the core also remaining rather high. The PP index, in particular, appears to be fairly positive correlated with the absolute abundance curve of calcareous nannofossils and negatively with the abundance curve of *F. profunda*, which proliferates during low nutrient intervals. Calcareous nannofossils appear, therefore, to be a major component of the primary producers. Comparing these data with the benthic oxygen isotope curve for the Middle–Late Pleistocene and therefore to the glacial-interglacial cycles, it is possible to observe carbonate dissolution maxima mainly during deglaciations, whereas the maximum efficiency of the biological pump and the nannofossil abundance maxima are recorded in the glacial phases. In conclusion, during the glacial phases the CO_2 sink is driven mostly by the shallow biological pump, partly buffered by the CO_2 producing carbonate pump. On the contrary, during deglaciations the main mechanism of CO_2 sink is the carbonate dissolution in the deep waters. It must be noted, however, that the oceans' capacity to absorb atmospheric CO_2 is further complicated by other parameters such as temperature, water dynamics, deep ocean carbonate chemistry, climate and so on.

Microfossil and geochemical evidences in reconstructing Pleistocene paleoceanography of the South West Pacific (MD 97-2114 Chatham Rise)

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The research aims to reconstruct, through a multidisciplinary approach based on micropaleontological and geochemical analyses, the main paleoceanographic and paleoclimate changes that have influenced the surface- and deep-water circulation in the South West Pacific Ocean (Chatham Rise, eastern New Zealand) during the last 1Myr.

The oceans are the largest ecosystem on Earth and best record global changes in climate and atmospheric composition. Changes in the mean state of regional and global surface- and deep-water circulation regimes both contribute to and are diagnostic of different states in the evolution of Pleistocene. Past surface- and deep-water ocean circulation patterns may be mostly reconstructed using measurements of biological and chemical properties. However, the interpretation of data is complex or ambiguous in several cases and a multi-proxy approach to improve the comprehension of past changes has become imperative. Given the importance of calcareous plankton (calcareous nannofossils and foraminifers) as biomineralizers and important players in the biologic organic pump, the quantification of their changes in abundances and taxonomy is an excellent proxy of past surface water-masses, as they are extremely sensitive to temperature, fertility, salinity and *pCO2.* The characterization of palaeoecological indexes within planktic groups and within benthic foraminifers allows the identification of functional taxa for sustaining environmental changes, included those at the deep sea-floor.

A continuous marine sedimentary section containing high-quality and expanded record of the last 1.1 Myr has been recovered, by the IMAGES (*International Marine Past Global Change Study)* cruise, in the Southwest Pacific Ocean, east of New Zealand (Core MD 97-2114, 42°22'27"S; 171°20'42"W).

This region represents a key area for investigating the evolution during the Pleistocene of the biogeochemistry and dynamic of the southern oceanic fronts (Subtropical, Subantarctic, Polar Fronts). In fact, in this area the largely wind-driven Antarctic Circumpolar Current (ACC) interacts with the west Pacific Ocean circulation *via* Deep Western Boundary Current (DWBC) coming from the Antarctic region. The DWBC is a fundamental component of the global thermohaline circulation (Conveyor Belt) and it is also the major source of deep water for the whole Pacific Ocean.
Micropaleontological and the geochemical analyses were carried out on the same samples following standard tecniques. Quantitative data on the calcareous planktic and benthic microfossil record are integrated with the C and O isotope data performed both on planktic and benthic foraminiferal tests, to understand coupling or decoupling events between sea surface and bottom waters in terms of productivity, current activity and carbon export dynamics.
Results show that the biogeochemical data reveal the occurrence of long- and short-term patterns of climate and ocean circulation in the last one million years. These patterns seem to result by the interplay of ice-sheet dynamics, surface tropical *versus* polar water inflow and trophic status of the surface water. In particular, the events recorded seem to be related to a variation in the volume of the DWBC like a response to changes in the water production from the Antarctic source, as already proposed in previous papers.

Microfaunas and nannofloras from the Holocene deposits of the NW Black Sea

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This work is focussed on the fluctuation pattern in microfaunal (i.e., foraminifera and ostracods) and calcareous nannoplankton assemblages, encountered in several drillings performed in the Holocene deposits of the NW Black Sea. The investigated cores are placed in the inner Romanian Shelf, at various water depths, from a very shallow setting (i.e., 12 m) up to 100 m. Several cores have been taken from the Danube Delta front, as well as in front of the Razelm-Sinoie lagoon. The analysed cores cover an interval comprises between 7,500 BP up to the present, which is a crucial time in the evolution of the Black Sea that shifted from a brackish or even lacustrine basin into a marine one.
In the Holocene deposits of the Black Sea, Ross & Degens (1974) recorded three stratigraphic units (from young to old): Unit 1 (the microlaminated coccolith ooze, deposited under marine conditions), Unit 2 (the sapropel mud, corresponding to a brackish, anoxic phase), and Unit 3 (the lacustrine lutite deposited during the freshwater or oligohaline stage). Because these units were sedimented only in deeper parts of the Black Sea, i.e., at a water depth over 200 m, they could not be recognised in the studied area. There, the only unit of Ross & Degens (1974) recognised is Unit 3, which is followed by the Shallow Unit (*sensu* Giunta *et al.*, 2007), made by alternating sequences of mud and clay, interbedded with coquina levels (Oaie & Melinte-Dobrinescu, 2010).
On the continental shelf of the NW Black Sea (i.e., in front of the Danube Delta), Giunta *et al.* (2007) recorded as a youngest lithological unit the "Shallow Unit" that commonly contains coquinas with marine molluscs. This unit overlies a centimetre-thick, silty-sand layer yielding mixed marine and brackish mollusc faunas. This particular level was previously referred as the 'shell hash layer' (Major *et al.*, 2002)

and tops the lutites of Unit 3 described by Ross and Degens (1974). Therefore, Unit 3 is the single lithological unit that is present both in the basinal and shallow settings of the Black Sea.

Holocene calcareous nannoplankton assemblages are absent from the sites located seaward near the Danube Delta. This fact could be explained by the Danube Delta evolution, including changes of the coastline position (Panin, 1997). Hence, we may suppose a low salinity for the surface waters in this area during Holocene times, below the limit permitting the coccolith survival. In the other studied sites, calcareous nannoplankton assemblages are present in the youngest Holocene deposits, yielding a very low diversity. In fact, the assemblages *in situ* are represented by only two species, *Emiliania huxleyi* and *Braarudosphaera bigelowii*, both taxa being able to survive in low salinity environments (Bukry, 1974).

The foraminiferal assemblages are mainly composed of taxa belonging to the genera *Ammonia*, *Haynesina*, *Porosononion*, *Elphidium*, *Cribroelphidium* and *Quinqueloculina*. Most of the assemblages are made by *Ammonia beccarii* s.l. and *Cribroelphidium poeyanum*. The most common identified ostracods in the Holocene studied deposits are: *Cyprideis littoralis*, *Leptocythere multipuncatata*, *L. devexa*, *L. histriana*, *Amnicythere striatocosta*, *A. reticulata*, *A. cymbula*, *Callistocythere diffusa*, *Cythereiss rubra pontica*, *Heterocythereiss amnicola*, *Loxoconcha granulata*, *L. gibboides*, *L. aestuarii*, *Limnocythere inopinata*, *Cytherura euxinic*a, *Cytheroma variabilis*, *Paracytherois agigensis*, *Pontocythere bacescoi*, *P. tchernjawskii* and *Xestolebris decipiens*.

The changes in microfaunal and nannofloral composition and abundance indicate that salinity increased during Holocene times in the NW Black Sea, from a brackish setting to a marine one, similar to the one found in modern times. Taking into account the fluctuation pattern of nannofloras, a sudden increasing in salinity could be assumed for deeper parts of the Romanian shelf, while a progressive increasing could be supposed for extremely shallow areas.

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Surviving strategies of nummulitids. Three-dimensional analysis of the *Nummulites fabianii* group at the Eocene/Oligocene boundary.

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The calculation from 3D images of chamber volumes and shapes and their changes during ontogeny provides a large amount of information quite impossible to obtain by the traditional two-dimensional methodology of oriented thin sections. The volume measurement itself does not give information about shell geometry but indicates the influence of temporal changes during the foraminiferal growth.

Environmental changes are therefore reflected in deviation from a specific Bauplan. Such deviation can be observed by a three dimensional study of the ontogeny of larger foraminiferal shells through geological time. A pilot study has been done on the *N. fabianii* group which survives the prominent cooling event at the Eocene/Oligocene boundary. The calculation on the chamber volumes shows a drastic growth speed reduction across the boundary. Among the investigated species, the Oligocene specimens (i.e., *N. fichteli*) reach the same size of the Late Eocene ones (*N. fabianii*) 40 chambers later. Such reduction in growth speed may testify to an adaption by nummulitids to survive in colder environments and possibly lower nutrient levels. A complete trend in speed reduction has been observed from the Late Eocene nummulitids through the late Priabonian to the early Oligocene. As a linear correlation has been confirmed between chamber volume measurements and chamber area in equatorial section, the same trend has been observed through thin section analysis with a larger number of specimens. Size reduction is a well-known adaptation to climatic changes but has never been fully demonstrated so far on larger benthic foraminifers.

The occurrence of the Early Cenomanian at southern Moravia (Czech Republic)

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The Cenomanian sediments of the Waschberg Zone (Ždánice Nappe) were found in the limestone quarry near Mikulov in the Pavlovské vrchy hills. They can be characterized as green-grey glauconitic sandy claystone to clayey sandstone containing few discontinuous laminae of clayey limestone. It seems to be conformable to the underlying Ernstbrunn Limestone that is laminated in the top 10 centimetres. The Cenomanian sandy claystones are actually sandwiched between underlying limestone and overthrusted another tectonic slice of the same limestone as a part of a duplex structure well visible in the quarry wall. The sandy claystones form 3 m long and 18 cm thick lens tectonically reduced by the overthrust.

The microfossil taphocoenosis consists of abundant phosphatic faecal pellets, sponge spicules replaced by glauconite, benthic and planktonic foraminifers, and broken shark tooth. Calcareous nannofossil taphocoenosis is poor (15 species) and the nannofossils poorly preserved. Dominance of *Watznaueria barnesae* (>90%) indicates strong diagenetic impoverishing of the taphocoenosis. Rare Polycyclolithaceae, including strongly recrystallized specimens of *Eprolithus floralis*, unidentified fragments of placoliths, and single specimens of poorly preserved representatives of genera *Prediscosphaera*, *Zeugrhabdothus*, *Vagalapilla* form the rest of taphocoenosis. Presence of *Prediscosphaera cretacea* and broadly oval specimens of *Manivitella pemmatoidea* (estimated length 15–25 µm) may indicate the Cenomanian age.

Poorly preserved planktonic foraminifers *Rotalipora gandolfii* Luterbacher & Premoli Silva, *R. globotruncanoides* Sigal, *R. montsalvensis* Morn., *Praeglobotruncana delrioensis* (Plummer) and *P. stephani* (Gandolfi) give evidence for an early Cenomanian age - the middle part of the *R. globotruncanoides* Zone. In the benthic assemblage agglutinated species prevail over calcareous. Among the agglutinated taxa *Marssonella oxycona* (Reuss), *Hagenowella gibbosa* (d'Orbigny), *H. courta* Marie, *Dorothia* sp., *Arenobulimina* sp., *Heterocoskinolina*? sp. and (?)*Eggerellina mariae* ten Dam were identified. Calcareous benthics comprise *Quinqueloculina* gr. *antiqua* Franke, representatives of genera *Laevidentalina*, *Lenticulina*, *Hemirobulina*, *Gyroidinoides*, *Valvulineria*, *Gavelinella*, *Globorotalites* etc.

The occurrence of the Lower Cenomanian at Pavlovské vrchy hills represents a normal marine facies of the Tethyan margin. Other known sediments of this age covering the Bohemian Massif are preserved in the Blansko Graben. They, anyhow, represent fluvial to estuarine sandstones to mudstones with brackish agglutinated foraminifer assemblages. The Lower Cenomanian at Pavlovské vrchy hills can be assigned to the Klement Formation or Ameiss Formation respectively.

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The Foraminiferal fauna of the Oxfordian limestones in the vicinity of Brno (Moravia)

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The occurrences of Oxfordian limestones around Brno (Švédské šance, Hády, Stránská skála, Bílá hora) and near Blansko (Olomučany) are the remnants of a carbonate platform covering in the Jurassic eastern Moravia. Historical studies of the ammonite fauna by Uhlig and Oppenheimer assigned the limestones to the transversarium and bimammatum zones. Foraminifer fauna was not studied in detail yet. Uhlig (1881) described from Olomučany area six species including four new. Hanzlíková & Bosák (1977) evaluated Olomučany fauna in thin sections.

Recently, the classical Jurassic locality Švédské šance (Schwedenschanze) in Brno – Slatina was revisited (Bubík, 2010). The foraminifer fauna was extracted by dissolution of limestone using 80% acetic acid. 20 species of foraminifers dominated by the genera *Spirillina*, *Trocholina* and *Paalzowella* were identified. The foraminifers *Trocholina nodulosa* S. & S. and *Spirillina andreae* Bielecka indicate a Middle Oxfordian age.

Small remnant of Jurassic sediments at the Hády hill near Brno - Maloměřice comprises 8 m thick conglomerates and detritic limestones and overlying 5 m thick cherty limestones. The detritic limestones with bivalve fauna contain foraminifers *Paalzowella feifeli feifeli* (Paalzow), *Spirillina kuebleri* (Mjatliuk), and *S. andreae* Bielecka. The cherty limestones are rich in brachiopods, belemnites, and ammonites assigned to the transversarium zone by earlier authors. Recorded benthic foraminifer assemblage contains high proportion of agglutinated taxa. The assemblage contains *Glomospira variabilis* (Kubler & Zwingli), "*Textularia*" gr. *jurassica* (Gümbel), *Recurvoides universus* (Haeusler), representatives of genera *Tolypammina*, *Thurammina*, *Haplophragmoides*, *Bicazammina*, *Spirillina* spp., *Trocholina nodulosa* S. & S., *Paalzowella feifeli feifeli* (Paalzow), *P. feifeli seiboldi* Lutze, *Lenticulina* spp., *Ophthalmidium* sp., etc. Rarely the planktonic *Globuligerina oxfordiana* (Grigalis) occurs in the cherty limestones. While the *G. oxfordiana* is considered to be Lower Oxfordian marker, the ammonite fauna evidence the Middle Oxfordian. The proportion of planktonics increases upwards up to 20% and together with faunal turnover from bivalve to cephalopod biofacies shows trend towards deeper and open-marine habitat.

Jurassic limestones at the Bílá hora hill in Brno are grey cherty bioskeletal limestones with sponge biostromes in living position. Benthic foraminifer fauna comprises *Paalzowella feifeli elevata* (Paalzow), *P. feifeli seiboldi* Lutze, *Trocholina nodulosa* S. et S., *Spirillina andreae* Bielecka, *Glomospira variabilis* (Kubler & Zwingli), etc.

Preliminary results of foraminifer study confirmed usefulness of an acetolysis for retrieving the calcareous foraminifers from limestone. Some controversy in biostratigraphical interpretations showed the need for modern revision of ammonites and integration with local foraminifer biostratigraphy.

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Foraminifera and calcareous nannofossils from the lower Jurassic Rosso Ammonitico Umbro-Marchigiano unit, Marche, Italy

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Two outcrops exposing the Rosso Ammonitico Umbro-Marchigiano unit were studied for their micropaleontological content in the Marche area of central Italy: the Gorgo a Cerbara section and an abandoned quarry at Furlo. Both sections expose the condensed Rosso Ammonitico unit overlying directly the Corniola limestone with thickness not exceeding 8 m (at Gorgo a Cerbara).

The calcareous nannofossil assemblages yield a low diversity with fewer than 10 species present in both locations. The most frequent species is *Discorhabdus striatus*, present in all the studied samples from the base to the top of the sections. Based on the presence of *Discorhabdus striatus* and *Watznaueria barnesae* the age of the studied sections is middle Toarcian following the biozonation scheme of Baldanza & Mattioli (1992).

In order to investigate the foraminifera, samples were prepared using two micropaleontological methods: the hydrochloric acid method (obtaining acid residues virtually containing only agglutinated foraminifera) and the acetic acid method (for investigating calcareous benthic foraminifera). This allowed us to have a better image of the foraminiferal assemblages. While calcareous benthic foraminifera have been previously studied in the area (e.g., Nini *et al.*, 1995) either in washed residues of marly intervals or in thin sections, the agglutinated foraminifera were disregarded or even thought to have disappeared at the base of the Toarcian as a consequence of the paleoenvironmental changes associated with the early Toarcian anoxic event.

High abundance of benthic foraminifera (both agglutinated and calcareous benthics) was observed in both sections, and also a moderate diversity was recorded. Agglutinated foraminifera show an impressive increase both in abundance and diversity from the top of the underlying Corniola unit.

Fragile komokiaceans (*Rhizammina*) and attached tubular forms, such as *Tolypammina*, dominate the agglutinated assemblage followed by spherical forms, such as *Thurammina* and small species of *Haplophragmoides* and *Trochammina*. Minor components are represented by species belonging to the genera: *Hippocrepina*, *Ammobaculites*, *Reophax* and *Verneuilinoides*. Overall the epifaunal morphotypes of agglutinated foraminifera dominate almost all of the agglutinated assemblage with the shallow infaunal morphotypes having a low proportion, while the deep infaunal morphotype is hardly represented by few specimens of the genera *Reophax*, *Ammobaculites* and *Verneuilinoides*. By contrast, the calcareous benthic foraminiferal assemblage is dominated by infaunal forms, mostly nodosariids, lageniids, polymorphinids with a minor proportion of shallow infaunal – epifaunal forms, such as *Astacolus* and *Lenticulina*.

This foraminiferal assemblage indicates a well oxygenated, oligotrophic palaeoenvironment with common condensation intervals dominated by adherent agglutinated foraminifers. Such attached foraminifers employed suspension feeding strategy usually associated with weak bottom currents.

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The Boreal lower/upper Maastrichtian boundary and foraminiferal events: An example from SE Poland

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During the Second International Symposium on Cretaceous Stage Boundaries, held in Brussels in 1995, a subdivision of the Maastrichtian stage into two substages was recommended. However, there was no agreement on the boundary criterion for the base of the upper Maastrichtian.

In the traditional belemnite zonal scheme, the base of the Boreal upper Maastrichtian is defined by the first appearance of *Belemnitella junior*.

In the Lublin Basin, lower/upper Maastrichtian transition interval is developed in marly chalk facies and characterized by a continual sedimentation.

We analyzed benthic and planktonic foraminifer distribution across the boundary interval in a series of natural and artificial exposures in the so-called Middle Vistula section (outcrops at Boiska, Jarentowskie Pole, Chotcza and Podgórz) and in the Lublin Upland (the Chełm quarry). In addition, one borehole section (Puławy IG-2) was studied.

We observed in the studied interval a few important foraminiferal events, e.g., the LO of *Stensioeina pommerana*, LO of *Gavelinella monterelensis*, FO of *Anomalinoides acutus* and FO of *A. kurganicus*, the re-appearance of globotruncanids after a longer absence and a short-term “bloom” of *Globotruncanella petaloidea*. Some of these events were also noticed in western Europe (Robaszynski *et al*., 1985).

Changes in planktonic foraminiferal assemblages in the studied interval reflect a global sea-level rise which was earlier recognized near the lower/upper Maastrichtian boundary (Hancock, 1993).

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Seasonal variation of recent benthic deep-sea foraminifera in the Northeast Pacific

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Benthic foraminifera are important contributors to the faunal community and diversity in deep-sea sediments. Abyssal plains are often characterized by oligotrophic conditions with seasonal increased primary production in the surface waters and a resulting higher flux of organic matter to the sea floor. Population density and distribution of foraminifera are mainly influenced by the availability of food and the oxygen concentration in the bottom water. Therefore, foraminiferal assemblages could in theory mirror the unstable delivery of food as differences in the composition and density of the resident fauna. To study the influence of different seasons on the foraminiferal community, we investigated the standing stock of benthic foraminifera at 4,100 meter depth in the Northeast Pacific (Station M, 34°50' N, 123°00' W) in September (fall) 2007 and May (spring) 2008. Sediment cores of 7 cm inner diameter were taken within close vicinity of each other, sliced on board in 1 cm steps and frozen (-20°C). Living and dead foraminifera were identified, classified to species level and counted. The total foraminiferal assemblage (>63 µm) contained about 200 taxa and showed a higher number of species in fall (~190 taxa) than in spring (~150 taxa). In both seasons, living foraminifera were present down to 5 cm sediment depth with highest total numbers at the sediment surface and a clear decrease with sediment depth. Individual species showed microhabitat preferences with the epifaunal and shallow-infaunal habitats being most common. During spring mainly soft-walled and agglutinated species contributed to the living fauna while in fall soft-walled foraminifera were found to clearly dominate in individual numbers. Dead foraminifera showed no trend in their vertical distribution and predominantly agglutinated tests were found. Calcareous foraminifera were also present, with few main species and numerous species with single appearances. Variation in species composition and population density of foraminifera will be compared statistically on a spatial and temporal scale. In summary, we found the foraminiferal community at Station M to reflect a typical abyssal environment in terms of species composition, density and microhabitats. Spatial patchiness has been observed as well as seasonal variation in the benthic foraminiferal assemblage.

Reconstructing seasonality using Mg/Ca palaeothermometry: a multi species, single specimen approach.

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Here we present results using an approach to reconstruct the full seasonal range (i.e., annual mean,

minima and maxima) of sea surface temperatures by means of the geochemistry of fossil planktonic foraminiferal calcite. Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) enables determination of the calcitic Mg content from a very small volume (less than one foraminiferal chamber). This leaves enough material to determine the oxygen isotope ($\delta^{18}O$) composition of the same individual. Combined Mg/Ca and $\delta^{18}O$ from a number of single specimens allows reconstruction of the range of past sea surface temperatures. Obtained data show the range of calcitic Mg/Ca of 300 specimens of the species *Globigerinoides ruber*, *Globigerina bulloides* and *Neogloboquadrina dutertrei* from two intervals from core NIOP905P recovered off the coast of Somalia. This region is characterized by alternating NE- and SW-monsoon conditions and a strong upwelling-induced seasonal change in SST. Presence of species that are dominant in either of these two monsoonal modes enables reconstruction of summer and winter temperatures separately. Specimens were taken from intervals spanning Interstadial 8 and Heinrich Event 4 to reconstruct millennial-scale changes in monsoon intensity in this region.

