10th ESSEWECA conference

December 1 - 2, 2016
Bratislava, Slovakia

Environmental, Structural & Stratigraphical Evolution of the Western Carpathians

Abstract book (online version)

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Preface

The scientific board and organizing committee were most honoured to cordially welcome guests and presenters to Bratislava, for the 10th ESSEWECA conference, organized in Bratislava at December 1st–2nd 2016. Its plenary and topical sessions were held in the Congress centre of the hotel Družba. 61 participants attended 23 oral presentations and 32 presentations of posters.

The biannual conference is devoted to environmental, sedimentary, stratigraphic and structural evolution of the Western Carpathians together with the Pannonian domain and related Alpine orogenic zones and it is good opportunity to bring together specialists of neighbouring countries to participate and discuss the various geological topics useful for the interregional correlation.

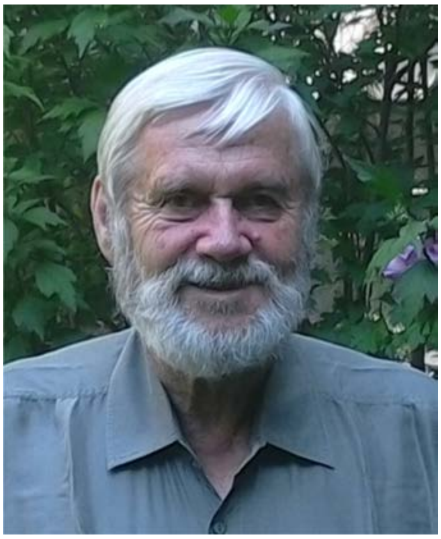
Presentation of new results and ideas concerning the fundamental questions of the structural evolution of the Alpine-Carpathian-Dinaridic orogenic systems during Paleoalpine and Neoalpine evolutionary stages and the tectonic control on the sedimentation and basin development should be the main goal of the talks.

A relationship of the magmatism and tectonics is also one of the critical points of the existing and new models of geodynamic development. A reconstruction of the tectonic evolution of the lithosphere supports the palaeogeographic models of ALCAPA, Tisza-Dacia and other related domains in a micro-continental or continental scale from the Mesozoic to Cenozoic eras.

The 10th ESSEWECA conference was devoted also to the three Slovak geologists who significantly enriched geological knowledge in the Western Carpathians, our colleagues, who are celebrated their anniversaries this year. On this occasion, Assoc. Prof. Peter Reichwalder, Assoc. Prof. Milan Sýkora and Assoc. Prof. Jozef Michalík were awarded by the Medals of Comenius University, a prizes granted by the Rector of Comenius University in Bratislava.

Assoc. Prof. Dr. Milan Sýkora is an expert in carbonate sedimentology. He deals with the lithostratigraphic and biostratigraphic study of Mesozoic carbonate sedimentary sequences, the analysis of exotic material of conglomerate bodies of Cretaceous sedimentary sequences mainly from the western section of the klippen area and also the analysis of coeval clastic sediments of Tatric and Fatric units of the Western Carpathians. He devoted his research to clastic sedimentary rocks of the Pieniny Klippen Belt during the last ten years, focusing on the mineralogical composition of sandstone heavy fraction, in particular the occurrence of minerals and rocks of blue schist facies. His important contribution to the palaeontological research in Slovakia was finding the footprints of Mesozoic reptiles in the Upper Triassic sedimentary rocks, on the base of which the model of ancient dinosaurs was created and located in the Slovak National Museum in Bratislava. Dr. Sýkora participated in the years 1988 and 1989 in geological expeditions to the Far East region of Russia – mountains Cherski and Suntar Chajim, areas of volcanic phenomena on the Kamchatka Peninsula and the area of subduction melange on the Chukotka Peninsula. He participated in geological exploratory works (geological mapping, lithological and microfacies analysis) - the exploration for highway tunnel of Višňové - Dubná Skala. He was the secretary of Slovak Geological Society, which granted him by the letter of thanks for his active work in favor of the Slovak Geological Society and for his contribution to geology in Slovakia and for its development. His research results were summarized in 56 scientific publications; one of them is a monograph. He is a co-authors of the textbook of the Physical Geology. In 2010, on the occasion of the 70th anniversary of Comenius University in Bratislava, Dr. Sýkora was awarded by graphic print for teaching and scholarly activity at the Department of Geology and Paleontology, and for contributions to the development of teaching of the General Geology, the Sedimentology of carbonate rocks and their microfacies analysis. The scientific community celebrates the jubilee of 70 years of Dr. Milan Sýkora this year.

For the occasion of his important jubilee Assoc. Prof. Dr. Milan Sýkora was awarded by the Bronze Medal of Comenius University for his successful scientific and educational work in the field of carbonate sedimentology and general geology of Slovakia and thereby increase overall the scientific and educational credit of the Comenius University.



Assoc. Prof. Dr. Peter Reichwalder, the former member and also the head of the Department of Geology and Paleontology during the period 1986-1990, celebrated the important anniversary of 75 years this year. He devoted his scientific research to a comprehensive geological study and geological mapping of the Palaeozoic and Mesozoic of the Spiš-Gemer Mountain and Slovak Karst area, also to structural geological analysis and synthesis of geology of the Inner Western Carpathians. Among the first he applied the knowledge of plate tectonics in the reconstruction of geological development and palaeotectonics of the Gemeric and the Meliatic areas. He worked in detail on issue of south Gemeric younger Palaeozoic and high pressure rock associations linked with subduction-accretion processes accompanying the conclusion of the Meliata Basin. In the years of 1988-1989, he was appointed as the UN expert at the UNDP in Ethiopia, for the purpose of postgraduate education of local geology. In 1998 he prepared and led the cycle of lectures of geology of Central and Outer Western Carpathians for students of master and doctoral studies