Evolution of Cretaceous oceans: A 55 million year record of Earth's temperature and carbon cycle

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We produced new stable isotope data sets of Cenomanian to Santonian benthic foraminifera from the western equatorial Atlantic (ODP Leg 207) and from the tropical Pacific Ocean (DSDP Sites 305 and 463). Together with literature data our results are compiled into a global isotope compilation, resulting in a continuous benthic $\delta^{18}O$ record for the last 115 Ma. The new 115 million year global compilation of benthic foraminifera $\delta^{13}C$ and $\delta^{18}O$ shows that the Cretaceous super-greenhouse world saw the widespread formation of bottom waters with temperatures >20°C. These bottom waters filled the silled North Atlantic and probably originated as thermocline or intermediate waters in the tropical oceans.
The high temperatures are explained by a lack of cold bottom-water formation, the restricted nature of the North Atlantic, and the formation of warm saline bottom waters that sporadically were formed within epicontinental seas. The parallel positive trend in $\delta^{13}C$ is believed to reflect massive storage of C_{org} during Cretaceous black shale formation. Interestingly, however, $\delta^{13}C$ values of the tropical Atlantic show a similar trend but more negative values. We propose that this reflects a combination of extensive remineralization of ^{12}C and a long residence time due to the sporadic formation of warm and saline waters.
Overall, carbon burial during the Cretaceous OAEs produced a positive $\delta^{13}C$ shift in global carbon reservoirs, but this is not particularly large, especially by comparison with the remarkable late Paleocene carbon maximum. The inter-basin $\delta^{13}C$ gradient was unusually large during the Cretaceous super-greenhouse, probably because the North Atlantic was a silled basin filled with unusually old, poorly-exchanging deep water. The super-greenhouse and massive black shale deposition ended when the Equatorial Atlantic Gateway opened sufficiently to flood the deep North Atlantic with relatively cool polar waters formed in the Southern Ocean. This explanation is supported by the global decrease in $\delta^{13}C$, proposed to reflect the better connection of the former restricted North Atlantic that allows the oxidization of the organic-rich sediments formed in this basin.

Benthic Foraminifera as Bioindicators of Pollution: What can these Protists tell us? A Review of the Italian Experience in the Last Three Decades

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Half a century has passed since Zalesny (1959) documented for the very first time the effects of pollution on benthic foraminiferal distribution in Santa Monica Bay, California. Since then, numerous studies have been carried out from different parts of the world in areas exposed to different kinds of pollution and have demonstrated the value of benthic foraminifera in detecting ecosystem contamination. This interest in benthic foraminifera has partly been driven by government policies and programs aimed at developing suitable, non-invasive bioindicators of marine environmental quality. The introduction within the Italian arena is dated back to 1997 when Coccioni investigated the benthic foraminiferal assemblages and trace element in surface sediments of the Goro lagoon. Since then, the Italian foraminiferal literature has experienced an exponential growth and the Italian researchers along with their expertise have played a marked role in the development of new methodologies for foraminiferal monitoring of different contaminants.

This review provides a synthesis of Italian research onto the emerging field of benthic foraminifera as pollution bioindicators over the last three decades and reveals that the Italian contribution has, on the whole, played a considerable part in the advancement of our knowledge of environmental micropaleontology (Frontalini & Coccioni, in press). In addition, it has been possible to qualitatively summarize the degree of sensitivity of selected taxa to different sources of pollution (organic vs. chemical pollution), as well as to confirm that benthic foraminifera are sensitive bioindicators and successful candidates for inclusion in an integrated pollution-monitoring program. Although our experience and knowledge have been greatly enhanced in recent decades, this field is still far from being completely understood or exploited, as is evident from the absence of a protocol. In fact, biomonitoring is based on comparative studies of the taxa at a particular site and time. However, to make these studies readily comparable and reliable, the same set of techniques must be used from the initial sampling to the final treatment of data at least for the same environmental setting. This can only be guaranteed if there is an agreement among scientists and a flexible protocol(s) is developed. Accordingly, several issues have to be addressed before foraminiferal-based biomonitoring is introduced in the form of governmental and international protocols.

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Foraminiferal assemblages and the Cretaceous-Paleogene boundary in turbiditic deposits of the Skole Nappe, Polish Carpathians

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Recent studies of the Ropianka Formation in the Skole Unit (Husów area, Bąkowiec section) of Polish Carpathians (Gasiński & Uchman, 2011, *in press*), based on 58 samples, allowed the recognition of the Late Cretaceous and Paleocene standard biozones.

In the turbiditic sequences of the deep Alpine basins, the K–T boundary is very difficult to identify due to the rare occurrence of index planktonic foraminiferids and strong redeposition causing the occurrence of mixed foraminiferal assemblages. Only in a few cases, the identification was narrowed to some relatively thin intervals. The boundary occurs within about a metre thick interval in the Magura Unit in Moravia, Czech Republic, based on dinocyst assemblages (Bubík *et al*., 2002). In the Romanian Carpathians, it was identified within tens of meters by means of the calcareous nannoplankton and foraminiferids (Melinte 1999; Chira *et al*., 2009).

From the base of the studied section, the Gansserina gansseri Zone can be recognized. Planktonic foraminiferal assemblages contain the index species. The first appearance (FO) of *Abathomphalus mayaroensis* (Bolli) is noted from the sample Bak 6a and it delineates the base of the A. mayaroensis Zone. FO of *Racemigeumbelina fructicosa* Egger in sample Bak 2a and its last occurrence (LO) in sample Bak 7 allowed to recognize the Racemigeumbelina fructicosa Zone, which is used by some authors as the Partial Range Zone within the lower part of the A. mayaroensis Zone. The LO of *A. mayaroensis* in sample Bak 14A1 just below the FO of *Subbotina cancellata* Blow, *S. triangularis* (White) and *Eoglobigerina edita* (Subbotina) in sample Bak 14A4 has been interpreted as the latest Maastrichtian (A. mayaroensis). The latter three taxa indicate the P1 Zone of the early Paleocene. It should be underlined that the K–T boundary is indentified within the sequence that is only 40 cm thick. The rusty layer overlain by the dark boundary layer, known from pelagic and hemipelagic sections are not recognized here, but this can be explain by the turbiditic deposition.

A rapid decrease in abundance and diversity of planktonic foraminifers in noted above the boundary. Qualitative analysis of the studied foraminiferal assemblages has been performed. The correlation of quantitative charts of composition of foraminiferal assemblages between the studied samples and those collected from the Gaj section (next thrust sheet Ropianka Formation, Skole Unit; Gasiński & Uchman, 2009) points to their close similarity, especially in the part dated as the latest Maastrichtian. This suggests that the similar factors influenced boundary section environment in this part of the Skole Basin.

Conclusions: 1. The K–T boundary was identified in the turbiditic sediments with the accuracy of 40 cm for the first time. 2. The Gansserina gansseri, Abathomphalus mayaroensis (Late Maastrichtian) and P1 (Early Paleocene) standard biozones were recognized in the studied section on the basis of planktonic foraminiferids. 3. The Racemiguembelina fructicosa Zone as the Partial Range Zone within the lower part of A. mayaroensis Zone has been determined for the first time in the Carpathians and the flysch sediments. 4. Qualitative and quantitative significant fluctuations among the studied foraminiferal assemblages were recognized around the K–T boundary similarly to those indicated in the Gaj section (Skole Nappe, next thrust sheet).

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Otwornice *Amphistegina* środkowego miocenu Karpat – profil Olimpów (Polska)

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Stanowisko w Olimpowie (SW od Rzeszowa) należy do paraautochtonicznych utworów dolnego badenu w Karpatach (Alexandrowicz, 1971; Gonera, 1994a). Odsłania się tutaj ich rodoidowa facja (margle i wapienie litotamniowe) o łącznej miąższości do 8 m. We wkładkach marglistych występują otwornice należące do Discorbacea, Rotaliacea i Orbitoidacea (Gonera 1994b). W tych utworach licznie reprezentowana jest *Amphistegina hauerina* d'Orbigny; stanowi 10-39% zespołu. Celem obecnych badań było zastosowanie tezy o wpływie środowiska (dostępność światła, turbulencja wody) na sferyczność skorupy *Amphistegina* (Larsen & Drooger, 1977; Hallock *et al*., 1986).
Zmierzono średnicę (D) oraz grubość (T=L1+L2) osobników tego taksonu w profilu. Pomiary wykazały, że 76-98% osobników w badanych próbkach wykazuje sferyczność (indeks T/D) poniżej 0,4. Zatem dominuje morfotyp „płaski", typowy dla wód o niskiej turbulencji wody i siedlisku słabo naświetlonym, czyli głębszej strefy eufotycznej.
Pomiary biometryczne skorup *Amphistegina* wykazała ponadto, iż wypukłość ich strony umbilikalnej (L1) i spiralnej (L2) jest nieomal jednakowa. Zaobserwowano, że badane osobniki posiadają w niektórych komorach intersepta. Wymienione cechy morfologii i paleosiedliska mogą oznaczać, iż obecny w Olimpowie takson jest pokrewny *Amphistegina* aff. *radiata* zasiedlającej głębsze wody Zatoki Aqaba (Hottinger i in., 1993).
W środkowej części profilu Olimpowa *Amphistegina* wykazują nieznacznie większą sferyczność skorup. Czy to dokumentuje epizod spłycenia basenu? W tej części profilu dojrzewanie osobników *Amphistegina* następowało szybciej (mają mniejszą średnicę) a tanatocenozę tworzyły osobniki poreproduktywne (struktura populacji jest jednomodalna). Na spadek batymetrii wskazują również inne składowe zespołu otwornic (plankton, taksony symbiontyczne, morfotyp *Elphidium*). Być może jest to kopalny zapis eustatycznego spadku poziomu morza spowodowanego globalnym oziębieniem Mi3, jakie znajduje odzwierciedlenie w faunie otwornic dolnego badenu śląskiej części Paratetydy (Gonera, 2001). Jednak ze względu na strukturalne położenie osadów Olimpowa (paraautochton) udokumentowany epizod spłycenia mógł być wywołany niestabilnością podłoża.

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Brown, organic-walled foraminifera (*Nodellum*, *Placopsilinella*, *Resigella* and their allies): a widespread and diverse component of deep-sea assemblages

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The genus *Nodellum* was established by Rhumbler (1913) to accommodate *Reophax membranacea* Brady 1884. A characteristic feature of this species is the brownish, relatively thick, organic test wall. Several other genera with similar wall types were described by later authors: *Chitinosiphon* (considered to be a synonym of *Nodellum*), *Placopsilinella* and *Resigella* (Gooday *et al*., 2008a). The type species, *P. aurantiaca*, *N. membranacea* and *R. monilliforme*, are fairly well known and widely reported in deep water. However, faunal surveys from the deep Atlantic, Indian, Pacific and Southern Oceans have revealed a diversity of similar, mainly undescribed, morphotypes, often diminutive in size. They include: 1) very elongate, slender, needle-like forms (*Chitinosiphon*-like); 2) shorter, fatter, tubular, often segmented forms, sometimes attached to particles by trumpet-shaped apertural extensions (*Nodellum*-like); 3) forms comprising a linear sequence of 2-4 globular to oval chambers (*Resigella*-like); 4) tiny tapered or conical forms with colourless transparent tests, for which the genus *Conicotheca* was recently erected. These morphotypes are widely distributed at bathyal to hadal depths. *Nodellum*- and *Resigella*-like forms, together with *Conicotheca*, were the dominant meiofaunal organisms in a core from the Challenger Deep (10,895 m water depth), the deepest point in the oceans (Todo *et al*., 2006; Gooday *et al*., 2008b). Similar species dominated a sample from the North Pole (4,200 m depth) (Gooday *et al*., 2010). Elsewhere, they tend to be a consistent, albeit often relatively minor, component of deep-sea assemblages. At lower bathyal (~2,500 m) sites on the Mid-Atlantic Ridge, a chambered form, similar to *Placopsilinella*, occupies empty planktonic foraminiferan tests. This probably belongs in *Hospitella*, a genus not reported since its description by Rhumbler (1913).

Attempts to obtain DNA sequences from these unusual foraminifera have failed and their taxonomic affinities remain uncertain. Detailed examination of the test wall of the Challenger Deep species by SEM reveals that, although the wall exhibits no discernable internal features, it has a complex surface structure at the submicron scale. Features include finger-like projections, somewhat resembling the organic cement of agglutinated foraminifera, as well as rod- and flake-like particles. X-ray microanalyses indicate that the organic wall contains Fe. It seems likely that the brown wall is equivalent to the thick organic lining (‘sheath’) present in some large agglutinated foraminifera (Gooday *et al*., 2008a).

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Data analysis with PAST for micropaleontologists

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Quantitative analysis of microfossil data is not difficult. Modern "nonparametric" statistical methods are in fact much easier to understand than the classical parametric ones. In this lecture, the author of the popular data analysis software PAST will demonstrate a number of techniques relevant for micropaleontologists, using real paleontological data sets. We will look at methods for comparing and ordering samples and taxa (correspondence analysis, NMDS, cluster analysis, ANOSIM), biostratigraphy (UA, RASC, CONOP), biodiversity (including rarefaction), time series analysis (especially spectral analysis), and paleoenvironmental reconstruction (e.g. the Modern Analog Technique and CABFAC). We will focus on practical aspects, especially the graphical presentation of results.

Jurassic planktic foraminifera and palaeoceanographic change in southern Poland and adjacent areas of Europe

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In recent years our understanding of Jurassic planktic foraminifera as increased markedly, thanks to the work of Marcel BouDagher-Fadel (London, UK), Michael Simmons (London, UK), John Whittaker (London, UK), the late Fred Banner, Agnes Görög (Budapest, Hungary), Roland Wernli (Geneva, Switzerland), Robert Campbell (Houston, USA) and Melissa Oxford (Dharhan, Saudi Arabia). There is growing evidence that, after arising in the mid-Toarcian, the planktic foraminifera dispersed rapidly across northwestern Europe and by the Bajocian occupied much of the area covered by the Western Peri-Tethys. Arising in the Aragonite ll ocean, the early planktic foraminifera appear to have constructed their tests of aragonite and were subject to the same dissolution issues that beset the modern aragonitic plankton (notably the pteropods). Though well-known throughout the Bajocian–Kimmeridgian interval in the Carpathians and southern Poland, there is a "flood" of planktic foraminifera in the latest Callovian and earliest Oxfordian. At the same time there is independent evidence of a cooling, including migrations of northern taxa (e.g., ammonites) into more southerly latitudues. This may represent a lowering of atmospheric *p*CO2 and, thereby, enhanced preservation of the planktic foraminifera. The classic Jurassic localities near Ogrodzieniec (northwest of Kraków) are critical in this debate as they contain very abundant assemblages of *Conoglobigerina* spp., *Hauslerina* spp., and *Globuligerina* (?) spp., especially in the Ogrodzieniec Glauconitic Marl Formation of very latest Callovian age. In the same material are a number of other taxa (benthic and pseudo-planktic) that were described by Werner Fuchs in 1973 but which are all invalid as they were based on internal glauconitic moulds with no preservation of test wall, aperture or external ornamentation.

The Foraminifera.eu Project-status and perspectives

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The Foraminifera.eu-Project wants to foster the interest in foraminifera. It builds a bridge between science and community. It is run by amateurs. Experienced foraminiferologist get a platform to share their knowledge with inexperienced ones. We offer practical help in sample-processing, imaging and classification. Foraminifera.eu has become a popular website with more than 2400 monthly unique visitors viewing about 22.000 pages and staying on average for 8 minutes. More than 100 people have contributed samples, images, drawings, ideas and/or are working on mutual projects such as publications, exhibitions, talks and collections. Reasons for the popularity of the foraminifera.eu-project and perspectives for its development are discussed.

Searchable foraminiferal database and images: As a major service and outcome we have established a freely accessible foraminiferal database with an online multi-criteria search query based on high quality SEM and optical images and drawings. So far 3500+ illustrations are searchable on 19 data-criteria with 1100+ defined values. Six of the criteria are taxonomical, two morphological, four geographical, four stratigrafical, two source-related and one is faunal. An illustrated key to genera offers for about 400 genera a multi-criteria search query on 7 criteria with about 100 defined values. If connected well to the internet any query results within seconds in a plate like presentation of images accompanied by information on genus, species and geological time. Each entry in the database has a single webpage with a bigger image and accompanying information.

A survey has revealed that visitors like most the easy-to use and well structured interface, quality of images and the possibility to choose from a set of parameters in the database-query. They ask mainly to broaden the coverage of genera and species and consider as a major flaw, that many classifications are not reviewed by scientists and may not be reliable. As a response we are integrating since October 2010 primarily images and drawings provided by scientists, resulting in 1000+ reviewed entries. Along with it the number of genera has risen by about 50% to 400+. Still on the wish list is the establishment of more faunal criteria such as water depth, temperature, faunal province and salinity. A useful geographical interface has been established for recent foraminifera with maps to choose from rather than from text. As the background of the visitors is manifold such are individual wishes to enlarge or change the database.

Community character and practical help: About 40 of the 2400 monthly visitors contact us. Most want information, literature, samples or technical help. With about 3 we are able to establish a mutual project, resulting in more than 100 contributors after 3 years of existence. A major group provides samples and/or specimens in order to receive SEM-images and discuss its classification. The second largest group are scientists contributing illustrations as a courtesy or to get the own collection accessible worldwide and selectable through the database-query. It is intended to further foster the interest in foraminifera with practical help, sharing samples and mutual projects. Thus a section of mini-lectures has been added and the illustrated key-to-genera has been created. In September 2011 a weekend workshop for beginners "Introduction to Micropaleontology" will be held in Hamburg.

Beginning and division of the Badenian Stage (Middle Micocene, Paratethys)

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The beginning of the Paratethyan Badenian stage is yet regarded to coincide with the beginning of the Mediterranean Langhian stage. The subdivision of the Badenian into the Moravian (lower Badenian), Wielician (middle Badenian) and Kosovian (upper Badenian) reflects the subdivision in the Vienna Basin based on benthic foraminifera with the "Lagenidae Zone", the "*Spiroplectammina* Zone" and the "*Bulimina/Bolivina* Zone". Most characteristic are the widespread evaporates of the Wielician in the Carpathian Foredeep and the Transylvanian Basin. According to this subdivision, the beginning of the Kosovian coincides with the Mediterranean Seravallian stage.

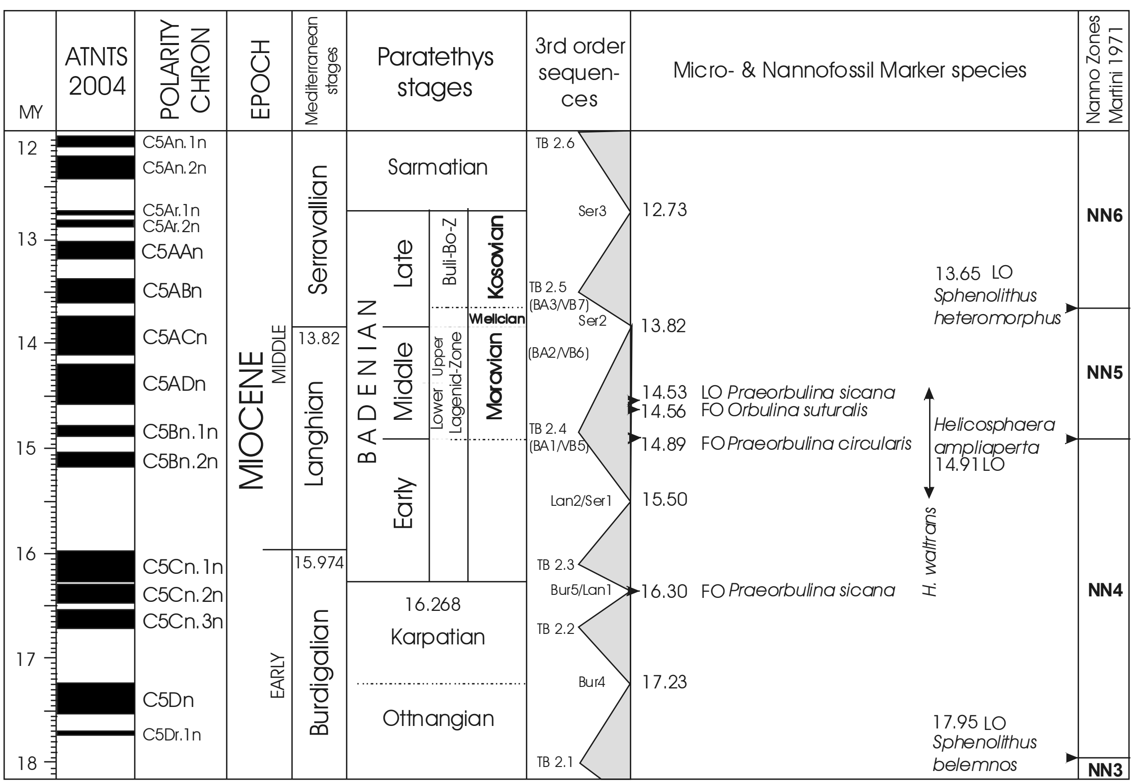

Figure 1. Integrated stratigraphy of the Early/Middle Miocene in the Central Paratethys.

Investigations of the Karpatian and Badenian in the Austrian Molasse Basin and the Styrian Basin resulted in the detection of a large interval between the uppermost Karpatian and the base of the Lower Lagenidae zone, the latter correlated with the NN4/NN5 boundary at -14.91 Ma. Since the boundary between the Early and Middle Miocene will be placed at the beginning of polarity chron C5B at -15.974 Ma, biostratigraphically approximated by the LCO of *Helicosphaera ampliaperta* and the Paracme Zone of *Sphenolithus heteromorphus*, the lowermost Badenian should be placed between -15.974 and -14.91 Ma assuming the coincident beginnings of the Langhian and the Badenian. Detailed integrated stratigraphical investigations in the Styrian Basin (Austria) resulted in a clear paleoenvironmental change documented by shallow benthic foraminifera and the occurrence of the planktonic foraminifer *Praeorbulina sicana* together with the marked change in nannofossil composition at polarity chron C5Cn.1n (-16.268 Ma). This change was caused by the major alpine tectonic event called the "Styrian Tectonic Phase". Therefore, the beginning of the lowermost Badenian must be placed at -16.268 Ma and does not coincide with the Burdigalian/Langhian boundary at -15.974 Ma!

The "Lower Lagenidae Zone" belonging to the NN5 Zone starts at -14.91 Ma and is terminated at -14.357 Ma due to the LCO of *Helicosphaera waltrans*, which is well documented in both the Styrian and Vienna Basin. The stratotype of the Badenian stage belonging to the "Upper Lagenidae Zone" could recently be calibrated by cross-correlating geophysical and geochemical variables with the mid-summer insolation curve. This resulted for the stratotype section in an age between -13.982 and -13.964 Ma, still belonging to the Moravian substage. Taking the NN5/NN6 boundary at -13.654 Ma as the Wielician/Kosovian boundary, then the significant $\delta^{18}O$ increase at -13.82 Ma determined as the Langhian/Seravallian boundary must be equalized with the beginning of the Wielician; then this substage covers only 166 kyr. Therefore the question arises, if the Wielician substage is necessary or it reflects only the beginning of the Kosovian substage or the end of the Moravian stage.

The division of the Badenian into the three substages "Early Badenian", "Middle Badenian = Moravian" and "Late Badenian = Kosovian" can be remained, but spanning different time intervals compared to the former subdivision. This new division correlates well with 3rd order sequences (Fig. 1).

Types of the shallow-water biotops in the Early Badenian of the Moravian part of the Carpathian Foredeep based on foraminiferal and calcareous nannoplankton assemblages

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In the studied part of the Carpathian Foredeep, comparison of foraminiferal, calcareous nannoplankton and geochemical proxies enable distinguish three types of shallow marine environments from clastic facies and one type from carbonate deposits:

(i) Bay influenced by seasonal phytodetritus supply connected with bloom of opportunistic taxa (small-sized *Cibicidoides*, small-sized *Globigerina* and *Reticulofenestra minuta*). Negative carbon isotopic values distinguish this ecosystem from other parts of the Central Paratethys;

(ii) Dynamic shore characterized by variable isotopic compositions of foraminiferal tests probably due to postmortal mixing of indigenous, transported and reworked tests;

(iii) Shore of alternating environments characterized by periods with seasonal changes in water circulation: in the spring, non-stratified well oxygenated water with bloom of epifaunal suspension feeder (*Cibicidoides* spp.) and small-sized five-chambered *Globigerina* sp. According to preliminary isotopic results non-stratified water column can be interpreted from similar oxygen and carbon isotopic values for plankton and benthos. During summer, stratification with hypoxic bottom environment was established which enabled to survive only to infaunal species. Succession of seasonal populations of plankton has not been recorded because in assemblages only small-sized *Globigerina* sp. were recorded. These horizons alternate with intervals characterized by stabile bottom condition with sea-grass meadows interpreted due to high abundance of epyphitic species mainly *Asterigerinata*. Corroded and abraded tests are common what can indicate high-energy environment. Planktonic assemblages suggest seasonal succession of planktonic foraminifera: *Globigerina* spp. may dominate during high-nutrient conditions, *Globigerinoides*, *Orbulina* and *Globorotalia* during warmer and more oligotrophic seasons. Preliminary isotopic results confirm the hypothesis: higher carbon and lower oxygen values for *Orbulina* and *Globigerinoides* may indicate oligotrophic, warm-water while low carbon and higher oxygen values for *Globigerina* could characterize eutrophic, colder water and intermediate carbon and oxygen values for *Globorotalia* transitional less oligotrophic and warmer water.
(iv) Fossil ecosystems from biohermal bodies are distinguish by lower abundance of planktonic organisms, higher ratios of warm-water plankton, appearance of assemblages of calcareous dinoflagellate cysts *Thoracospheara* sp., only positive isotopic values and low abundance of high-nutrient markers and infauna. Stabile oligotrophic condition with seagrass meadows and high oxygen content can be interpreted at the bottom. Upper part of water column is very probable also oligotrophic. Some oscillations of salinity cannot be excluded.

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Life and feeding strategy of the Barrandian Early Devonian Foraminifera vs. morphogroup distribution

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Five morphogroups of agglutinated Foraminifera (ED1-ED5) were defined for the Lower and lower Middle Devonian of the Barrandian area. Morphogroups recorded in the Barrandian Lower Devonian represent only narrow part of the Mesosoic and Cenozoic morphogroup variability. Missing of the morphogroups with deep infaunal life strategies may indicate absence of this strategy and corresponding feeding strategies (bacteria scavengers) among the Early Devonian foraminifera. Morphogroup distribution has been strongly affected by oxygen concentration, energy of environment and postmortal processes.
Globular morhogroup was recorded in all lithofacies including facies deposited in stress condition and associates opportunistic taxa. Globular tests may be also accumulated by shape sorting of tests during postmortal transport. Attached morphogroup indicates more energy environment. Tubular foraminifers represent suspension feeding strategy and their bloom indicate sufficient amount of nutrients in suspension. Invasion of planispirally coiled morphogroup with phytal life position may indicate enlargement of sea-grass meadows at the bottom.

Horizons with diversified and abundant foraminiferal assemblages containing all morphogroups can be correlated with positive $\delta^{13}C$ excursions and with deposition of nodular limestones.
The Lower Devonian assemblages from Barrandian area were compared with isochronous assemblages from Australia, North America, Poland, Slovakia and Sardinia. Though taxonomical composition of the Lower Devonian assemblages from different areas is rather different, the morphogroup composition is well comparable and indicates globally similar life and feed strategies of the Early Devonian Foraminifera. Low diversified assemblages contain globular, tubular or simply attached forms. Deep infaunal life strategies are extremely rare.
In contrast to Barrandian area, foraminifera from other areas are more common and diversified also in dark probable hypoxic facies though hypoxic conditions could be only in sediment during deposition of these dark lithotypes. Astrorhizas, which are common in Australia, may represent carnivorous trophic level. Barrandian and Sardinania assemblages from light nodular limestones are characterized by specific assemblages dominated by planoconvex complicatedly meandering tests.

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The foramBarcoding project – a molecular catalogue of foraminifera

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What is the foramBarcoding project?
The identification of foraminiferal species is mainly based on the morphology of their tests. Here we propose a complementary identification system based on short DNA fragments specific to each species, called DNA barcode. For each species present in our database, you will find its general description, photos, collection data, DNA sequences, and references to related publications. Only sequenced species are included in our database.

Methodological approach
A fragment of the SSU rRNA gene is amplified and sequenced with primer pairs s14F3-sB or s14F3-s20r. The fragment is used for phylogenetic analysis and includes the barcoding region. It is usually necessary to perform a nested PCR, replacing primer 14F3 by primer 14F1. The barcoding region is situated at the 3’ end of the fragment and is amplified using the primer pair s14F3-s17. It spans two foraminifera-specific hypervariable expansion segments, 37/f and 41/f that were shown to be sufficiently variable to distinguish closely related species in most of examined genera (Pawlowski & Lecroq, 2010). The length of barcoding region varies between 400-600 nt depending to the species.
For some species, barcode sequences might slightly differ in variable regions between specimens. In these cases a representative sequence showing less than 1% difference will be chosen as barcode sequence.
Most amplifications are done on single-cell DNA extractions. Because of intra-individual polymorphism, the amplification products are cloned and 2-3 clones are sequenced. Whenever it is possible, this is done for 3 specimens of the same population to evaluate intraspecific variation.

Planktonic foraminiferal content of the Eocene sequences in the İncesu area (Western part of Taurides, Turkey)

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This study focuses on the Kırdağları Series in the İncesu area, composed mainly of Eocene marine sequences that include sandstone and mudstone alternation in flysch facies, massive limestone and pelagic limestones. The objective of this study is to provide for the first time planktonic foraminiferal evidence from upper side of the Kırdağları series, to obtain precise ages and to ascertain depositional environments. Planktonic foraminiferal assemblage consists mainly of *Acarinina bullbrooki*, *Acarinina echinata*, *Acarinina rohri*, *Acarinina topilensis*, *Catapsydrax globiformis*, *Catapsydrax howei*, *Catapsydrax unicavus*, *Globigerinatheka barri*, *Globigerinatheka index*, *Globigerinatheka kugleri*, *Globigerinatheka mexicana*, *Globigerinatheka subconglobata*, *Hantkenina alabamensis*, *Hantkenina compressa*, *Hantkenina dumblei*, *Hantkenina liebusi*, *Morozovella spinulosa*, *Morozovella lehneri*, *Orbulinoides beckmanni*, *Subbotina angiporoides*, *Subbotina corpulenta*, *Subbotina eocaena*, *Subbotina hagni*, *Subbotina linaperta*, *Subbotina senni*, *Subbotina yeguaensis*, *Turborotalia cerroazulensis*, *Turborotalia frontosa*, *Turborotalia pomeroli* which indicate Lutetian–Bartonian age.

Lower Jurassic foraminifer assemblages as an indicator of the environment of deposition of the spotty limestones, Western Tatra Mts

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Lower Jurassic bioturbated (“spotty”) limestones of the Fleckenmergel facies were studied in the Križna Unit, Polish part of the Western Tatra Mountains, in the Lejowa and Długa valleys sections. These deposits consist of alternating, mostly thin- to medium-bedded limestones and marlstones, which are 150 m thick. They are characterized by the occurrence of dark-filled trace fossils on a bright and totally bioturbated background. Ammonites suggest a late Sinemurian–early Pliensbachian age.
A total of 23 agglutinated and calcareous benthic foraminiferal species are distinquished in the studied material, and they are arranged into eight morphogroups. The most numerous foraminifers are represented by two morphogroupes; calcareous foraminifers belonging to morphogroup C3 and representatives of agglutinated foraminifers belonging to the morphogrup A1. The morphogroup of C3 is dominated by the epifauna and shallow infauna morphotypes of multilocular straight and planispiral forms of the genera: *Nodosaria*, *Dentalina*, *Frondicularia*, *Geinitzinita*, *Marginulina*, *Pseudonodosaria*. The flattened and coiled morphotypes like *Involutia* (morphogrup C1) and biconvex (*Astacolus*, *Lenticulina*) classified as morphogroup C4 are occasionally found. Among the agglutinated forms the most numerous are the tubular specimens of morphogroup (A1) as *Hyperammina*, *Rhabdammina* belonging to erect epifauna. Representatives of the other agglutinated morphogroups with genera: *Ammodiscus* (A2) *Haplophragmoides* (A3), (A4) are scarce.

The described microfauna is dominated mainly by two morphotypes of the representatives of epifauna and shallow infauna. The association of the benthic foraminiferal assamblages consists mostly of an "opportunistic", r-selected species, which can provide the stressful environment. It is suggested that the studied series was deposited in the external neritic-upper bathyal environment, with the periodic influence of turbidites.

Trace fossil assemblage include *Planolites*, *Thalassinoides*, *Chondrites*, *Zoophycos*, *Teichichnus*, *Taenidium* and *Trichichnus*. Their small-scale vertical changes suggest fluctuations in nutrient supply and variations in the oxygenation of sediments. These results are confirmed by geochemical analyses which indicate changes in oxygen levels from fully oxic to strongly dysoxic conditions. The limestone-marlstone alternations are caused mainly by the rhythmic delivery of siliciclastic material and organic matter from the adjacent lands. Such processes are dependent on the climatic changes, probably related to the Milankovitch cyclicity.

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Influence of monsoon on the flux of planktic foraminifera in two sediment traps off the Sunda shelf (southern South China Sea)

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The monsoon and the El-Nino-Southern-Oscillation system (ENSO) are two important influencing factors on the oceanography of the southern South China Sea (SCS). The Southwest Monsoon (SWM) is affecting the local oceanographic parameters between June and August, whereas the North-East Monsoon (NEM) is active from October to April. As a result, surface temperatures, ocean currents and sea-surface topography change dramatically between seasons. One of the main changes is the position and strength of upwelling induced by the monsoon regime in the SCS. In this work, we aimed to identify the effects of mainly monsoon induced upwelling occurring off the Vietnamese coast on planktic foraminiferal productivity and faunal assemblage variability. Therefore, we investigated the planktonic foraminiferal flux sampled from two sediment traps, one ca. 80 km east off the Vietnam coast (trap SCS-SW), the second ca. 80 km off the Sunda Shelf (trap SCS-S). All traps were deployed at 1200m below surface in 1750 to 1850m water depth. Three trap series from 2004-2005 and 2006-2007 have been analysed in four size subfractions.

The most abundant species in all three sediment traps have been *G. sacculifer*, *G. ruber*, *G. siphonifera*, *N. dutertrei*, *G. ruber* (platys), *P. obliquiloculata*, *G. rubescens*, *G. bulloides*, *G. glutinata* and *G. scitula*. Since most of these species are symbiont-bearing and dwell in the euphotic zone, their changes in relative abundance can be directly linked to changes in the sea surface water chlorophyll-a concentration; the abundances of *G. rubescens* and *G. scitula* are not correlated directly to chl.-a levels since they are barren of photosynthetic symbionts and depend completely on a diet of other planktonic organisms.

In general, total foraminiferal flux is high in June and October and, with a smaller peak, in August and November in the coast-near trap. We found little differences in the temporal signal between the trap series from 2004–2005 and those from 2006–2007. The high peaks in planktonic foraminiferal flux occurred mainly in the trap series between July and November, with lower average levels in the shelf-near trap than in the SCS- SW-trap.

The diversity of planktonic foraminiferal species found in the three traps is between 27 and 29. The total flux of planktonic foraminifera (pF) in SCS-SW-04 deep was 7707.16 pF*m^{-2} *d^{-1}, the recorded flux in SCS-S-02 deep was 5919.32 pF*m^{-2} *d^{-1} and SCS-SW-06 deep trapped 5001.84 pF*m^{-2} *d^{-1}. During total particulate flux, lithogenic matter, opal, organic matter and organic carbon flux are at their highest peaks, total foraminiferal flux tends to be low in almost all samples. Lithogenic matter flux shows diverging signals between trap series from 2004-2005 and 2006-2007. In total, series SW-06 deep has the highest values of lithogenic matter flux with 2197.76 mg m^{-2} d^{-1}, S-02 deep with 1875.97 mg m^{-2} d^{-1} and SW-04 deep with 1111.8 mg m^{-2} d^{-1}.

By analysing results we can point out a significant decrease in pF flux during an increase of sedimentary particulate matter, which is an indicator for monsoon seasonality and climate. Other results are to recognise in variations in pF faunal assemblage composition during monsoon season in comparison to inter-monsoon times. The southern South China Sea has not often been investigated before in non-ENSO-years in that detailed aspects that we are offering in this work.

An Assemblage of Mangrove Foraminifera from the Wadi Haliy Delta on the Red Sea coast of Saudi Arabia

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The Wadi Haliy Delta is located on the southern Red Sea coast of Saudi Arabia. The delta consists of three lobes, the southernmost of which is now active, with the modern channel of the ephemeral Wadi Haliy stream. The delta is comprised largely of terrigenous sandy deposits carried from the metamorphic and volcanic hinterland.

The intertidal zone of the central part of the Wadi Haliy Delta is host to healthy Mangrove community, characterized by soft fine-grained muddy sediments that are anoxic beneath a thin surface layer. We collected surfical sediment samples from areas between the mangrove roots and from shallow channels between clusters of mangroves with the aim of documenting the associated foraminiferal fauna. The mangroves in the area are under threat from development of coastal areas by the tourist industry, and the Wadi Haliy is no exception. The purpose of this study is to establish baseline information on the foraminiferal assemblages from a relatively undisturbed deltaic setting on the Red Sea coast.

The foraminiferal fauna from the intertidal Mangrove community on the Wadi Haliy delta is unlike Mangrove communities described from the Caribbean and the Pacific Islands. The Wadi Haliy Mangroves host a low-diversity foraminiferal fauna dominated by an undescribed species of *Trochammina* with a very coarsely agglutinated wall. *Trochammina*-dominated agglutinated foraminiferal assemblages are also known from Miocene terrigenous deposits in the Red Sea drilled by the petroleum industry. Documentation of the modern assemblages of Mangrove foraminifera on the Wadi Hali delta will provide baseline information for the interpretation of older hydrocarbon-bearing sediments in the Red Sea.

Pliocene–Pleistocene Dysoxic Benthic Foraminiferal assemblages in the Bering Sea, initial results from IODP Expedition 323, Hole 1341B.

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The primary objective of drilling at Site U1341 was to study high-resolution Pliocene–Pleistocene paleoceanography in the southern part of the Bering Sea at a western flank location of Bowers Ridge. Previous DSDP coring (Site 188) and subsequent piston core studies in the region documented high sedimentation rates of 100–138 m/m.y., and the presence of appropriate microfossils for paleoceanographic studies.

Drilling at Site U1341 – located at a water depth of 2177 m in the southern Bering Sea recovered nearly 600 m of diatomaceous sediment, and provides a record of past intermediate water conditions in the Bering Sea. The site is located just below the modern OMZ, which causes the formation of laminated sediments. Fluctuations in the intensity or depth of the OMZ should be captured by benthic foraminiferal proxy records of past oxygenation measured at this site and compared to shallower sites.

We present the first record of benthic foraminiferal assemblages from 110 samples collected at 3 m resolution in IODP Hole 1341B. Pliocene assemblages from the base of the hole to ~320 m consist entirely of agglutinated foraminifera strongly dominated by the infaunal genera *Eggerella*, *Karreriella*, and *Martinotiella*. The ecological information gained from this assemblage supports other proxy information indicating high levels of organic productivity in the Bering Sea. Occasional horizons with calcareous benthic foraminifera dominated by buliminids are present, possibly owing to fluctuations in the CCD.

Calcareous benthic foraminifers (mostly comprised of *Bulimina*, *Globobulimina*, *Uvigerina*, *Melonis*, *nodosariids*) show improved preservation in the upper part Hole 1341B starting at ~320 m (ca 2.3 ma). This level coincides with abundant sea ice diatoms and radiolarians living in cold and oxygen-rich intermediate water masses. The fauna still indicates dysaerobic conditions, but productivity may have been reduced by seasonal sea ice coverage and an enhanced stratification of the water masses. The preservation and diversity improves again at ~150 m (ca 1.1 ma), close to the "mid-Pleistocene transition".

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Bering Sea benthic foraminiferal changes over the past 2 Ma: implications for deep-water ventilation over glacial–interglacial cycles

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The Bering Sea is the third largest marginal sea in the world, yet until deep coring during IODP Expedition 323 in 2009 (Takahashi *et al*., 2011), very little was known of its palaeoceanographic past. Understanding the palaeoceanography of the Bering Sea is important as it contains upwelling CO_2 and nutrient-rich waters supplied from the Pacific, which are potentially important for changes in glacial–interglacial atmospheric CO_2. The Bering Sea may also have been a source of North Pacific Intermediate Water during glacials. The sediments recovered are predominantly composed of diatom frustules and fine terrigenous clay and silt, with occasional ash layers. Shipboard biostratigraphy and magnetostratigraphy reveal high sedimentation rates averaging ~30 cm/kyr on the Northern Slope and ~15 cm/kyr on Bowers Ridge. The sediments have low $CaCO_3$ content, but contain well to poorly preserved calcareous foraminifera over the last ~1–2 Ma. Sedimentary gamma ray attenuation and colour reflectance predominantly respond to changes in the ratio of biogenic to terrigenous material, and show cyclical variability that most likely correspond to glacial–interglacial changes in primary productivity, related to upwelling and sea ice, and terrigenous input, related to ice sheet extent and sea level changes.

We use the commonly occurring bathyal benthic foraminifera *Elphidium batialis* and *Uvigerina* spp. to constrain bottom water $\delta^{18}O$ and $\delta^{13}C$, which reveals the major glacial–interglacial cycles and long term trends. Bottom water $\delta^{13}C$ (~-0.5 to -2.0 ‰) is generally lower than the Pacific (~0.5 to -1.0 ‰), indicating that the Bering Sea contained aged and nutrient rich deep water over the last ~2 Ma. Benthic foraminiferal faunas are predominantly composed of shallow and deep infaunal species, such as *Bulimina* spp., *Elphidium batialis*, *Globobulimina pacifica*, *Nonionella labradorica* and *Uvigerina* spp., which are tolerant to low oxygen and indicate that the Bering Sea experienced varyingly moderate to poorly oxygenated deep water cycles throughout the last ~2 Ma. Initial results indicate that the relationship between glacial–interglacial cycles and bottom water oxygenation was complicated, but that during the middle Pleistocene glacial intervals coincided with lower oxygen deep water. The deep Pacific is the modern source of Bering Sea deep water. As the deep Pacific appears to have been more poorly ventilated during glacials of the middle Pleistocene, this relationship may indicate that middle Pleistocene Bering Sea ventilation was also controlled by the deep Pacific as it is today. The occasional well-oxygenated glacials of the past ~1 Ma may therefore be due to a change in this relationship, with a possible local ventilation source perhaps due to greater sea ice extent and duration.

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Campanian-Maastrichtian deep-water changes in the high latitudes: benthic formaniniferal evidence

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During the latest Cretaceous cooling phase, a superimposed positive shift in benthic $\delta^{18}O$ values lasting about 1 Ma (71–70 Ma) can be observed in the South Atlantic Ocean (Campanian-Maastrichtian Boundary Event, CMBE). This oxygen isotope excursion is either interpreted in terms of a change in deep-water circulation or as a temporal built-up of ice sheets in Antarctica. In this study we test if benthic foraminiferal assemblages from a southern high-latitudinal site near Antarctica (Ocean Drilling Program Site 690, Maud Rise, Weddell Sea, southern South Atlantic) are influenced by the CMBE. If the positive oxygen isotope excursion reflects a change in deep-water circulation from low-latitude to high-latitude water masses, this change would result in cooler temperatures, higher oxygen concentration, and possibly lower organic matter flux at the seafloor. As a consequence, a major shift in benthic foraminiferal assemblages would be expected. If, however, the $\delta^{18}O$ excursion was exclusively triggered by ice formation, no considerable compositional difference in benthic foraminiferal assemblages would be expected. Samples of Site 690 were taken in a mean resolution of 35 kyr spanning the latest Campanian to late Maastrichtian time interval (73.0–68.0 Ma). Our data show a clear separation of the studied succession into two parts with distinctly different benthic foraminiferal assemblages. Species dominating the lower part (73.0 to 70.5 Ma) tolerate less oxygenation and higher organic matter flux (e.g., *Globorotalites* spp., *Paralabamina hillebrandti*) or are typical components of low-latitude assemblages (*Reusella szajnochae*). In contrast, the upper part (70.0 to 68.0 Ma) is characterized by species that indicate well-oxygenated bottom waters under more oligotrophic conditions (e.g., *Nuttallides truempyi*) or species common in high-latitude assemblages (*Pullenia* spp.). The benthic foraminiferal assemblages therefore clearly respond to the CMBE. We interpret the observed changes in benthic foraminiferal assemblages towards a well-oxygenated environment associated with the CMBE to reflect the onset of a shift from low-latitude dominated deep-water masses towards the dominance of a high-latitude deep-water source. As the benthic fauna would not be influenced by ice formation in Antarctica, the formation of an ice sheet as sole cause for the oxygen isotope excursion can be excluded.

The Latest Danian Event in the Eastern Desert, Egypt

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The Latest Danian Event (LDE; Bornemann *et al*., 2009) in the Eastern Desert of Egypt is characterized by an anomalous lithology and geochemistry, a negative $\delta^{13}C$ shift and a peculiar succession of benthic foraminiferal faunas. The 1-2 per mil negative $\delta^{13}C$ excursion in the Egyptian sections correlates with

$\delta^{13}C$ shifts in the eastern Atlantic (Zumaia, SpaIn: Arenillas *et al*., 2008; Bornemann *et al.*, 2009), ODP 761B offshore NW Australia (Quillévéré *et al*., 2002) and ODP 1209 (Shatsky Rise: Westerhold *et al*., 2011), suggesting a perturbation of the global carbon cycle characteristic of a hyperthermal event. In the field the LDE is commonly developed as a couplet of a purplish-brown marl bed and a black shale bed intercalated in the Dakhla Formation, with a total thickness of 5-25 cm. The lower LDE bed is laminated and contains pyritic molds, fish remains and coprolites; together with absence of benthic microfossils evidencing anoxia at the sea floor. We studied benthic foraminifera in five sections along a paleobathymetric transect ranging from middle-outer neritic to bathyal paleodepths. In all sections the lower LDE bed is barren of benthic foraminifera, whereas the upper bed records an incursion of a low-diversity benthic shallow-water assemblage dominated by *Neoeponides duwi*. The LDE appears to be related to the rapid transgressive phase after the lowstand of a regional (global?) sea-level cycle, causing anoxia at the sea floor. The presence of the *N. duwi* assemblage, earlier interpreted as shallowing, is more likely explained by this shallow-water assemblage migrating to deeper waters, thereby filling niches temporarily vacated by other taxa.

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Micropaleontological data of limestone clasts from the Upper Cretaceous Ostravice Sandstones (Silesian Nappe, Western Outer Carpathians, Poland)

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The Ostravice Sandstones were divided as the Upper Cretaceous lithostratigraphic unit of Silesian Series occurring in the in the Silesian-Moravian Beskidy. Cieszkowski *et al.* (2010. *Mineralia Slovaca*, 40, 2, 508-509) interpreted them as the lowermost member of the Godula Formation, formed by the complex of thick- and very thick-bedded, mostly coarse-grained or conglomeratic, massive, often amalgamated sandstone turbidites. The sandstones consist of the monomineral grains of quartz, rare feldspars, muscovite and glauconite, as well as clasts of magmatic rocks, sandstones, siltstones, cherts and especially rich limestones. The age of the Ostrovice Sandstones was estimated as Coniacian-Santonian (Cieszkowski *et al*., 2010). This division is widespread in the Silesian Nappe between Ostravice in Czech Republic and Ustroń, Czchów and Tuchów in Poland. The samples of discussed sandstones were collected from Ustroń and Czchów and 22 thin sections were prepared and microscopically studied.

The limestone clasts are poorly rounded and measured from 1 mm to several cm. They represent shallow-water and pelagic limestones and could be classified mainly as: bioclastic mudstone/wackstone, bioclastic-peloid wackstone/packstone, peloid-bioclastic grainstone, ooid grainstone, lithoclastic-bioclastic grainstone. Some studied fossils in part of the clasts indicate the age of limestones as the Upper Jurassic–lowest Cretaceous. The most important taxons of foraminifera recognized in the thin section are: *Andersenolina alpina*, *Andersenolina elongata*, *Crescentiella morronensis*, *Mohlerina basiliensis*, *Protopeneroplis ultragranulata*, *Scythiloculina confusa* and *Quinqueloculina cf. histri*. Other foraminifera are: *Bullopora* sp., *Arenobulimina* sp., *Dobrogelina* sp., *Gaudryina* sp., *Glomospira* sp., *Hagimashella* sp., *Lenticulina* sp., *Mesoendothyra* sp., *Nautiloculina* sp., *Paleogaudryina* sp., *Protopeneroplis* sp., *Spirilina* sp., *Trocholina* sp., *Verneulina* sp. and taxons representing Nubeculariidae, Nodosariidae, Textulariidae and Miliolidae. Calpionellids *Calpionella alpina*, *Calpionella elliptalpina*, *Calpionella elliptica*, *Calpionellopsis oblonga*, *Crassicolaria* sp. and calcareous dinocysts *Schizosphaerella minutissima*, *Colomisphaera heliosphaera* and *Comittosphaera sublapidosa* were also noticed. In the thin sections were also recognized calcimicrobes, green algae *Globochaete alpina* and *Globochaete* sp., microproblematica *Koskinobulina socialis* and *Bacinella*, worms *Terebella lapiloides*, Dasycladaceae including *Actinoporella podolica* and *Clypeina* cf. *catinula*, ?red alga *Solenopora* sp., spines and other remnants of siliceous sponges, fragments of bryozoans, mollusks, brachiopods, calcareous sponges and corals, plates of crinoids, echinoderm spines, gastropods and ostracods. Carbonate grains are represented by peloids, lithoclasts, ooids and cortoids.

The limestones represented by clasts occurring within the Ostravice Sandstones were deposed during the Late Jurassic and the Early Cretaceous in the southern part of the Proto-Silesian basin on the deep shelf and slope of the ridge bordered basin from south. Late Cretaceous tectonic activity restructured the basin. Then formed the proper Silesian Basin and Silesian Ridge. Part of the previous shelf and basinal slope was tectonically uplifted and incorporated to the structure of the Silesian Ridge. Intensive erosion of the ridge caused dynamic sedimentation of sandstones of the Godula Formation in the Silesian Basin. The first were eroded discussed limestones, so their clasts derived to the Silesian Basin by turbidity currents substantly composed primary sandstone sequences of the Godula Formation.

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Morphometrics of Judea Group Orbitolinids (Larger Foraminifera) in Israel and their Paleoenvironmental Significance

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Major environmental change in the Tethys took place at the Cenomanian/ Turonian Anoxic Event (the Bonarelli anoxic event), but the changes in oceanic fertility and oxygenation of the sea floor that culminate in that event already affect the continental shelf and slope from the Middle Cenomanian. We describe here results from a morphometric study of orbitolinid larger foraminifera from coeval sections of the Cenomanian Judea Group from different parts of Israel. Normal univariate statistical methods were used to evaluate variations in shape and size among the orbitolinid faunas between these sections. This study was aimed at identifying the changing environmental conditions along the carbonate ramp of the Levant.

A non-parametric 1 Way- ANOVA showed a significant difference in the shape of orbitolinids from different sections in the Negev, but no significant difference in size of the populations. Orbitolinids from Avnon Formation, early Late Cenomanian, at the Har Avnon section near Yeruham, and from the Ef'e section east of Dimona, show no difference in shape or size and represent the same orbitolinid species (*Orbitolina conica*). At Makhtesh Gadol, orbitolinid foraminifera from the top of the Ein Yorke'am Formation, some 2 Myr older in the Middle Cenomanian, show the same pattern in size, but differ in shape. A significant difference in both shape and size was recorded between populations from the section at Makhtesh Gadol, and from coeval material from the Carmel outcrop and Manara.
Shape variations in orbitolinid foraminifera have been attributed to water depth, while size variations may occur under different nutrient levels. There are two models when it comes to nutrient levels. The one says that large size represents an environment that is rich in nutrients, and the second approach suggests that the *Orbitolina* is symbiotic bearing foraminifera and its size represent an oligotrophic environment. Microfacies analysis will help us decide between the two approaches.
For now we can conclude that in the Negev there was different sea level at different times but the same nutrient level. Also at the same time space there was a difference in the sea level and the nutrient level between south and north Israel.

Changes of palaeoenvironment recorded in the Late Glacial and Holocene deposits of the middle coast of the Southern Baltic Sea based on biostratigraphical research.

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Research area included lake fields of: Resko, Jamno, Bukowo and Wicko and lake sandbars: Jamno-Mielno and Łazy, Kopań and land area Darłówko, Modlinek. The aim of this work was to analyse changes of ostracods and diatoms assemblages and plant communities succession. The analysis was done to define palaeoenvironmental changes of lacustrine and fluvial biotops` domains on the ground of lithofacies. Reconstructed assemblages` successions allow to characterize each stage of lacustrine development during Late Pleistocene and Early Holocene.
The obtained results indicated that the lacustrine deposits of the above-mentioned reservoirs (Resko, Kopań, Darłówko i Bukowo) are genetically connected with the Baltic Sea development starting from the phase of Baltic Ice Lake. Environmental type of accumulation of studied deposits is determined by the presence of freshwater ostracods such as: *Candona angulata*, *Candona neglecta*, *Cytherissa lacustris*, *Cypridopsis vidua*. The change of freshwater environment into marine one is very evidently recorded in the deposits of the stand: Jamno, Bukowo, Mielno, Łazy by total disappearance of freshwater ostracods and diatoms which were replaced with marine ostracods and planktonic diatoms with typical forms for the Litorina sea. Confirmation of increasing salinity is occurrence of *Cyprideis torosa* and also increasing number of *Pediastrum kavraiskyi* in the deposits. The beginning of the deposition of these sediments was determined by both radiocarbon dating and palynological analysis on the Atlantic period. After the maximum of Litorina (Atlantic) transgression, the waters of the reservoirs became brackish. It is marked by increasing number of freshwater diatoms and disappearing species typical for the Litorina sea. Climate changes caused simultaneous changes in species composition of forest communities within the coastal area. The last phase of the studied reservoirs development is connected with the Baltic eutrophication

which resulted in decreasing euphotic zone. It is mainly indicated by the results of diatom analysis that show meaningful increase in planktonic forms occurrence. The forms are connected with high-trophic waters. Palynological research indicates progressive shallowing of the reservoirs and widening rush and meadow communities zone.

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Relationship between pore density in benthic foraminiferal species and oxygen concentration in bottom waters

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The overall aim of our study is to improve our understanding of the relationship between benthic foraminiferal (BF) pore characteristics and oxygenation in order to develop a proxy for quantification of bottom-water oxygen concentrations. Such a proxy will enhance the reliability of paleoceanographic reconstructions of deep-water environments, where, at the present, it is difficult to separate changes in oxygenation and organic matter flux (e.g., deposition of sapropels, ocean anoxic events).

In order to investigate the relationship between pores in BF tests and bottom-water oxygenation, pore characteristics in tests of living (Rose Bengal stained) BF taxa from locations spanning a wide range in bottom-water oxygenation across oxygen minimum zones off SW Africa (Namibia and Angola), and off Pakistan were analysed. We compared pore densities of the infaunal BF species *Fursenkoina mexicana*, *Globobulimina turgida*, *Bolivina pacifica*, and *Bolivina dilatata* with measured oxygen concentration of the ambient bottom-water, and provide a first quantification. In addition, pore densities were compared to further bottom-water characteristics like water depth, temperature, salinity, and nitrate concentration. In both regions, all investigated BF species display a negative exponential correlation between pore density and oxygen content indicating a morphological response of the foraminifers to decreasing oxygenation. Supporting previous results, we suggest that an increasing number of pores improves the ability of oxygen uptake in low-oxygen environments.

Middle Miocene biostratigraphy and paleoecology (calcareous nannoplankton) of the Machów Formation (Carpathian Foredeep, Poland)

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The Polish Carpathian Foredeep Basin (PCFB) is the northern part of a large foreland basin system that surrounds the Carpathian orogenic belt. Like other foreland basins, the PCFB is asymmetric and filled mostly with clastic sediments of the Miocene age up to 3,0 km thick at the Carpathian front and to few hundred meters in the northern marginal part. Molasse deposits of the PCFB, underlain by the platform basement, dips southward underneath the Outer Carpathian napes to a distance at least 50 km. The PCFB is subdivided into two sub-basins: the inner and outer ones, located respectively south and north of the Carpathian frontal thrust. The outer sub-basin is composed of Middle Miocene autochthonous marine strata. The Miocene succession is subdivided into three formations: the Skawina Fm- sub-evaporitic, Wieliczka/ Krzyżanowice Fms.- evaporitic and the Machów Fm- supra-evaporitic. The Machów Fm, being the subject matter of our work, is predominantly composed of siliciclastics sandstones and shales couplets. Its age traditionally was assigned as Late Badenian and Early Sarmatian on the basis of foraminiferal research mostly. Our studies of the Machów Fm were concentrated in the eastern part of the PCFB, north of the Rzeszów. In this area we collected samples from five boreholes, in the following depth intervals: S-2 (Stobierna): 1016-1338 m; S-3: 715-1669 m; S-4: 1016-1238 m; SB-1 (Stara Brzóza): 350-356 m and 1043-1667 m; P-2 (Pogwizdów): 1161-1390m. The uppermost (above 350 m) and lowermost (beneath 1669) part of Machów Fm. was not studied because of lack of the core material. The aim of this work was to provide the biostratigraphical and paleoecological analyses for the Machów Fm. For this purpose simple smear slides were prepared using the standard method, and analyzed under light microscope Nikon Eclipse E600POL (LM, 1000x magnification) at normal and crossed nicols. The qualitative and the quantitative analysis were carried out for all the samples. The obtained biostratigraphical data gave evidence for the upper part of the NN6 (the Early Sarmatian) and for the NN7 (the lowermost part of the Late Sarmatian) Zones. The whole sections investigated in S-2, S-4 and P-2 were classified to NN6 Zone. In S-3 interval 1669-1113 m was assigned to NN6, whereas section 843-715 m to NN7 Zone. In SB-1 interval 1667-1043 m belongs to NN6 Zone, interval 350-356 m was classified to NN7 Zone. The paleoecological preferences of nannoplankton species were considered in regard to temperature and nutrient availibility (trophy). Our interpretation is based on variations in the relative abundances of such species as: *C. pelagicus*, small *Reticulofenestra*, *Sphenolithus spp.* and *Helicosphaera* group. The enrichment of *C. pelagicus* in sediments, being the important paleoclimatic marker, could indicate the nearshore eutrophic environment with high nutrient level in surface water and upwelling paleoconditions. The scarcity of discoasterids, which are more common in open ocean assemblages, could confirm shallow and coastal paleoenvironment as a negative indicator however its distribution depends on paleogeographical settings. Deposition near the coast and relatively shallow water depth could result in high percentage of reworked specimens, which prevails over autochthonous ones in most samples from studied boreholes. The percentage of autochthonous specimens is less than 50% and fluctuates between 40-50%. Reworked material of Cretaceous and Paleogene age comes from the south, from the eroded Carpathian orogene.

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The orthophragminid (larger foraminifera) rudstones as paleoecological indicators, Upper Bartonian deposits, Tatra Mountains

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The Middle–Upper Eocene deposits crop out along the northern margin of the Tatra Mountains (southern Poland). These deposits represent a transgressive sequence. The sequence commences with conglomerates, composed of bedrock clasts. The conglomerates are covered by littoral extraclastic packstones that are locally capped by nummulitic bank facies. These deposits are, in turn, covered by orthophragminid rudstones, which are overlain by Upper Eocene glaucony marlstones and limestone facies containing numerous nummulites, orthophragminids, coralline algae and bryozoa. Locally, a higher stratigraphic position is occupied by conglomerates, which suggests synsedimentary tectonic activity. The orthophragminid rudstones are one of the most distinct facies among the Tatra Eocene deposits. The upper Bartonian orthophragminid rudstones occure at the localities: Strążyska Valley, Spadowiec Valley, Pod Capkami Quarry, Olczyska Valley, Jaszczurówka, and the Chłabówka Stream. The rudstones are up to 2 m thick and are built almost exclusively of the tests of orthophragminids dominated by macrospherical species of *Dicocyclina*. The lower part of the the orthophragminid rudstones are dominated by saddle-shape orthophragmnid *Discocyclina ephippium* (Schlotcheim), moreover *Discocyclina sella* (Archiac), fusiform and not numerous *Discocyclina pratti* (Michelin), *Orbitoclypeus varians* (Kaufmann), *Asterocyclina stellata* (Archiac). The orthophragmionid tests are 9–12 mm in diameter and 1–1.3 mm thick, with the thickness/diameter (T/D) ratio 0.11–0.15. In the upper part of the facies the orthophragmind tests become thinner and flattened, dominated by disc-shaped *Discocyclina sella* (Archiac), *Discocyclina augustae* Wejiden, with single *Discocyclina radians* (Archiac), and saddle-shaped *Discocyclina ephippium* (Schlotcheim). These specimens are generally up to 10 mm in diameter and approximately 1 mm thick with the average T/D ratio 0.1. The tests are horizontally orientated, densely packed, with rare signs of fragmentation or abrasion.

The studied orthophragminid rudstones represent parautochthonous deposits lain down in the outer ramp setting, in the photic zone. The low degree of tests abrasion and the scarce occurrence of micrite is an effect of intense winnowing below the storm wave base. Vertical transition within the orthophragminid rudstones from more ovate, saddle-shaped *Discocyclina ephippium* (Schlotcheim). towards the thin and flat *Discocyclina sella* (Archiac) is interpreted as a result of gradual increasing depth, diminishing energy and gradual shadowing of the depositional milieu.

Upper Cretaceous deposits in the vicinity of Kraków determined on the foraminiferal assemblages

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In the vicinity of Kraków the following Upper Cretaceous stages represented by deposits with both macro and microfossils assemblages have been documented:

Albian and Cenomanian. For a long time, Albian deposits, from Korzkiew were considered as diagonal and cross-bedded sands, without macro or microfauna. Tarnowski and Liszka (1982) described from this sandy complex, the low diversified foraminiferal assemblage with *Gavelinella cenomanica*-the index taxon which indicates the Cenomanian age. This suggests that the Albian/Cenoman boundary is located within sands from Korzkiew. As a result, to date, there are no micropaleontological evidences to improve upon this (Machaniec, *et al*., 2004). In the Januszowie and Korzkiew vicinity the Cenomanian deposits have only been documented by echinoid macrofauna (Kudrewicz & Olszewska-Najbert, 1977). The age was established in conglomerate on the echinoderm fauna of the genera of irregular *Pyrina* and *Pygaulus* and also regular *Phymosoma*.

Turonian. These deposits are lithologically diversified. In the area of Trojanowice-Korzkiew, they occur as sandy limestones with a high concentration of conglomerate fraction, and limestones with quartz pebbles. An abrasion surface suggests the sedimentary break occur within the Turonian deposits. Additionally, in the vicinity of Kraków the older abrasion surface in the Jurassic deposits was also documented. The occurrence of these surfaces is characteristic for the Kraków area (Zabierzów, Bonarka). In the Zabierzów quarry, where the stromatolits have been documented on the abrasional surfaces, the Turonian deposits are developed as conglomerate limestones (Machanice *et. al*., 2004).

Coniacian?. The occurrence of deposits of this age is still not clear in the Kraków area. An attempt to establish the age may be carried out on deposits only from the Zabierzów quarry, where the green and yellowish-green glauconitic marls occur, with very poor foraminiferal assemblage, which are poorly preserved. Barczyk (1956) and Kudrewicz (1992) presented that in this area, a stratigraphic gap from Upper Turonian through Coniacian occur, reflecting what seems to be proved, by studies presented here.

Santonian. The Santonian deposits in the Kraków area generally are represented by marly facies with relatively well-preserved and diversified foraminiferal assemblage (Gołcza, Zabierzów and Korzkiew). The micropaleontological criteria in the Bonarka quarry are not sufficient to determine the Santonian age.

Campanian. These deposits occur *In*: Korzkiew (marly complex from "U Krzywdy" quarry), Bibice, Wola Zachariaszowska, Garlice, Owczary and Pychowice (white marls with cherts).
Foraminiferal assemblages from deposits described above, suggest the sedimentation on the outer shelf of the Cretaceous Sea on the European Platform.

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Upper Cretaceous and Miocene foraminiferal assemblages from the Bibice area (vicinity of Kraków)

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Upper Cretaceous sediments from the vicinity of Bibice (Kraków area) are light-grey and greyish-green marls, and irregularly bedded gaizes intercalated by thin layers of whitish-grey marls. The gaizes interbed the light-grey marls and contain light-grey cherts together with fragments of bivalves shells belonging to *Inoceramus*, molds of sponges representing the genus *Ventriculites* and plates of echinoderms of the genus *Echinocorys*.

The foraminiferal assemblage found in washed material is dominated by taxa representing the genus *Stensioeina*: *Stensioeina gracilis* Brotzen, *S pommerana* Brotzen, *S. exsculpta* (Reuss), *S. clementiana* (d'Orbigny). The second abundant group includes members of the genus *Gavelinella*: *Gavelinella stelligera* (Marie), *G. costulata* (Marie), *G. umbilicatula* (Vassilenko), *G. tenuissima* Gawor-Biedowa. The agglutinating foraminifers are rare but reveal high biodiversity and are represented by *Arenobulimina obessa* (Reuss), *Arenobulimina minutissima* Gawor-Biedowa, *Arenobulimina donica* (Marie), *Orbignyna ovata* Hagenow, *Orbignyna variabilis* (d'Orbigny), *Ataxophragmium depressum* (Perner), *Spiroplectammina dentata* (Alth), *Marsonella trochus* (d' Orbigny), *Gaudryina pyramidata* (Cushman), *Tritaxia dubia* Reuss, and *Verneulina muensteri* Reuss. Planktonic foraminifers are also scarce being represented by species *Marginotruncana marginata* (Reuss) as well as quite common representatives of the keel-free genus *Hedbergella*.

The age of studied sediments was determined as the Early Campanian basing on the range of *Gavelinella* (Zapałowicz-Bilan *et al.*, 2009).

In the vicinity of Bibice the Miocene sediments overlie upon the Cretaceous marls and are divided into the Kłodnica Formation (marly conglomerates) and the Skawina Formation (grey and light-grey, marly clays with glauconite). In the bottom part of the Skawina Formation the foraminiferal assemblage is dominated by planktonic forms such as: *Globigerinoides bisphaericus* (Todd). *G. trilobus* (Reuss), *G. immarturus* (Le Roy), *Globoquadrina altispira* (Cushman & Jarvis) and *G. venezuelana* (Hedberg). In the higher part of the sequence, the composition of assemblage changes and dominating species become: *Globorotalia bykovae* Aisenstat, *Paragloborotalia mayeri* (Cushman & Ellisor), *Turborotalita quinqueloba* (Natland), *Globigerina tarchanensis* Subbotina & Chutizieva accompanied by stratigraphically important species *Orbulina suturalis* Brönniman. Benthic foraminifers are represented by species: *Lenticulina* div. sp. with *Spirorutilus carinatus* (d'Orbigny), *Cylindroclavulina rudis* (Costa), *Uvigerina pygmoides* Papp & Turnovsky, *U. howei* Garrett, *Anomalinoides badenensis* (d'Orbigny), *Cibicidoides chropovensis* (Cicha & Zapletalova), *C. pseudoungerianus* (Cushman), *Globocassidulina crassa* (d'Orbigny), *Heterolepa dutemplei* (d'Orbigny), *Bolivina antiqua* d'Orbigny and by less common: *Nodosaria hispida* Soldani, *Marginulina hirsuta* d'Orbigny, *Siphonodosaria verneuili* (d'Orbigny), *Laevidentalina scripta* (d'Orbigny) and others. This assemblage indicates an Early Badenian age (Zapałowicz-Bilan *et al.*, 2009).

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Paleobathymetric and depositional evolution inferred by micropaleontological data: the case of the Oligo–Miocene Northern Apennine foreland basin (Italy)

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This work aims to provide new insights on the Oligo–Miocene paleobathymetric and depositional evolution of the Northern Apennine foreland basin through a multidisciplinary approach mainly based on micropaleontological data derived by quantitative analyses on foraminiferal assemblages. Particularly biostratigraphic and paleobathymetric data (as initial water depth of the basin) are used as a tool for highlighting the sedimentary and tectonic evolution of the basin, *i.e.*, the chronology of the recorded geological events and the sedimentary response to belt uplift and eroded materials accumulation in the new accommodation space created by crustal flexure (geohistory analysis).

The Northern Apennine fold-and-thrust belt is composed of mostly NE-verging tectonic units pilled up first, during the Cretaceous-Eocene subduction-related convergence and then, during the Oligocene to Neogene collisional setting. The deriving foreland basin, which developed at the leading edge of the chain, is filled by over 5000 m thick Oligo-Miocene deep-sea siliciclastic sediments with a roughly northern provenance, particularly from central-western Alps. These sediments are worldwide famous because on them were pointed out the first concepts of turbidite sedimentation and facies analysis. The Northern Apennine foreland system can be, therefore, considered a very interesting geological topic to check the role of paleobathymetric and geohistory analyses that constitute a relatively new approach for this chain above all because a comprehensive study on the Northern Apennine foreland basin as a whole is still lacking.

In order to fulfil the aim of the research about 260 samples from thirteen composite sections sampled in the Oligocene to upper Miocene Falterona-Cervarola and Marnoso Arenacea units were used to perform an integrated study of both benthic and planktic foraminiferal assemblages. The sections are distributed in an area located along the main Northern Apennine watershed among Florence, the Po Plain and the Adriatic Sea, covering a total thickness of about 16000m.

Collected micropaleontological analyses provided the database to unravel the initial water depth along the studied sections at the beginning of flexure and the following paleobathymetric evolution of the foreland basin up to the superimposition of the Ligurian nappe and/or the progressive migration towards NE of the foreland basin system.

Results show that following flexure, paleobathymetry cyclically decreased recording the progressive infilling of the new created accommodation space, providing also evidence for the sedimentary response to tectonics through belt erosion and sediment accumulation in the foreland basin.

Particularly note-worthy is that the initial water depth supposed for the beginning of the Falterona-Cervarola sedimentation during Chattian was markedly deeper (average water depth over 2500m and often below the CCD) then the initial paleobathymetry reconstructed during latest Burdigalian for the Marnoso Arenacea depositional system (ca. 1500m depth). Thus this study could also represent a good opportunity to decipher the last phases of mountain building by means of timing resolution and basin development.

Some clues on the causes of mid-Pleistocene last global extinction undergone by lower bathyal benthic foraminifera in the SW Pacific (IMAGES Site MD 97-2114)

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This work aims to improve the knowledge of the possible causes that impacted deep-sea benthic foraminifera, mostly characterized by elongate, cylindrical morphologies, occurred during the mid-Pleistocene and recently named Last Global Extinction (LGE).
The studied core is approximately 28m length and covers a continuous record of the past 1,07 Ma. It comes from the IMAGES site MD 97-2114 (SW Pacific Ocean) located on the northeastern slope of the Chatham Rise (New Zealand) at lower bathyal water depth (1936m). This site lies into the Pacific Deep Water, with average temperature of 1.8-3.0°C and salinity of 34.5-34.7 psu; moreover it is within the oxygen minimum zone and slightly above the present-day upper boundary of the Deep Western Boundary Current (DWBC), at ca. 2000m. The DWBC is a fundamental component of the Global Thermohaline Circulation and it is also the major source of deep water for the whole Pacific Ocean.
The applied methodology is strongly multidisciplinary basing on the integration of microplaeontological quantitative studies of foraminiferal assemblages and isotopical data (both oxygen and carbon) derived by analyses on isolated specimens of *Uvigerina peregrina*.
Results show that, at the IMAGES site, the dynamics of the LGE, note previously as "*Stilostomella* Extinction", are quite well recorded in agreement with literature data. Particularly the relative abundances of the elongate-uniserial taxa (Extinction Group), belonging mostly to the families Stilostomellidae and Pleurostomellidae and to the superfamily Plectofrondiculariina, show a strong and positive correlation with the major climate cycles. They decrease mostly during glacials and are partially recovered during interglacials. Since MIS 21, however, the recovery doesn't compensate the loss leading to the Extinction Group disappearance at the MIS 14/13 boundary (ca 543 kyr).
During the same time interval, other biological and geochemical evidences are recorded. Benthic assemblages abruptly change their distribution patterns: buliminids (particularly the *Bulimina marginata* group), *Oridorsalis umbonatus*, *Cassidulina neocarinata* and *Epistominella vitrea* strongly increased in abundance. We interpret this faunistical change, that becomes more accentuated since MIS 14, as related to an important variation of the food supply to the sea floor towards more changeable conditions, with higher nutrient fluxes but more seasonally pulsed.
Moreover, the foraminiferal conservation index (Fragmentation Index) shows a first slightly decreasing trend from the bottom core to the MIS 16/MIS15 transition (ca 600 kyr) and a second increasing trend from MIS14 to MIS4 (ca 80 kyr), with the lowest values registered during interglacials and the highest ones during glacials.
Finally, the $\delta^{13}C_b$ curve records a weak long-term positive excursion from the bottom to the top of the core with two mid-term maxima centred, respectively, at the MIS26/MIS25 (ca 900 kyr) and MIS16/MIS15 transitions (ca. 600 kyr). Those carbon-value maxima perfectly fit the lowest abundances of the elongate Extinction Group.

A possible explanation for the heaving of the carbon values is an increased inflow of younger, cooler and more corrosive water probably produced around Antarctica and then transported to East New Zealand region *via* DWBC. Particularly an increase of the Deep Western Boundary Current volume could be expected in each glacial phase, reflecting the Antarctic ice sheet expansion.
We hypothesize that the loss of the deep-sea Extinction Group could have been caused by a co-occurrence of environmental changes: (i) variations in the food source (more abundant but also more seasonal and pulsing), (ii) cyclical inflows of younger, colder and more corrosive waters produced around Antarctica during glacial expansion phases.

Calcareous nannofossil events associated with the K/T boundary in the Romanian Carpathians

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The K/T boundary event, produced around 65 million years ago, led to an abrupt and massive extinction of the Cretaceous nannofloras. From 130 nannofossils documented in the latest Maastrichtian, only 10-15 taxa survived the K/T catastrophic event, representing an extinction of around 90 % (Bown, 2005).
In the Romanian Carpathians, a continuous K/T transition was observed in a few sections that are mainly located in the Carpathian bend area and in the central and northern parts of the Eastern Carpathians (Melinte & Jipa, 2005; Bojar *et al*., 2009). The uppermost Maastrichtian-lowermost Paleocene sediments are represented by a hemipelagic deposition (i.e., red marlstones in the southern part), and a turbidite one in northern areas.
The late Maastrichtian nannofloras of the Romanian Carpathians are characteristic for the Tethyan Realm, but several species more related to cold water high palaeolatitudes are present. Their presence is possibly linked to pulses of cold oceanic water that occurred in the studied area towards the Cretaceous end. The studies carried out on the calcareous nannoplankton assemblages revealed that, in the Romanian Carpathians, as elsewhere, the K/T boundary is marked by the disappearance of most Cretaceous taxa (over 90 %). However, the deterioration of nannofloras started towards the top of the Maastrichtian, being expressed by a slight and continuous decreasing in nannofloral abundance and diversity, shift which was previously observed in other Tethyan sections (Lamolda *et al*., 2005). From the survivor nannofossils, which are Cretaceous taxa yielding a consistent and increasing abundance in basal Paleocene sediments, only *Cyclagelosphaera reinhardtii* and *Octolithus multplus* commonly occurred both in Maastrichtian and Danian investigated samples.
Successive blooms of the calcareous dinoflagellate *Thoracosphaera spp*. (up to 80 %) and of the calcareous nannoplankton species *Braarudosphaera bigelowii* (up to 50 %) were identified at the base of the Danian. Both above-mentioned taxa are the most successful survivors across the K/T boundary. Possibly, their survival strategy is linked to their capability to encyst, and to produce subsurface blooms in the lower photic zone, where K/T post-impact conditions were less stressful than at the surface-water. Other survivals that show peaks in the basal Danian are the opportunistic species *Octolithus multiplus*, *Cyclagelosphaera reinhardtii* and *Markalius inversus*, taxa which are mostly related to middle and high palaeolatitudes (Bown, 2005).
In basal Danian deposits of the Romanian Carpathians, the incoming Tertiary nannofossils are mainly represented by *Neobiscutum* taxa. Rarely, *Biantolithus sparsus* was also observed. Taking into account

the sedimentary rate of the studied successions, the Tertiary nannofossils became dominant in nannofloral assemblages around 350,000-400,000 years after the K/T impact event.

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Quantifying the Impact of Anthropogenic CO_2 on planktonic foraminiferal shell mass: a field experiment to quantify the effect of post depositional dissolution

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Anthropogenic emissions of Carbon Dioxide are reaching unprecedented levels in the atmosphere. Current observations show that the increase in carbon dioxide (CO_2) is outpacing natural variability on both short term (Glacial-Interglacial cycles) and long term timescales. Yet, atmospheric concentrations correspond to only two thirds of emitted CO_2; the remaining third has been absorbed by the oceans, with direct consequences for calcifying organisms. The reaction of CO_2 with the ambient carbon species present within seawater lowers the pH and reduces the availability of carbonate ion (CO_3^{2-}). Planktonic foraminifera, like other calcifying organisms, utilise CO_3^{2-} in their calcification process. It is this combined with their near global distribution and high abundance in the sediment that make them a crucial group in aiding our understanding of this phenomenon. A number of proxies exist for quantifying the invasion of anthropogenically produced CO_2: shell mass and the geochemical signal recorded within their shells (i.e. $\delta^{18}O$, $\delta^{13}C$, and $\delta^{11}B$). Yet, proxy based research requires a knowledge of both the source signal and any potential factors changing it. Shell mass observations, a measure of shell thickness, represent a proxy for the initial shell mass at calcification, but it also records the potential impact of post-mortem dissolution. In this study we address the modulation of shell mass with respect to dissolution for different species. Our study involves a depth transect comparison of foraminiferal shell weight and shell size observations from seven sites. These sites are located perpendicular to the Mid-Atlantic Ridge in the North Atlantic and spatially situated close to one another. This allows us to explain the differences between sites largely as a function of dissolution. Results indicate that the shell weights of *Globigerina bulloides* increase with depth. This trend is explained by a relative enrichment of the fossil *G. bulloides* population towards heavier shells, as smaller and thinner shelled specimens were removed preferentially. Our data also indicate that the deeper sites are older compared to the shallower sites and hence have been exposed longer to corrosive waters. The longer exposure time to corrosive waters at the deeper sites complicates the interpretation of the data, as it adds a second mechanism to explain the differences in the shell weights. On our poster we will discuss the impact of exposure time on carbonate dissolution.

Stilostomella Guppy, 1894, its shell wall ultrastructure with discussion on the taxonomic position of the genus (Foraminifera)

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The details of the shell wall ultrastructure of the *Stylostomella* ex. gr. *S. lepidula* (Schwager, 1866) and *Stilostomella lepidula* (Schwager, 1866), subsp. nov. were investigated for the first time. The inner structure of the shell and the ultrastructure of the shell wall of the representatives of the genus *Stilostomella* Guppy, 1894 were not investigated previously, and the taxonomic position of the genus also remained unclear. In the widely adopted classification of Loeblich & Tappan, 1987 the genus was included into the family Stilostomellidae Finlay, 1947 of the superfamily Stilostommellacea Finlay, 1947, which together with Bulliminacea entered suborder Rotaliina Delage & Herouard, 1896. Meanwhile one of the main taxonomic features of this suborder according these authors was the presence of the bilamellar shell wall. It was supposed under this approach that the representatives of the family Stilostomellidae also possess such a bilamellar wall. Stilostomellid group of genera differs from the overwhelming majority of the other rotaliins in its uniserial shell character. Such shell form is characteristic of the big groups of nodosriids. Placing these uniserial forms into Rotaliins one needs to suppose the secondary origin of stilostomelids from the elongated trochospiral forms which theoretically thinking could be possible. It seemed that the presence in some of stilostomellids of the inner apertural tooth also shows their affinity to rotaliins. Though their outer nodosariid appearance looks like exclusive case among rotaliins. In the rare cases of the true uniserial rotaliin shells such as for instance *Siphogenerina* Schlumberger, 1882, the small rudimental initial trochoid part is nevertheless preserved at least in one of the generations. All these facts give reasons to investigate the *Stilostomella* structure and ultrastructure in detail in the SEM to affirm or to change its taxonomic position, which was the purpose of the present study.

The study results showed that calcareous shell wall of these two subspecies is monolamellar consisting of one layer of crystals going in radial direction. Such ultrastructure is characteristic of the monolamellar calcareous shell wall. Inner and outer pore openings are disposed between the ends of these elongated crystals. The inner shell wall was rough in all the specimens studied, the outer shell wall may be of the same or even much rough character as the inner one or may be smoothly finished. The fact that both of the subspecies studied possess a monolamellar shell wall necessitates changing the taxonomic position of the genus, moving it from the class Rotaliata characterized by a bilamellar shell wall where they were earlier placed, into the class Nodosariata whose representatives have a momolamellar shell wall. Some other peculiar details of the shell and wall structure of the two subspecies studied are described and are now in the process of publication. The new subspecies differs from the *Stilostomella* ex. gr. *S. lepidula* (Schwager) in its apertural structure, ornamentation of its surface and even in the form of the elongated crystals forming the shell wall. The genus *Stilostomella* is placed here into the family Stilostomellidae of the order Stilostomellida reinsteined after the suborder Stilostomellina Saidova, 1981.

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High-resolution record of planktic foraminiferal response to oceanographic forcing during MIS 2 and 3 in the Mozambique Channel

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The Mozambique Current is part of the western boundary current of the Indian Ocean Subtropical Gyre and is considered as an important source region for the modern Agulhas current. The current is characterized by the development of mesoscale eddies in the Mozambique Channel, which significantly affect the regional hydrography.

A detailed high-resolution study of an 830 cm piston core from the central part of the Mozambique Channel was carried out. The objectives were to determine how the faunal assemblage composition reacted to the glacial environment in this area. As the Agulhas current provides a relevant source for salt and heat to the thermohaline circulation of the Atlantic, it is important to understand the processes that controlled the variability of the current regime during glacial intervals. The record extends back to ca. 70,000 years and covers the Holocene, Marine Isotope Stage (MIS) 2 and 3, as well as adjacent MIS 4. A total of 37 planktic foraminiferal species were identified and counted in four consecutive size fractions. The assemblage composition was highly dominated by *Globigerinoides ruber* throughout the studied interval. Additionally, the distribution of further dominant species, in particular *Globorotalia inflata*, *Globigerinita glutinata*, *Globorotalia menardii*, *Globigerina bulloides* and *Neogloboquadrina incompta* changed significantly, with respect to the glacial intervals.

Correspondence analysis was used to determine major trends in the fauna. Apart from a weak temperature signal, the faunal data also carries evidence for changes in the physical environment of the Mozambique Channel during the glacial intervals. The findings point to a very variable system of the vertical water mass properties and changing trophic conditions. This secondary control of the planktic foraminiferal fauna is confirmed by an analysis of the similarity of the glacial samples with modern core tops. The glacial planktic foraminiferal assemblages are less similar to any fauna in the calibration data set. This suggests a local, isolated faunal development during the glacials.

Biotic response to the Paleocene-Eocene Thermal Maximum in Spitsbergen

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Based on drill cores and field sections, the Paleocene-Eocene Thermal Maximum (PETM) was newly recognized in the Central Basin of Spitsbergen by the Paleo Arctic Climate and Environments project (PACE). The present study is concentrated on the dill core SNSK BH9/05, located in the axial belt of the basin. The sediment infill of the basin is a 2300 m thick succession of shales, siltstones and sandstones deposited during Paleocene and Eocene times. The depositional conditions show multiple changes ranging from delta plain, through lagoonal, prodelta to marine shelf environments. The Spitsbergen depositional area was marginal to the paleo-Arctic Ocean, and the overall environmental conditions of this ocean (semi-isolated during Paleogene) are reflected by the sedimentary infill of the Central Basins, although modified by local facies changes.

The foraminiferal succession of the Central Basin consists of agglutinated taxa, except for a few horizons containing calcareous benthic forms in very low amounts. The species diversities are low (average alpha 2.3), and many taxa are endemic to the Arctic. The organic carbon content of the sediments is intermediate (average 1.1%), while the calcium carbonate content is extremely low (averages 0.4%). The foraminiferal assemblages reflect restricted environmental conditions with low salinity and locally low oxygen content developed in a carbonate-starved water column with thermohaline stratification.

In the Central Basin, the PETM is recognized at five localities in prodelta shelf shales composing the lower part of the Frysjaodden Formation, and appears to be a stratigraphic key horizon for basin-wide correlation. Also here, the PETM shows an abrupt onset and a gradual recovery period. The pre-PETM foraminiferal assemblages are characterised by high dominance of *Reticulophragmium arcticum*, and common occurrence of *Labrospira turbida* and *R. borealis*. Closely similar assemblages are reported from the Late Paleocene of the Beaufort-Mackenzie Basin, Sverdrup Basin, Lomonosov Ridge and Western Siberia. The inception of the PETM is marked by a faunal turnover involving disappearance of several species typical of the *Reticulophragmium* assemblages.

In the Spitsbergen sections, the PETM is characterized by extremely low diversity foraminiferal assemblages dominated by the small-sized *Trochammina* aff. *inornata*, which locally forms monospecific assemblages. Appearance of the dinocyst *Apectodinium augustum* is also a typical feature. The foraminiferal assemblages suggest restricted environments, where low oxygen content is assumed as an important restricting factor superimposed on the overall brackish conditions of the Central Basin. Geochemical signals of the PETM include peak values of the kaolinite content reflecting warm and moist climate. In addition, minimum values of the Th/U ratio suggest hypoxic conditions in the lower part of the water column. Above the culmination of the PETM, the foraminiferal diversity increases gradually with increasing dominance of *Thurammina* aff. *papillata* and *Reophax* aff. *metensis*.

The PETM level of the Central Basin coincides with the maximum transgressive interval of a depositional sequence resting on the subaerial unconformity marking the base of the Frysjaodden Formation. The thin transgressive systems tract composing the lowermost part of the formation leads to the maximum flooding interval revealing oxygen-depleted benthic conditions. This is followed by the regressive systems tract forming an upward shallowing succession of prodeta mudstones, delta front sandstones and delta top paralic strata. During the prodelta to delta front transition, upwards decreasing salinity becomes the dominant restricting factor also reflected by the foraminiferal faunas and bioturbation.

Conodont biofacies record of the Givetian transgressive levels in the Lublin and Łysogóry-Radom basins

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Klapper & Johnson (1980) presented a general model of a rapid diversification and migration of conodonts due to eustatic transgressions. This model is particularly adequate for the widespread Mid-Devonian epeiric seas of Laurussia. Conodont faunas were then dominated by representatives of *Icriodus* and *Polygnathus*, the former genus being ascribed to shallower shelf while the latter to deeper facies. In the Givetian of the Lublin and Łysogóry-Radom basins moderately abundant conodont assemblages occur only in certain carbonate-rich levels with a marine macrofauna, separated by barren restricted, shallower-water and continental deposits. In the Lublin Basin, terrigeneous, restricted facies become more important in marginal parts (Terebiń IG 5 and Krowie Bagno IG 1 boreholes). In the Łysogóry-Radom Basin clayey-carbonate sediments with an open-marine fauna prevail. The biostratigraphic studies (Narkiewicz & Bultynck, 2007) demonstrate that the maximum conodont diversity and frequency is found in the *ansatus* (Mid-Givetian) and *norrisi* (latest Givetian) zones. In both cases it coincides with the transgressive episodes equivalent to the IIa and IIb transgressions of Johnson *et al.* (1985).

In our biofacies study of the above levels we investigated percentage of *Polygnathus* (separately *linguiformis* and *ansatus* species), *Icriodus*, *Pandorinellina* and *Belodellidae*. We analysed the data for the basal transgressive part of the IIa cycle (Giełczew PIG 5, Terebiń IG 5) and for slightly higher part in Komarów IG 1 and Korczmin IG 1. The data were compared to the Bąkowa IG 1 section from the Łysogóry-Radom Basin, where the transgression is less clear. The vertical succesion of the *ansatus* Zone (Giełczew PIG 5, Komarów IG 1) documents transition from the polygnathid-icriodid biofacies just above the cycle boundary, to upper icriodid-polygnathid, and to the highest shallow-water icriodid biofacies. In spite of lateral changes in depositional systems, the polygnathid-icriodid biofacies predominates in the basin, except for the polygnathid-dominated Korczmin IG 1 assemblages. The percentage of *P. ansatus* is nearly constant except for the Terebiń IG 5 where it considerably decreases. *Polygnathus linguiformis* predominates only in Korczmin IG 1 (42%). *Belodellidae*, regarded as relatively shallower-water, attain their peak in Terebiń IG 5. The results show rather uniform open-marine biofacies distribution across both basins. Slightly deeper/more open shelf occurred in the SE Lublin Basin (Korczmin IG 1), while shallower/more restricted prevailed near Terebiń IG 5.

The biofacies for the *norrisi* level (transgressive part of the IIb cycle) were studied in three assemblages. The nearshore Lublin Basin area (Krowie Bagno IG 1) is characterized by an icriodid biofacies with a significant percentage of *Pandorinellina*, in Świdno IG 1 (offshore area) the latter genus is replaced in the same biofacies by *Polygnathus*, which in turn dominates the Łysogóry-Radom assemblage (Bąkowa IG 1). Such a lateral biofacies-change is consistent with a transition from a basin margin towards open shelf conditions.

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The Polish Outer Carpathians-a witness of geohistory of adjacent sedimentary realms-implications from micropaleontological investigations

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In the lecture during the 1st Carpathian Micropaleontological Workshop " Mikro'98", I had the priviledge to present the state of foraminiferal investigations in the Polish Carpathians after edition of the fundamental paper issued in the year 1963 on the occassion of the VIth Congress of the CBGA in Poland. The lecture focused on the stratigraphical research carried on exclusively within the main lithostratigraphic subdivisions of the flysch succession. This time I'd like to turn attention on other aspects of the research.

Both sedimentary types (turbiditic and hemipelagic) building up the Carpathian succession contain abundant information concerning not only the Outer Carpathian basin but also its predecessors and successors. Geohistory of previous sedimentary basins is contained in exotic pebbles frequent in sedimentary sequences of all tectonic units of the Outer Carpathians. In the Skole unit exotic rocks occur in the Spas shales, Inoceramian beds, Węgierka marls, Babica clays, Hieroglyphic beds, Popiele beds, Menilite shales and Krosno beds. In the Silesian unit exotic rocks occur in the upper part of the lower Cieszyn shales, in the Grodziszcze, Verovice, Lgota, Godula and Istebna beds, in the Ciężkowice sandstones and in the Menilite-Krosno series. In the Magura unit exotic rocks occur in the Inoceramian beds and in majority of the Paleogene sandstones. Layers with exotic rocks are known also from remaining units (Dukla, Grybów, Fore-magura units). The age of majority of exotic pebbles covers the time span late Callovian-late Eocene. Rarely there occur fragments of Paleozoic (Devonian-Carboniferous), Triassic (middle), middle Jurassic or Oligocene rocks. Microfossils assemblages suggest that majority of exotic rocks come from various parts of neritic environments. Pebbles representing pelagic environment are rare and usually occur in "inner" units (e.g., Magura unit). In "outer" units (e.g., Skole, Silesian) shallow-water exotics prevail. Identification of the source areas of Outer Carpathian exotic rocks is very difficult but possible. Micropaleontological research suggest that so called "Andrychów klippes" are fragments of the desintegrating West European Platform, whereas "Kruhel Wielki klippes" come from basinal sediments of the Bilche-Volytsya zone (W. Ukraine). The unique Bachowice succession represents remnants of areas with pelagic sedimentation from the Middle Jurassic to the Late Cretaceous rather distant from the edge of the continent.

Sedimentary succession of the Outer Carpathians includes also information of various coeval sedimentary environments existing during its evolution (e.g., Węgierka and Frydek marls).

Transition of the Outer Carpathian basin into its successor the Central Paratethys basin is documented in the sediments of the Skole unit in the western Ukraine. There, in the river Chechva valley sediments of the upper Menilite beds of the Outer Carpathians pass gradually into Paratethyan Polyanitsya beds of the Boryslav-Pokuttya unit. The transition took place during the Early Miocene (Aquitanian-Burdigalian). The disappearing Outer Carpathian basin found its continuation in the emerging Paratethys basin.

These fact young adepts of geology have to bear in mind when starting their investigations in the Outer Carpathians. The sedimentary succession of the Outer Carpathians is a "present state" between "ancient" and "future" stages of geological development of the region.

The position and age of the Magura Sandstones at Klimkówka near Gorlice (Magura Nappe, Polish Outer Carpathians)

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The marginal part of the Beskid Niski Mountains, south from Grybów and Szymbark, is composed of Cretaceous-Paleogene deposits of Rača facies zone of the Magura Nappe. These strata belonging to the Ropianka, Łabowa, Beloveza and Magura formations. These formations are formed into NW-SE trending folds, indicating in the morphology as the narrow ridges and depressions. Between the Łosie and Klimkówka villages this belt crosses the valley of the Ropa River. In this place was built Klimkówka dam in 1994, whose reservoir reaches Uście Gorlickie. Below the dam, on the left bank of Ropa River, is located a big quarry of sandstones of the Magura Formation.

This exposure belong to Kiczera Zdrzar-Czerteżyk syncline underlain by thin-bedded flysch of the Beloveza Formation and variegated shales of the Łabowa Shale Formation. The foraminferal studies of Morgiel *et al.* (1981) documented that variegated shales of the Kiczera Zdrzar-Czerteżyk and Sucha Homoli synclines vary in age between them. The first is the Early Eocene age, while second belongs to the middle Eocene. This problem was studied by us, once again, using calcareous nannoplankton methods. For this purpose, several samples were taken from the marly cleystone and mudstone intercalations of the Magura Sandstone. Collected samples contained a moderately rich calcareous nannoplanton belonging to the uppermost part of the middle Eocene and lowest part of the Late Eocene (NP17/18 Zone). Taking to account the age difference between variegated shales which underlain and overlain the Magura sandstones in the Łosie quarry we are willing to recognize that these sandstones as an equivalent of the Piwniczna Sandstone Member of the Magura Formation.

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Calcareous nannoplankton biostratigraphy of the youngest sediments of the Magura Basin-the problem of recycling (Outer Western Carpathians).

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History of the stratigraphic studies of the Magura Nappe has more than 100 years. The first information (beginning of XXth Century) about the Eocene age of the youngest deposits of the Magura Nappe was based on a few determinations of large foraminifera. This point of view has persisted until the mid-50ties of the last century, when the first analyses of small foraminifers were made. These investigations conducted in the northern, marginal part of the Magura Nappe in the Gorlice area revealed the presence of assemblages of small globigerinas, characteristic for the Submenilite Globigerina Marls. This datum level marks the Eocene-Oligocene boundary in the more external units (Krosno Zone or Moldavides) of the Outer Carpathians. Few years later, the Malcov Beds (Oligocene) were discovered in the Nowy Sącz area (for references see Oszczypko-Clowes, 2001) over the Magura sandstones, regarded as the youngest deposits of the Magura Nappe at that time.

A significant qualitative change in biostratigraphic studies took place after application of calcareous nannoplankton. This resulted in the introduction of formal stratigraphic schemes in the Krynica and Bystrica zones (for references see Oszczypko-Clowes, 2001). Contemporary research of calcareous nannoplankton from the Krynica and Bystrica zones suggested mainly early-middle Eocene age of formations, while the younger data were found in the outer zones, mainly in the Siary Zone of the Magura Nappe. Such biostratigraphical framework strongly affected the palaeogeographic and palaeotectonic reconstruction not only for the Magura Nappe, but also for the entire outer Carpathians.

Since than the author with co-operators provided the biostratigraphical data on the final Oligocene to Early Miocene stages of sedimentation in the Magura Basin, based on calcareous nannofosils. It proved that the level of reworked microfossil associations were so far underestimated (Oszczypko *et al*., 1999, 2005, Oszczypko-Clowes, 2001, Oszczypko & Oszczypko-Clowes, 2010). Recently detail quantitative studies of calcareous nannoplankton of the Magura, Malcov (Oszczypko & Zydek, in press), Zawada and

Kremna formations documented degree of of nannofossil recycling in these formations. In the pelagic Leluchów Marl Member of the Malcov Formation. The amount of redeposition is very low (0%-3.80%) in the flysch depoits of the Malcov Formation this increases to 31.35% while in the "molasse" type deposits of the Zawada and Kremna Formation redeposition reaches 43,7 and 69%.

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Late Miocene paleoenvironmental evolution of the lower Guadalquivir Basin, northern Gulf of Cádiz (SW Spain), based on benthic foraminifera

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Benthic foraminiferal assemblages of the lower Guadalquivir Basin (northern Gulf of Cádiz, SW Spain) have been analysed in order to reconstruct the paleoenvironmental evolution during the late Miocene. The studied material is the 260 m-long Montemayor-1 core, located close to Huelva (SW Spain), which ranges from the latest Tortonian to the early Pliocene. Eighty-nine samples were collected each 2.5 m along an interval of 220 m including marine sediments of the whole age range. We analysed benthic foraminifera from the size fraction >125 µm. Relative abundance of species and several diversity indices, including number of taxa, Shannon index, evenness and species dominance, were calculated. Furthermore, Q and R-mode principal component analyses (PCA) were performed to establish benthic foraminiferal assemblages. In addition, benthic foraminifera were classified according to their microhabitat preferences. Other parameters, including planktonic/benthic ratio (P/B ratio), sand content, sedimentation rate, and total number of benthic foraminifera and glauconite grains per gram of dry sediment were calculated as well.

A complete transgressive-regressive sea-level cycle from the bottom to the top of the section is inferred. An abrupt sea-level rise, from inner-middle shelf to upper slope, is recorded at the lowermost part of the core (latest Tortonian-earliest Messinian). Coinciding with the onset of the Messinian Salinity Crisis in the Mediterranean, sea level dropped from the upper slope to shelf edge and, finally to outer shelf and remained approximately stable during deposition of most of the core. A very subtle decrease in the P/B ratio might account for a slight sea-level drop but within the outer shelf range. Finally, the early-Pliocene deposits are interpreted as inner-middle shelf.

The distribution, composition, diversity and microhabitat preferences of the benthic foraminiferal assemblages are mainly controlled by the trophic conditions, specifically by the quantity and quality of the organic matter reaching the sea floor. The outer-shelf fauna, which has a relatively low diversity and dominance of epifaunal-shallow infaunal taxa, indicates an oligotrophic environment with high oxygenation. The shelf edge is also interpreted as a well-oxygenated oligotrophic environment since it was inhabited by a low diversity fauna with abundant epifaunal-shallow infaunal and epifaunal taxa. A mesotrophic environment with moderate oxygenation is inferred for the upper slope and some parts of the outer shelf. A high diversity fauna dominated by shallow infaunal species is characteristic of this environment. *Uvigerina peregrina*, a species that thrives in marine waters with labile organic matter supply related to upwelling events, is very abundant in this mesotrophic environment. Therefore, upwelling currents could have affected the upper slope and some parts of the outer shelf. Finally, eutrophic conditions with low oxygen content characterised by a very low diversity, dominance of intermediate infauna, and the highest percentages of deep infauna are typical for the inner-middle shelf assemblage. This environment is inhabited by *Nonion fabum* and *Bulimina elongata* that can tolerate continental low-quality organic matter. River run-off could be the main source of this continental organic matter.

Miocene microfossils from deposits of the Kłodnica Formation (Chełm 7, Carpathian Foredeep, Poland)

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Miocene deposits are widespread in the Carpathian Foredeep. In the vicinity of Oświęcim, these deposits are mainly represented by the Skawina and Kłodnica Formations (Alexandrowicz *et al.*, 1982). Sediments of the Kłodnica Formation from the borehole Chełm 7, which was the subject of micropaleontological study, are located at a depth of 106.5-151 m, and consist of a diversified complex of clay-sandy deposits formed in terrestrial, freshwater, and brackish environments (Alexandrowicz & Pawlikowski, 1978). The most diversified marine and brackish fauna were observed in samples from a depth of 135.5-144.0 m. They are represented by numbers of molluscs (gastropods and bivalves – in different stages of fragmentation), foraminifers, ostracodes, and fish remains. The stage of preservation of some microfossils can provide environmental information. The foraminiferal assemblage represents mostly shallow water species, dominated by *Ammonia beccari* (Linne), with local co-occurrence of *Quinqueloculina akneriana* d'Orbigny and sporadically *Q. buchiana* d'Orbigny. *Ammonian beccari* shows a high variation of thickness and size of tests. The occurrence of numerous specimens with thick-walled and smooth tests suggests a high-energy environment. Further, the aberrant tests of foraminifera abundant in samples from 139.5 m, also suggests a dynamic environment of the littoral zone (comp. Korecz-Laky & Nagy-Gellai, 1985). The occurrence of outer organic layer (periostracum) preserved in a number of molluscs shells indicates rapid burial. In the sample from a depth of 139.5m an abundant accumulation of pellets is found. Generally, they are a fusiform with a circular cross-section, occurring as separated forms, not aggregated. The scanning electron microscopy study of some pellets reveals organic debris and high accumulation of pyrite. Bałuk & Radwański (1979) from coeval, nearshore deposits, from Korytnica described similar forms in shape and size, but these occurred in characteristic aggregates and are interpreted as a fecal pellets produced by a polychaete. The studied pellets with different preservation and occurrence are fecal pellets most likely produced by molluscs, common in studied material. The ooids, which have been found as separated grains and fragments of aggregates, can also be used as paleoenvironmental proxy, as these forms are typically linked with dynamic, shallow water, environments, and can also indicate the littoral zone.

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Foram extraction and rock disintegration using liquid nitrogen [LN_2]-a report

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An extremely fast, easy and clean method of microfossil extraction [especially forams] from variously lithified porous rocks with the application of liquid nitrogen [LN_2] is proposed. The LN_2 method falls into the category of freeze-thaw methods [a natural erosion process]; it is however, extremely accelerated, leading to microfossils extraction in a simple way.

This method markedly limits the time of rock disintegration from days to only minutes, and allows drinking a cup of tea or a bottle of wine during the process. In the experiment, the LN_2 method was used to decompose rock samples and simultaneously to extract the forams hidden in them. This method seems to be safe for forams and does not require special chemical labs.

The freeze-thaw methods can be generally summarized as follows: 1) saturating the rock with water; 2) placing the sample in a freezer; 3) formation of ice crystals in the pore system leading to disintegration (e.g. Hanna & Church, 1928; Pojeta & Balanc, 1989). A specific type of the freeze-thaw method is the well-known and widely used Glauber's Salt method (e.g. Syrluk, 1972; Green, 2001), to which comparison is made.

In the LN_2 method, the rock sample is treated with LN_2 and hot water until the rock is sufficiently disintegrated to a fraction containing microfossils. The step by step procedure is as follows: 1) break the rock into fragments [0.5 – 1cm]; 2) leave the fragments in the water for a couple of hours or overnight, then decant the water; 3) add the LN_2 to cover the rock; 4) wait few moments until the LN_2 vaporizes; 5) add the boiling water to cover the deeply frozen rock sample; in this step, the rock fragments can be gently crumble between fingers; 6) decant the suspension by a sieve e.g. 63µm; 7) repeat steps 3-6 if needed.

Before the presented experiment, many variously lithified Upper Cretaceous rocks were processed by the LN_2 method to test its effectiveness, especially for extracting forams. After reaching positive results, three samples of Upper Campanian and Lower Maastrichtian opokas [= siliceous limestones] were selected and crushed into smaller fragments [0.5 – 1cm]. Each sample was then sub-divided into two parts, 100g each, which were subjected to further processing by 1) the conventional Glauber's Salt method and 2) the LN_2 method. The following results were obtained including the weight of the residue in the fraction 0.5 – 0.063mm for microscope examination, number of the process cycles, time required for rock disintegration, and the ratio of planktic/benthic forams [P/B]:

sample	Raj N		Kłudzie S		Bliżów	
lithology	marly opoka; Upper Campanian		very hard opoka; Upper Campanian		hard opoka; Lower Maastrichtian	
method	Glauber's Salt [100g]	LN2 [100g]	Glauber's Salt [100g]	LN2 [100g]	Glauber's Salt [100g]	LN2 [100g]
res. 0.5 - 0.063mm	47.8g	35.37g	33.24g	28.42g	47.80g	48.67g
cycles	11	18	17	20	11	18
time	10h	1.5h	14h	1.5h	10h	1.5h
P/B ratio	19/81	47/53	22/78	74/26	2/98	11/81

Comparison of the two methods shows how significantly the application of a particular method [Glauber's Salt *vs* LN_2] may influence the final results and conclusions. The use of the Glauber's Salt method seems to underestimate the number of planktic forams even 5 times in comparison to the LN_2 method and simultaneously lead to biased calculations of the P/B ratio. In the case of the Kłudzie S sample, the Glauber's Salt method gave P/B = 22/78, whereas the LN_2 method gave an opposite result P/B = 74/26. Therefore, the use of P/B may lead to completely different ecological and palaeoenviromental conclusions, depending on the method.

Conclusions:

1) The use of the LN_2 method is fast, clean and saves a lot of time [compare the table].

2) The abundance and state of preservation of benthic forams is similar in both methods.

3) The rock sample is better disintegrated to a finer fraction by the LN_2 method in comparison to the Glauber's Salt method. It allows extracting a significantly higher number of smaller planktic forams, what markedly changes the P/B ratio.

4) The Glauber's Salt method does not provide enough finer fraction. Moreover, it cannot be excluded, that this method can be destructive for planktic forams, since they are subjected to repeated salt crystallization. This method may underestimate the number of planktic forams even five times in comparison to the LN_2 method.

5) Depending on the applied method, the calculated P/B ratio may lead to false ecological and paleoenviromental conclusions.

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Present-day Sea Surface Tempearture estimates based on coccolithophore fluxes on the Chilean continental slope

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We provide a present-day Sea Surface Temperature (SST) reconstruction based on coccolithophore fluxes estimations. For this study we considered 74 surface sediment samples located offshore Chile ranging from 22.80ºS to 44.28ºS and from 70.49ºW to 75.86ºW.

We followed the methodology proposed by Flores and Sierro (1997) to prepare smear slides which were analyzed in Light Microscope at 1000X magnification. This procedure allowed us to estimate the total number of coccoliths per gram of sediment for each of the species. We also designed an approach to estimate NAR (Nannofossil Accumulation Rates, coccoliths cm^{-2} kyr^{-1}) regarding recent sedimentation and mass accumulation rates based on ^{210}Pb (Muñoz *et al.*, 2004) and bulk chemistry analyses of the same set of surface samples (Stuut *et al.*, 2007) measured by ICP-MS (inductively coupled plasma atomic emission spectrometry).

To establish the existing relationship between coccolithophore fluxes (NAR in this case) and SST (annual average) we did a stepwise regression analysis using MATLAB® software (note that SST were extracted from the World Ocean Atlas 2005 database).

We concluded that key species for SST reconstruction using coccolithophore fluxes in this specific case are: *Florisphaera profunda*, *Helicosphaera carteri*, *Gephyrocapsa muellerae*, *Coccolithus pelagicus* and *Oolithothus* spp. The SST estimates were finally compared with SST observed (real measurements), showing a good correlation.

This work corroborates the previous research done in the study area (e.g., Saavedra-Pellitero *et al.*, 2011) and states that coccolithophores (in this case from surface sediment samples) reflect environmental properties and constitute a very powerful tool for reconstructing (present and past) oceanographic conditions.

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The use of foraminifera for bio-monitoring of marine environments - results and recommendations from the FOBIMO workshop

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The European Community Marine Strategy Framework Directive (MSFD) was established to monitor the quality of marine ecosystems. In particular, a suite of measures has to be implemented in due course in order to achieve and maintain a healthy environmental status in the European Seas. Monitoring the status of marine environments is done by describing the impact of pollutants or human activities on organisms living in the particular ecosystems. A suite of habitat defining key species, functional groups, as well as biotic indices based on diversity scales or relative proportions of indicator organisms are used. Monitoring programmes are traditionally based on macrofaunal studies, for which operational methods have been established and calibrated. Benthic foraminifera are also suitable to describe the state of the marine environment because of their fast turnover rate and high degree of specialisation. These unicellular organisms have several advantages in comparison to the more commonly used macrofauna. Their density is an order of magnitude higher than for higher metazoans, the foraminiferal faunas are variable and rich in different species, and the foraminiferal shells are readily preserved in the sedimentary record. Hence, as opposed to macrofauna, foraminifera in sediment accumulation basins have the potential to document historical changes in ecological quality. Still, benthic foraminifera have so far not been used for monitoring purposes and a standardisation of monitoring methods has never been attempted.

In view of evident advantages of foraminifera for environmental monitoring, the Foraminiferal Bio MOnitoring (FOBIMO) Expert Workshop will gather 30 scientists from 21 institutions at Fribourg, Switzerland, in June 2011. The aim of the workshop is to standardise the sampling and data collecting methods of all European teams using foraminifera bio-monitoring of marine environments. Innovative technologies and methods are to be identified. A new and more sensitive foraminifera-based quantitative bio-indicator method for environmentally monitoring is to be developed, which will be adopted by all European laboratories. Synergies and networking between the foraminiferal and macrofaunal research communities are intended. The outcome of FOBIMO will be a proposal for a standardised protocol for foraminiferal monitoring the anthropogenic impact in vulnerable marine areas. The results and recommendations of the FOBIMO workshop will be presented and discussed on the MIKRO-2011 Meeting.

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Phylogeography of European neritic cibicidids (Rotaliida, Foraminifera) based on rDNA (partial SSU and ITS)

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The cibicidids (*Cibicides* and *Cibicidoides*) are often used to reconstruct marine palaeoenvironments. Several neritic morphospecies have been described in European waters, which include *Cibicides refulgens*, *Cibicidoides lobatulus*, *Cibicidoides ungerianus* and *Cibicidoides variabilis*. However, due to the high degree of morphological plasticity within the group, they are frequently lumped together under the name *Cibicidoides lobatulus*. Studies based on DNA sequences can help untangle this morphological muddle when combined with morphological analysis. To date, molecular phylogenies show that *Cibicides* and *Cibicidoides* form two major groups within the cibicidid clade. Within *Cibicidoides*, the morphospecies *C. lobatulus* and *C. ungerianus* also harbour distinct phylotypes which are likely to represent different species (Schweizer *et al.*, 2009, submitted).

Here we focus on neritic cibicidids collected in North East Atlantic and Mediterranean waters (Svalbard, Norway, Scotland, Iceland, France, Croatia). The morphology of the tests was documented using SEM imaging prior to the destruction of specimens for DNA extraction. The genotyped specimens were identified as belonging to several different morphospecies (*Cibicides refulgens*, *Cibicidoides lobatulus*, *C. ungerianus*, *C. variabilis*). Molecular phylogenies based on partial SSU rDNA sequences differentiate at least four different phylotypes in *C. lobatulus* and two in *C. ungerianus*, whereas *C. refulgens* and *C. variabilis* appear more genetically homogeneous. Further studies are ongoing to verify if this tendency is also observed within the more variable part of the rDNA cluster, the Internal Transcribed Spacer (ITS).

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Late Cretaceous palaeobiogeographic distribution of foraminifera in the Tethyan–Atlantic–Arctic transect

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The Late Cretaceous was a tectonically very dynamic period with rifting in different regions of the proto-North Atlantic and along the Lomonosov Ridge in the Arctic prior to the Paleogene opening of the oceanic basins and the separation of the Lomonosov Ridge from the Barents Shelf, and with the progressive isolation of the Arctic Ocean leading to the Paleogene "Arctic Gulf" (McNeil, 1990). The comparison of foraminiferal faunas from these regions gives us an opportunity to understand the palaeobiogeographic distribution of microfaunas and palaeoenvironmental conditions in the context of the aforementioned tectonic changes during the Late Cretaceous. The data set for this study includes our own taxonomic data of foraminiferal assemblages from the Campanian-Maastrichtian strata of the Lomonosov Ridge (IODP 302, ACEX), SW Barents Sea, mid-Norwegian Sea and Labrador Sea, supplemented with published data from the literature on the microfaunas of the Canadian Arctic, Western Siberia, Western Tethys and other proto-North Atlantic regions.

A cluster analysis of agglutinated foraminiferal assemblages reveals a high similarity among microfaunas of the Tethyan and proto-North Atlantic regions, showing a cosmopolitan distribution of deep-water agglutinated foraminiferal taxa. Calcareous benthic and planktic foraminiferal assemblages are poorly diversified in the high latitude regions, characteristic of the Boreal zone, but their component taxa are still cosmopolitan. In contrast to the Tethyan –Atlantic deep-water microfaunas, the Late Cretaceous Arctic fauna from the Lomonosov Ridge is devoid of calcareous foraminifera, and agglutinated foraminiferal assemblages show much reduced diversity. Furthermore, the component taxa and composition of the shallow-water Arctic fauna are highly endemic to the Arctic region, suggesting its isolation from the microfaunas of the surrounding basins. The different degree of faunal affinity and diversification among planktic, shallow- and deep-water benthic foraminifera of the Barents Sea indicates the existence of faunal communication between the SW Barents Sea and the Tethys through the proto-North Atlantic, but that the surface water of the restricted "Arctic Gulf" might have had different physicochemical properties from that of the other basins, which led to the high endemicity of the Arctic fauna and the absence of calcareous foraminifera in the Arctic.

The Western Siberian foraminiferal fauna is diverse and contains calcareous foraminifera, but shows a low similarity to the Arctic and Tethyan – proto-North Atlantic faunas, indicating that the faunal communication of Western Siberia to the Barents Sea through the Kara and Pechora seas in the north and to the Tethys in the south was restricted. The reasons for the isolation of Western Siberian fauna are still unclear.

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The usage of sieve size fractions in palaeoenvironmental reconstructions using foraminifera

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For Late Quaternary palaeoenvironmental reconstructions using foraminifera from sediment cores, various methods of sample analysis exist. The sieve size used is important as it determines the size and number of specimens to be picked and identified for further analysis. In a study of sediment cores from the Sunda Shelf, South China Sea, foraminifera were isolated from samples using a set of stacked sieves such as > 500 µm, 500-250 µm, 250-125 µm, and 125-63 µm. Foraminifera from each sample were thus sub-divided into these sieve sizes which made the picking easier due to less variability in specimen size. More importantly, this method revealed a trend in the sizes of foraminifera. Results from a core are presented here which show that foraminifera were primarily dominant in the finest sieve fraction examined, i.e. 63-125 µm, and secondarily dominant in the 125-250 µm sieve fraction. The key taxa such as *Trochammina* that defined a marginal marine palaeoenvironment within the core were exclusively present in the 125-63 µm and 250-125 µm sieve fractions. *Trochammina* spp. showed a relative abundance from 100% to 57% in the 125-63 µm sieve fraction, whereas they showed a relative abundance from 0% to 43% in the 250-125 µm sieve fraction. The usage of such a methodology reveals the importance of the finer size fraction in palaeoenvironmental reconstructions.

Foraminiferal assemblages as palaeoenvironmental bioindicators in the Middle Jurassic (Upper Bajocian–Bathonian) clays of the polish Jura (south–central Poland)

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The present study contains the summary results of micropaleontological analyses in the Sowa, Leszczyński, Gliński and Gnaszyn clays pits focuses near Częstochowa area, where the sequences of the of the Upper Bajocian Parkinsoni Zone (subzone Bomfordi) up to the Upper Bathonian (Retrocostatum Ammonite Zone) of the ore-bearing clays are exposed. Benthic foraminifera have been used as a tool for reconstruction of sedimentary environments.

The studied sequences of the ore-bearing clays are lithologically very monotonous, consisting of dark-grey clays without distinct facies changes. The only exception is the occurrence of horizons of sideritic concretion levels. The inorganic geochemical indices studied in these sediments do not show significant variations, suggesting stable redox conditions during Upper Bajocian to Upper Bathonian time – interval (Zatoń *et al.*, 2009). Benthic foraminiferal associations present in the study deposits proved much more sensitive for even faint changes in environments than it is recorded in geochemical indices.

To palaeoenvironmental studies the analysis of foraminiferal morphogroups (after Jones & Charnock, 1985: Koutsoukos *et al.*, 1990 and others) was used. The analysis of foraminiferal date shows that in the Upper Bajocian up to the Upper Bathonian sedimentation took place during changeable paleoenvironmental conditions. Generally two types of foraminiferal associatons were distinguished in deposits mentioned above. One of them is characterized by high taxonomic diversity; high abundance of specimens, and variable epifaunal and infaunal morphotypes representing mixed group of specialized feeding strategies. This suggests optimal living conditions controlled by slower sedimentation rate, relatively well oxygenated bottom waters and sufficient or high food supply related to the neritic paleodepth. In the study sequences such type of assemblages is generally connected with deposits that host continuous sideritic concretion levels or present nearby. They were noted in the Upper Bajocian (Bomfordi Ammonite Zone) and Lower Bathonian (lower part of the Zigzag Ammonite Zone) deposits in Sowa and Gliński sections but also in the upper part of the Lower Bathonian (Tenuiplicatus Ammonite Zone) deposits in Leszczyński clay pit and in the Middle Bathonian (Subcontractus and Morrisi Zone) and Upper Bathonian (Retrocostatum Zones) interval in Gnaszyn clay pit. Second type of assemblages contains low diversity of morphotypes dominated by small plano/concavo-convex epifaunal deposit feeders, restricted occurrence of shallow infaunal forms and scarcity of deep infaunal species suggests high deposition ratio and low-oxygen content both in sediment and bottom waters caused by abundant influx of terrestrial organic matter. These assemblages most likely inhabited areas of outer shelf and upper continental slope. In the study sections such assemblages are generally associated with the deposits of the dark-clays devoid of the sideritic concretion levels. They were noted in the Lower Bathonian (Yeovilensis Subzones of Zigzag Zone) deposits in Leszczyński clay pit and in the Middle Bathonian (Bremeri Ammonite Zone) in Gnaszyn section.

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Palaeoecological investigations, taxonomic and biostratigraphic revision in the Nógrádmegyer (Nm) 3 borehole (49.0–102.5m) on the basis of foraminifers

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This is a trial study of a new course at Eötvös Loránd University. The aim of the study was the revision of the foraminiferal fauna of Szécsény Schlier Formation (North Hungary, Eggenburgian) in the Nm-3 borehole. Nográdmegyer is situated about 100 km northeast from Budapest in Cserhát Mountains. The Nm-3 borehole was drilled in 1969 by the National Geological Drilling Company. The previous foraminifera investigations was made by Nagy Béláné. Previously there were determined 8 taxa, Upper Oligocene age (Nagy, 1969).

The documentation materials of the 1969 study were used in this investigation. The sampling was made according to the previous study (resample for the better comparison). A total of 22 samples were collected, of these 19 yielded sufficient number of foraminifera (at least 300 specimen/sample). The samples were dried, disaggregated with hydrogen peroxide and washed trough 63μm sieve. The dried samples were splitted by microsplitter and the foraminifers were counted.

Every specimen was tallied and identified at least at generic level following the taxonomy of Loeblich & Tappan (1987). The planktonic and benthic forms were used in biostratigraphic investigations. To take cognizance of the relevant amount foraminifera per sample the individual rarefraction were used. This and the diversity indices (Fisher's α, Shannon-Weaver, Simpson's dominance, evenness) were calculated by Past software (Hammer *et al.* 2001). BFOI, planktonic-benthic ratio (PBR) and genus-specimen ratio (GSR) were used further more in the palaeoecological investigations.

Previously there had been determined 12 taxa (12 species from 8 genus), this study there were identified 83 taxa (83 species from 49 genus) 76 taxa were never mentioned from this borehole before. Thus the foraminifera fauna of the studied section of the Nm-3 borehole is not foraminifera deficient as before concluded. The age of the sediment is Eggenburgian (on the basis of the occurrence of *Globigerina dubia*, *Globigerina ottnangensis* and *Textularia gramen gramen* from the deepest sample in the borehole), instead of the previously determined Upper Oligocene. The PBR is qiuet high in some part of the borehole so the Szécsény Schlier is not planktonic deficient as previously known by some author. The changes in the PBR reflect the connections of the studied area to the open marine region not the changes in the water depth in this case. On the basis of the previously mentioned methods normal salinity, outer shelf environment were proposed with occasional connection with the open sea region. The oxygen level of the bottom water was quite high through the depositional period of the sediment.

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Comparison of nannofossil assemblages from the Bohemian Cretaceous Basin and Tethyan foreland basins across the Cenomanian-Coniacian interval, Czech Republic

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On the territory of the Czech Republic, both Upper Cretaceous marine epicontinental sediments of the NW European Platform (Bohemian Cretaceous Basin) and deformed sediments of the Tethyan foreland basins (Outer Western Carpathians) occur. In this setting Tethyan and Boreal influences can be observed on closely spaced sections. Seaway between these two areas existed during the Cenomanian-Coniacian at the nowadays Blansko trough (Stráník *et al*., 1996). Nannofossil assemblages of the Bohemian Cretaceous Basin and Ždánice-Subsilesian Unit (deposited on SE border of North European Platform) show similar character. Nannofossils from the Silesian and Foremagura units and Magura group of nappes are different and mostly absent, because sediments were deposited within fluctuating CCD or below CCD.

Bohemian Cretaceous Basin

Marine ingression in the Upper Cenomanian is marked by poor nannofossils with *Corrolithion kennedyi*, *Lithraphidites acutus* (in the oldest marine deposits) and *Axopodorhabdus albianus*. *Watznaueria barnesiae* quantitatively prevails, relative common *Broinsonia signata* and *Prediscosphaera columnata*, few broadly elliptical *Manivitella pemmatoidea*. In the upper part, first *Quadrum intermedium* appears.
Turonian transgression is emphasized by sudden quantitative nannofossil rise of nannofossils and high species diversity. Succession of markers (FO): *Eprolithus octopetalus*, *E. moratus*, *Lucianorhabdus* sp., *Eiffellithus eximius*, *Liliasterites angularis*, *Lithastrinus septenarius*, *Marthasterites furcatus* (rare and not continual), *Zeugrhabdothus biperforatus*, *Quadrum-Micula*, *Broinsonia parca expansa*, *M. furcatus* (common and continual-?acme). Lowermost Coniacian is marked by the top of ?acme *M. furcatus* followed by FO *Micula starophora* and *Lithastrinus grilli.* The youngest deposits contain *Lucianorhabdus* ex gr. *cayeuxii.*

Outer Western Carpathians

• Ždánice-Subsilesian Unit

Cenomanian: nannofossils occur scarcely (*Watznaueria* sp.).

Turonian and Coniacian: nannofossils comparable with those from the Bohemian Cretaceous Basin inclusive of ?acme *M. furcatus* in the Turonian-Coniacian boundary interval.

• Silesian Unit

The Cenomanian is marked by the first *Prediscosphaera cretacea* followed by the FO of *C. kennedyi*, *Gartnerago theta*, *L. acutus* and *Q. intermedium*. Turonian and Coniacian deposits are characterized by the scarce presence of nannofossils. *M. furcatus* was found in association with *E. moratus* in the Lower Turonian. In overlying strata, *E. eximius*, *L. septenarius*, *M. staurophora* and *L. grillii* were recorded on rare occasions.

• Foremagura Unit

The upper Coniacian is marked by *L. grillii*. Low numbers of *M. staurophora* may indicate low-latitude Tethyan province. Underlying strata were deposited below the CCD.

• Magura group of nappes

The Cenomanian is documented by *C. kennedyi* in "black shales", Rača Unit.

Turonian and Coniacian: Mostly red-brown clays were deposited in the abyssal zone below the CCD. Exception forms matrix in breccias deposited by repeated gravity flows in continental rise where poor nannofossils with *M. staurophora* and *L. grillii* were found.

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Paleogene agglutinated foraminifera from the southern part of the Eastern Carpathian Foredeep (Pucioasa section, Romania)

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Recent studies at the southern end of the Carpathian Foredeep, near Pucioasa (Bizdidel Valley section), revealed planktonic and benthic foraminifera assemblages, characteristic for the Late Cretaceous to Miocene of the Carpathian region. The studied outcrops are part of the Tarcău Nappe, the largest and most complex unit in the East Carpathian flysch zone.

Samples collected from the variegated (red-green) claystones and marlstones, strongly affected by tectonics and diagenesis, outcropping north of the Pucioasa-type bituminous lithofacies, contain typical deep-water agglutinated foraminifera assemblages, sometimes associated with planktonic taxa and rare calcareous benthics.

The identified agglutinated foraminifera assemblage is diverse and includes species of *Bathysiphon*, *Nothia*, *Ammodiscus*, *Glomospira*, *Hormosina*, *Reophax*, *Hyperammina*, *Thalmannammina*, *Saccammina*, *Kalamopsis*, *Conglophragmium*, *Spiroplectammina*, *Karrerulina*, *Annectina*, *Trochamminoides*, *Paratrochamminoides*, and *Cribrostomoides*.

New data on Jurassic planktonic foraminifers from the Polish Outer Carpathians.

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From the Polish Outer Carpathians the records of Jurassic planktonic foraminifers are very scarce. These forms, informally included to the protoglobigerinids group, were known so far only from some exotic and tectonic carbonate blocks incorporated into flysch series of different ages. Relatively numerous forms belonging to *Globuligerina* genus were described in thin sections from red limestones with crinoids of the Early Oxfordian age and limestones of majolica-type and of Štramberk-type, which were dated at the Tithonian (Malata & Olszewska, 1998). While mentioned carbonate blocks from the Bachowice klippen succession sticking in the Subsilesian series are referred distinctly to pelagic environments of the Tethys these ones from the Kruhel klippe occurring in the Skole series are related to epicontinetal seas of the European Platform (Książkiewicz, 1956, Nowak, 1973). These areas were disintegrated and intensively rebuilt during initiation and opening of the Outer Carpathian basin in Kimmeridgian-Tithonian times. At the time this basin was filled with carbonate series (Cieszyn beds) including marls, which were transported by submarine mass movements (lower Cieszyn shales) and pelagic limestones intercalated by marls (Cieszyn Limestones). Only part of them has survived up to present. From these Tithonian deposits planktonic foraminifers were not known for a long time. The first record of isolated forms (*Compactogerina stellapolaris*, *Globuligerina*) was documented in marls that appear as intercalations in the upper Tithonian Cieszyn Limestones outcropping in Goleszów (Szydło, 2005, 2006). The presented research documents new occurrences of planktonic forms in marls from the Cieszyn Limestones (Grodziec-Górki Wielkie area), and also from the lower Cieszyn shales (Puńców, Gumna localities). Forms belonging to *Globuligerina* and *Favusella* (*F. hoterivica*) occur in the late Tithonian shelf assemblages, which are dominated by calcareous benthic forms and taxa that agglutinate calcareous material. Generally, the finds of Jurassic planktonic foraminifers in the Cieszyn beds are scarce, and sporadic in space and time. In addition marked forms were related with the ocean province of the Tethys (*Globuligerina*, *Favusella*) as well as with epicontinental seas of the Boreal realm (*C. stellapolaris*). Their number, diversity and paleobiogeographical distribution were strongly controlled by geotectonic and sedimentological factors, which had fundamental influence on the evolution of planktonic foraminifers in the Outer Carpathian basin at the end of the Jurassic. In the Cieszyn beds they also occur in low numbers and are poorly preserved because of their aragonite test well, which are very susceptible to chemical dissolution and recrystallization.

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Environmental and climate settings of changes in foraminiferal and calcareous nannoplankton assemblages in the Miocene of the Carpathian Foredeep (Poland)

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Presented micropaleontological studies concentrate on taxonomical variability, paleoecological preferences and preservation potential of foraminifers and calcareous nannoplankton, which found in Miocene deposits from the polish part of the Carpathian Foredeep. In this peripheral foreland basin of the Central Tethys fossil record were strongly controlled by high geotectonic activities and sedimentary regime. In consequence of it predominating clastic sedimentation, and periodical chemical or carbonate deposition in instable environmental conditions resulted in frequent changes in the availability of oxygen, access of nutrients, and also contents of dissolved calcium carbonate or silica in water. Changes in these parameters had very important role for live (growth, feeding, reproduction) as well as after death of studied organisms (transport, burying, fossilization). It resulted in diversity and composition of fossil assemblages including planktonic and benthic forms in different number and ratios. These forms lived under different marine and periodically brackish conditions. Among them microfauna and nannoflora, which were especial sensitive to changes in salinity and temperature or sunlight, were also noted. Sequences of these fossils in studied deposits were useful for discussion of changes in sea level and water circulation, and next for correlation with climate fluctuations in Miocene of the Central Tethys. The micropaleontological analyze focusing on these relationship indicate that numerous assemblages with calcareous benthic and planktonic foraminifers and calcareous nannoplankton refer to marine shelf and open sea environments, which appeared on shortly in the Early Miocene and finally widespread under climatic optimum during the Middle Miocene transgressions (early Badenian: Moravian, the end of the late Badenian: Kosovian). Fossils assemblages occurred in low number and variety during periods of high geodynamic activity in the Early Miocene and during the salt crisis in the Wielician (older part of the late Badenian) when depth of basin decreased and water stagnation took place. Presented results also supply documentary evidence for the short-term periods of lagoon and estuarial conditions, which locally occurred in the Early Miocene (Karpatian) and in the Late Miocene (Sarmatian) on the edges of the Carpathian Foredeep. In addition studied fossil refer marine environments, which locally survived to the Panonian in studied area.

The Life Cycle of *Enzia* (Foraminifera) in the Turda salt marsh (Romania)

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The studied area is situated in the northwestern part of Transylvanian Basin, in the Turda locality, 30 km south of Cluj-Napoca. What was once a large salt marsh is nowadays restricted to an area of about two square meters. The source of salt water is related to Miocene diapiric salt, which occurs in the entire

Transylvanian basin and is exploited commercially in many places, including the nearby Turda salt mine. The marsh is populated by specific vegetation consisting from halophyte species as *Salicornia herbacea*, *Festuca sulcata*, *Carex humilis* and *Stipa* spp.

The Turda salt marsh is little studied from the scientific point of view. As far as we know, it is the only place in Romania where a living *Entzia* population can be found. Despite this, it is in danger due to human activity. Such was the ultimate fate of the type locality where this foraminiferal genus was described for the first time, also in Romania, and which doesn't exist anymore owing to urban expansion.

The purpose of our study is to document the life cycle of *Entzia* in Transylvania. For this, a one year-long survey is underway, with monthly soil sampling. *Entzia* can be found close to the soil surface, among plant roots, in the very first centimeter of the marsh sediment. The collected soil samples are preserved with alcohol and Rose Bengal for one day, to separate dead and alive specimens, which are then counted. Additionally, the test size, population numbers, and number of chambers for both, live and dead specimens, are recorded. Various environmental parameters, such as humidity, temperature, salinity, and pH, are registered, in order to establish a connection between the environment and the appearance of the megalospheric and microspheric generations.

The survey began in October-November 2010, when a large number of live specimens was found. From December 2010 until present the entire *Entzia* population was found dead. Our study will continue for another five months, and at the end of the monitoring period we will attempt to separate the sexual and asexual reproduction periods.

OPEN DISCUSSION: eForams – old ideas behind and new ideas ahead

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Scientific information is stored and spread around the world in several ways, including our mental knowledge shared during the education and research, “classic” paper publications, electronic publications with online books and journals, data-bases, scientific community portals etc. Working on fossils, we should not forget about our empirical data available *in situ* (outcrops, cores) and stored in various institutional and private collections. This highly fragmented information is valuable only when it is easily accessible, shared, and understandable to the whole community. We experience a flood of scientific publications which are getting more and more specialized and fragmented. Scientific text books used to integrate such knowledge in the past, but they do not fulfil this requirement due to the overwhelming accumulation of data and new publications. We need to discover new ways to integrate existing knowledge and new information on foraminifera to keep them readily accessible.

eForams 1.0. In 2006 we created **eForams** web site to offer easy access to the current basic knowledge on foraminifera (Hottinger *et al.* 2006). eForams runs on MediaWiki, an open source, server-side software invented for internet encyclopaedias. Although the idea of sharing and spreading knowledge on foraminifera is still attractive, the project itself partly failed in fulfilling our expectations and public demands. The main problems include a limited number of contributors and limited time that could be spent on writing and editing. Scientific work is mostly evaluated based on peer-reviewed publications in best international journals. Our efforts on online sharing of scientific knowledge are valuable for the community, but not appreciated by supporting agencies. On the other hand, we have observed a few positive trends based on the statistics of page entries. The whole website experienced over a 1.5 million of page views in 4 years.

The most popular page called "FORAM-Links" (http://www.eforams.icsr.agh.edu.pl/index.php/FORAM-Links), provides Web links to other websites, societies, upcoming meetings, glossaries, and virtual galleries. This page has been accessed nearly 120 000 times indicating that we really look for up-to-date information on foraminifera. It is a clear hint for the future development of eForams to work as a map linking information from various sources.

eForams 2.0. We would like to upgrade this website and propose a more innovative community service focused on sharing knowledge and new information on foraminifera. We want to learn and discuss your current demands and future prospects for this portal to make eForams more profitable for the community. The website is moved to a new domain **eforams.org** which is independent and non-profitable. We would also like to establish a scientific editorial board responsible to maintain the credibility of the service. The site is so far accredited by the Grzybowski Foundation. We also propose a new structure of the website that includes: eForams-Wiki, new FORAM-Publications, FORAM-Links, FORAM-Meetings, and eForams LABS designed to focus on specific methods. This new structure may assist our scientific activities, such as enquiries on new publications spread in different global and local journals. We want to encourage all foraminiferologists to share their knowledge and to spread valuable information. We would like to invite senior editors responsible for selected aspects of foraminiferal research. We would also like to emphasize that we still want to keep the site non-anonymous, i.e., built by the community of registered scientists. In order to enhance the quality and encourage scientists to post their review articles, we may also plan to extend our service to a new peer-reviewed Open Access electronic journal associated with the eForams site. We are open to new ideas and new contributions.

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Shaping foraminiferal shells

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Living and fossil foraminifera show a great variety of shell (test) morphologies. We still do not know why foraminiferal tests are so extremely diversified and how these complex shapes are created. Therefore, we construct an adequate theoretical and computer model based on empirical observations to answer these questions. This scientific approach is called 'theoretical morphology' and covers two conceptual areas which take into account morphology of organisms, including the simulation of organic morphogenesis and the analysis of the possible spectrum of organic forms via hypothetical morphospace construction. Our studies focus on emergence of shell patterns in the simulated growth of polythalamous foraminifera. Previous models were purely geometric and referred to fixed reference axes, completely neglecting apertures. We applied a new approach in foraminiferal modeling based on a moving reference system referred to apertures (Tyszka & Topa, 2005; Tyszka, 2006). Now we are working on a new "in depth" model which would simulate complexity of real morphogenesis. Shapes of foraminiferal tests emerge from the cascade of morphogenetic processes, basically controlled by genetic information. We focus on the membrane scaffold plus the two cytoskeleton filaments, i.e., microtubules and actin filaments, powered by motor proteins (see Nedelec *et al*., 2003). This basic system seems to be responsible for morphogenesis of all eukaryotic cells. We also use previous results and current observations of granuloreticulopodial organization in *Allogromia laticollaris* Arnold (Travis *et al*., 1981; Bowser & Travis, 2002; Orokos *et al*., 1997, 2000). These complex pseudopodial networks are essential for understanding foraminiferal morphogenesis.

It is well knowm that foraminifera create a ``bubble'' of cytoplasm enveloped by the organic Anlage attached to the shell which is mineralized preserving the shape of the new chamber (e.g., Bé *et al*., 1979). The Anlage is shaped mainly by internal self-organization of the cytoskeleton. We want to reflect these processes in the computer model and present their impact on a final morphology of chambers. The DPD (Dissipative Particle Dynamics) method is applied, which is a technique employing a set of interacting particles governed by Newton's equation of motion. Different potentials of interaction are chosen, depending on types of particles that interact with each other (see Gao *et al*., 2007).

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Late Quaternary dynamics of the Congo (Zaire) River plume: planktonic foraminiferal evidence

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A planktonic foraminiferal sensus count record of the Core T89-24 was generated at 500-year resolution during the last 100 ka. Core T89-24 is located at the southern boundary of the Congo River plume, which is marked by a clear salinity gradient. This study will provide a detailed examination of processes steering the regional oceanographic conditions; river discharge, extent of the Congo River plume, the tropical, open ocean waters as well as coastal upwelling south of the river mouth. Changes in the paleoceanographical conditions and precipitation over western and central Africa are modulated by orbital-scale and millennial-scale oscillations. Peaks in relative abundances of *Globigerinoides ruber* (pink), reflecting the proximity of the Congo River plume, are in phase with negative values in stable oxygen isotope record. They reveal millennial-scale fluctuations in the river plume dynamics during the last 100 ka. The orientation of the Congo River plume is moreover steered by orbital-scale oscillations; a more northwestern orientation is reached during stadial and glacial periods.

Planktonic foraminifera and ocean acidification

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This NWO-funded PhD study builds on the basis of de Moel *et al.* (2009), in which shells of *Globigerinoides ruber* from surface sediments of the Arabian Sea reveal lower weights compared to shells below the mixed layer. The authors show that the thinner walled specimens within the modern core top have a negative radiocarbon age (a consequence of atomic bomb tests in the late 1950's) compared to thicker shelled specimens and thus have lived for the largest part in the second half of the last century. Thinner shelled specimens also show lower $\delta^{13}C$ values compared to thicker shelled individuals, reflecting the 'Suess effect'. The study area's proximity to an upwelling cell may also explain the thin shells and low $\delta^{13}C$ values.

In this project we focus on marine sediments on two scales: temporal and spatial. The use of high resolution cores allow for documentation of the natural variability in the mass of planktonic foraminifera over millennial timescales. Whilst the use of global sections, including upwelling and non-upwelling locations such as the Arabian, Banda and Mediterranean Seas and the North Atlantic, with the aim to verify the findings of de Moel *et al.* (2009). Whilst initial research focuses upon the surface-dwelling species, we will expand this into deeper dwelling species in an attempt to document how deep the ocean acidification process has penetrated the water column.

Tourmalines in the tests of deep water agglutinated *Reophax pilulifer* Brady-preliminary results on the base of Eocene specimens from Carpathian flysch

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Agglutinated foraminifera build test from material that is present in their living environment. Accretion of the test is the process of joining together single clasts by with a biogenic cement (organic or mineral). The test with particles of coccolithts, spicules of sponges, pyroclastic grains are common. Components of feldspars, heavy minerals, e.g., topaz, ilmenite, magnetite, titanite, zircon, minerals of garnet groups, apatites, amphiboles and others are also known (e.g., Makled & Langer, 2009; Heron-Allen, 1915).

The agglutinated forms prevail in microfaunal assemblages in the flysch deep water environments. Cosmopolitan forms with wide ecological tolerance, adapt to the high hydrostatical conditions constitute the main component within these foraminifera. In deep parts of basins, the tests are constructed by grains of quartz, which are very common in sediment.

The investigated material come from Eocene deposits of Flysch Carpathians of the hieroglyphic type beds (thin-bedded shall-sandstone flysch) of Silesian, Skole nappes and from Beloveza Beds and Zembrzyce Shale Member of the Magura Nappe. The single grains of tourmalines within silicified agglutinated tests of *Reophax pilulufer* Brady were observed.

The tourmalines represent typical short to long prismatic crystals (completed or damaged fragments). Some of them have gently rounded edges, which is due to mechanical erosion during the transport processes. Sizes of tourmaline crystals varies. The biggest one is 180 µm in length and 90 µm in width. Smaller crystals occur more often with lengths from 50 up to 100 µm. Tourmalines differ from other quartz grains not only by regular, lengthened shape, different color, but also because they constitute ones of the biggest components of foraminiferal tests. Two assemblages of tourmalines can be discerned in microscope under transmitted light in terms of optical properties e.g.: 1) light-brown to yellow-brown, transparent and semitransparent (predominant) and 2) black, opaque.

Selected foraminifera samples with tourmalines were glued to holders and then were analyzed in microarea using electron-microprobe (SEM-EDS) with field emission. Observations and photographical documentation were performed in secondary (SE) and back scattered electrons (BSE) images.

Tourmaline group minerals belong to borosilicates with general chemical formula $XY_3Z_6(T_6O_{18})(BO_3)_3V_3W$, where the $^{[9]}X$ position is substituted by Na^+, K^+ Ca^{2+} or vacancy, the $^{[6]}Y$ position is filled by Li^+, Mg^{2+}, Fe^{2+}, Mn^{2+}, Al^{3+}, Cr^{3+}, V^{3+}, Fe^{3+} and Ti^{4+}, the $^{[6]}Z$ position is filled mainly by Al^{3+}, and rarer by Mg^{2+}, Fe^{3+}, Cr^{3+} and V^{3+}, the $^{[4]}T$ position mainly by Si^{4+} and incidentally by Al^{3+} and excess of B^{3+}, while the V position by OH^- groups and O^{2-}, whereas the W position by OH^- groups and F^-, O^{2-}.

Preliminary semi-quantitative analyses show occurrence of at least two kinds of tourmaline assemblages in terms of chemical composition e.g., content of main elements (Al, Mg, Fe), and also traces (Na, Ti, K). Members rich in Mg – $NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$ (dravites) and rich in Fe^{2+} – $NaFe^{2+}{}_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$ (schorls) were identified. Al- and Li-dominant members $Na(Al,Li)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$ (elbaites) are not discerned.

The presence of heavy minerals in foraminiferal test is not connected with their significant concentration in surrounding sediment (Makled & Langer, 2009). Similar dependence is present in analyzed Eocene deposits, where the tourmalines are accessory component of deposits. The tourmaline crystals occurred randomly in sediment were selectively picked and incorporated into walls of test. *Reophax* belong to the mobile infauna group, it can penetrate up to 15 cm bottom sediments in deep water condition. Segregation of rare tourmalines crystals from sediment can depending of the mobility potential of foraminifera.

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Eocene foraminiferal assemblages from Hieroglyphic Formation of Skole Nappe (Polish Outer Carpathians)

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Hieroglyphic-type deposits are widespread within Outer Carpathians, and they are distinguished in several tectonic units e.g., the Magura, Dukla, Skole, Silesian, and Foremagura nappes. They are represented by thin-bedded flysch deposits. Gray and green muddy shales (rarely marly shales) in thin- to thick complexes prevail in profile. Shales are interbedded by thin- and medium gray quartzitic sandstones. The characteristic feature, which is reflected in their lithostratigraphic name, is the presence on the soles of the sandstone layers of numerous hieroglyphs, both biogenic and mechanical.

The Hieroglyphic beds were originally described in the Skole Nappe by Paul & Tietze (1877). Sedimentation of these beds took place in the Eocene. They are underlain by Lower Paleogene (Paleocene-Eocene) variegated shales (Żohatyn Fm.) and covered by the upper Eocene Globigerina Marls (Strwiąż Fm). In the Hieroglyphic Formation (Bachórz Fm.) deposits, deep-water agglutinated foraminifera assemblages prevail. Within these assemblages four Eocene biozones are distinguished:

- **Assemblages of the Saccamminoides carpathicus biozone**: the characteristic feature is the occurrence of the index taxon *Saccamminoides carpathicus* Geroch – an endemic form in the Early Eocene Carpathian basins (usually only a few specimens per sample). Additionally, the first occurrence of *Popovia beckmanni* (Kaminski & Geroch) and *Reticulophragmium amplectens* (Grzybowski) has been noticed in the upper part of this biozone. The relatively numerous presence of *Haplophragmoides walterii* (Grzybowski) also is typical here.
- **Assemblages of the Reticulophragmium amplectens biozon**e represent the interval between the last occurrence of *Saccamminoides carpathicus* Geroch and the first occurrence of *Ammodiscus latus* Grzybowski, *Reticulophragmium amplectens* (Grzybowski) is the marker of this biozone. Typical accompanying species (numerous and diversified) belong to the genera *Paratrochamminoides*. In the lower part of biozone, the acme of *Spiroplectammina spectabilis* (Grzybowski) and the first occurrence of *Haplophragmoides* cf. *nauticus* Kender, Kaminski & Jones was noted. In younger assemblages, more numerous specimens of *Reticulophragmium amplectens* (Grzybowski) (acme?) and the first occurrence of *Eratidus gerochi* Kaminski & Gradstein and *Prasphaerammina subgaleata* (Vasicek) were observed.

Apart from agglutinated foraminifera, assemblages of calcareous foraminifera are preserved as a typical component (mainly benthic forms, plankton is only occasionally preserved).
- Assemblages of the Ammodiscus latus biozone, represent the interval between the first occurrence of the index taxon and the first occurrence of *Reticulophragmium rotundidorstaum* (Hantken) (the index taxon of the next biozone). *Reticulophragmium amplectens* (Grzybowski) belongs to accompanying characteristic species, in the upper part of biozone it disappears. The index taxon simultaneously increases. In some samples numerous *Spiroplectammina spectabilis* (Grzybowski) are found.
- Assemblages of the Reticulophragmum rotundidorsatum biozone represent the interval of the index taxon, usually with *Ammodiscus latus* Grzybowski.
The occurrence of poorly taxonomically diversified assemblages of agglutinated foraminifera with dominant scrub specimens *Glomospira charoides* (Jones & Parker) – the phenomenon of the *Glomospira* Acme is also worth mentioning. A long-term *Glomospira* Acme is known from the Early Eocene and was noticed in many basins (Kaminski & Gradstein, 2005). This event is used in biostratigraphy. In the Outer Carpathians, it functions as a correlation level. Assemblages bearing features of the *Glomospira* Acme are identified at different times in the Eocene. They occur in the Lower, Middle and Upper Eocene within the Hieroglyphic Formation and indicate short-term changes in paleoecological conditions.

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The Upper Triassic cuticles from Lipie Śląskie (South Poland)

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Lipie Śląskie is a hamlet of the Lisowice village, near Lubliniec, Silesia Region (South Poland). Calcareous siltstones, interbedded with mudstones and sandstones are exposed at the local brick yard. Siltstones dominate in this sedimentary complex. They are brown, cherry-brown and grey in colour. Generally, laminated siltstones are often interbedded with mudstones, rarely with sandstones (Haisig *et al*., 1983).
The Upper Triassic sediments contain plant macrofossil like charcoalified tree trunks, rarely branched shoots, single leaves, cone-like specimens and seeds. The Lipie Śląskie sediments are also rich in dispersed small-sized plant remains (*cuticle dispersae*). They consist mostly of fragmentary leaf cuticles, but also seeds and shoots.
The cuticles were obtained from the sediment (*cuticulae dispersae)* and also from available, well preserved shoot fragments. Sediment samples were macerated using 65% HNO_3 and distilled water in proportion 1:1 with a small portion of $KClO_3$ (method of Schulz) (Taylor, 1999). To remove the rest of the sediment from the specimens they were macerated using 40% HF and then rinsed with distilled water.
The presence of Pteridospermophyta, Cycadophyta and Coniferophyta was distinguished through observations of well-preserved *cuticulae dispersae* and shoots. Cycadophyta and Pteridospermophyta were recognized mainly during *cuticulae dispersae* analysis. The state of preservation of the cuticles is good. Details of epidermal cells structure and stomata are recognizable. Many of the cuticles have well-

defined xeromorphic features such as papillae and sunken stomata.
Analysis of cuticle structure and taxonomy provides informations about paleoenvironmental and paleoecological conditions in the Late Triassic at the investigated area.

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Biogeography and depth-parapatry of cryptic species in the planktonic foraminifer *Hastigerina pelagica* and the phylogenetic enigma of the Hastigerinidae

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The Hastigerinidae stand out among the living planktonic foraminifera due to several unique morphological features, like their monolamellar shell wall and their completely triradiate spines. We have investigated the phylogeny of this group and their relationship to the rest of the modern planktonic foraminifera using SSU rDNA sequences. Our global survey of the genetic diversity in this group discovered three SSU rDNA genetic types of *H. pelagica* and the first sequences of its sister species, *H. digitata*. The two most abundant genetic types in *H. pelagica*, here referred to as Type IIa and Type IIb, showed an unexpected spatial distribution pattern that was observed in the Mediterranean Sea, the Caribbean Sea and the Pacific during different seasons. The two genetic lineages were present at all sampling locations with no evidence for geographic differences in abundance or distribution. However, the two lineages showed a surprisingly clear pattern of vertical separation. Type IIa was only found in waters deeper 100 m whereas Type IIb occurred, independent of season and locality, almost exclusively in plankton net samples shallower than 100 m. A similar pattern of vertical separation is observed between specimens of *H. pelagica* and *H. digitata*. The latter species was found in the Western Mediterranean below 300 m water depth, whereas individuals of *H. pelagica* were mainly found in the upper water column in this region.
The distribution of the genetic types of *H. pelagica* and *H. digitata* follows the hypothesis of niche partitioning based on earlier findings of the genetic types of *G. ruber* from the Mediterranean Sea. However, instead of a geographical separation between genotypes as found in two sister types of *G. ruber*, the genotypes of *H. pelagica* have partitioned their niche vertically. The existence of a depth-parapatric distribution supports a species level divergence between the two *H. pelagica* genotypes IIa and IIb. The observed distribution pattern provides the first indirect support for the possibility of speciation by depth-parapatry in planktonic foraminifera – a hypothesis often invoked to explain speciation events in the fossil record.
Next, we use the DNA sequences of Hastigerinidae to elucidate their position in the phylogenetic tree of the modern planktonic foraminifera. Earlier analyses indicated that Hastigerinidae group outside the modern spinose species. This would indicate that the presence of spines in this group is a convergent character with the spines of the Globigerinidae. We specifically addressed the probability with which the

genetic data support a placement outside of Globigerinidae or within the Globigerinidae as a member of the morphologically most similar genus *Globigerinella*. The results of this analysis and the consequences for the evolution of spines in planktonic foraminifera will be discussed.

Morphological variation of *Orbulina universa* in response to environmental change (Sapropel S5, Eastern Mediterranean Sea)

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Following the Eemian insolation maximum 125,000 years ago, the Eastern Mediterranean Sea experienced a pronounced environmental change that led to the deposition of the Sapropel S5. This time interval provides an excellent opportunity to assess the evolutionary and ecological response of marine organisms to environmental stress.
Gravity core M51-3 SL 104 (Pliny Trench, southeast of Crete) recovered an exceptionally well preserved and thick Sapropel S5 showing evidence for multiple local extinctions of several planktonic foraminiferal species. This work aims at investigating the influence of environmental change on the morphology and symmetry of specimens of *Orbulina universa* (characterised by the development of a large spherical last chamber) when exposed to environmental stress. The core was sampled at 3 mm intervals, resulting in a sample resolution of less than 20 years.
Orbulina universa was picked from 70 samples comprising two occurrence-local extinction-cycles of the species. We investigated the change of shell size, morphology (sphericity of the last chamber), calcification intensity (weight), and the incidence of abnormal specimens (i.e., '*Biorbulina bilobata*' and '*Orbulina suturalis*').
Preliminary results imply that during times of environmental stress (i.e., when the abundance of the species was decreasing) the mean shell size tends to increase. The weight shows a positive correlation with abundance, implying that during favourable conditions *Orbulina universa* shows higher calcification rates. The roundness of test seems to vary with no regard to the abundance of the species, however, samples with small abundances show considerably higher variance in test sphericity than samples with high abundance of this species. Moreover a significantly higher incidence of abnormal specimens could be observed in samples with lower abundances of *Orbulina universa* (i.e., less than 100 specimens per sample).

Middle Devonian conodonts from the Świętomarz-Śniadka section (Góry Świętorzyskie mountains)

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The study area is located in the northeastern part of the Góry Świętorzyskie Mountains. Conodont data were obtained from limestone beds of a severely tectonically disturbed Givetian succession, exposed in the Świętomarz-Śniadka section (Łysogóry region). All stratigraphic subdivisions, apart from the Śniadka Formation are accepted after Kłossowski (1985). The published data on conodonts from this section are sparse and brief (Kłossowski, 1985; Malec, 1988; Woroncowa-Marcinowska, 2001; Dzik, 2002). New, much richer material collected by the author in 2002, 2003 and 2005 has been studied.

Conodont data were obtained from 10 samples of the Skały Formation; the remaining 12 samples from the Świętomarz Formation do not contain conodonts. The assemblages are moderately diverse. More than 200 specimens collected were assigned to four genera: *Icriodus*, *Polygnathus*, *Belodella* and *Neopanderodus*, and 17 taxa in the species or subspecies rank. Four conodont assemblages assigned to *hemiansatus–rhenanus/varcus* zones (Bultynck, 1987) can be distinguished in the study material.

The first assemblage: *Polygnathus linguiformis linguiformis*, *Belodella devonica* and *Neopanderodus* sp., which represent the *Polygnathus hemiansatus / Polygnathus timorensis* zones were derived from coral-crinoid limestones of the lowermost part of the Skaly Formation (coral-crinoid member from Sitka). This assemblage does not contain index species.

The remaining assemblages are assigned to the *Polygnathus rhenanus/P. varcus* zones. The second assemblage is represented by *Polygnathus linguiformis linguiformis*, *P. ensensis*, *P. timorensis*, *P. weddigei*, *P. varcus*, *Icriodus regularicristens*, *I. obliquimarginatus*, *I. platyobliquimarginatus*, *I. brevis* and was obtained from the lower part of Sierżawy member. The third assemblage is the same as the second one, but differs from it by the presence of *I. difficilis*. It was found in the middle part of the Sierżawy member The last assemblage is the same as the second and third, but differs from them by the presence of *I. janae* (Sparling, 1995) The last assemblage was recognized in the upper part of the Sierżawy member (dark thin-bedded limestone - the part of the "Śniadka Formation" of Kłossowski, 1985)

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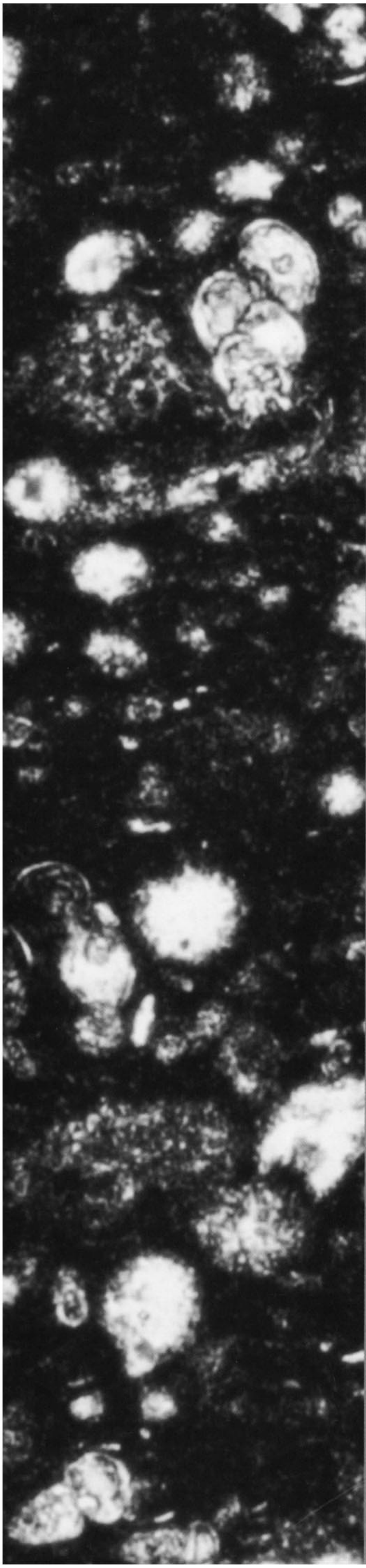
Some Useful Polish Words & Phrases:

Do you speak English?	Czy Pan/Pani mówi po Angielsku? [chi Paan / Paan-ee Moo-vee po An-ghel-skoo]
Good Moring, Good Day	Dzień Dobry [Jane-Doe-Brie]
Where is the...	Gdzie jest ... [G-je yest]
Toilet	W.C. [Voo – Tseh]
Center of town	Centrum [Tsent-room]
AGH	AGH [Aahh – Ghye – Ha]
Main Square	Rynek
Taxi	taksówka [tax – oof – ka]
I'd like to have a...	Poproszę [Po-prosh-eh]
Beer	piwo [pee-vo]
Coffee	kawę [Kah-ve]
Tea	Herbatę [Her-ba-teh]
Something to eat	coś do jedzenia [you figure it out!]
May I have the bill please.	Poproszę rachunek [Po-prosh-eh ra-hoo-neck]
How much does it cost?	Ile kosztuje? [Ee-leh cosh-too-yeh]
Thank you (very much)	Dziękuję (bardzo) [Jane-koo-yea bard-zoe]
See you!	Do widzenia [Dough Vee-jane-yea]
Bye	cześć [chesh-ch]
I'm a member of the TMS	jestem członkiem Stowarzyszenia Mikropaleontologicznego
We are here for a conference	Jesteśmy tutaj na konferencji



MIKRO-2011
Eighth Polish Micropalaeontological Workshop
TMS Foraminiferal-Nannofossil Group Meeting

The MIKRO- meetings provide a venue for Polish-speaking Micropalaeontologists to network and present current research topics. The meeting is hosted by the Grzybowski Foundation, and this event held in Kraków is the eighth such meeting in the series. For the first time, the MIKRO - meeting is held in conjunction with the annual joint meeting of Foraminiferal and Nannofossil Groups of The Micropaleontological Society. The meetings consist of three days of technical sessions and a joint field excursion. Satellite sessions of working groups are also scheduled to take place.
It is our sincere hope that joint activities such as these hosted by both the Grzybowski Foundation and The Micropalaeontological Society will foster further collaboration and in our field. This volume presents the collected abstracts of talks and posters presented at both meetings, as well as articles that provide background information on the Geology & Micropalaeontology of localities visited during the field excursion.

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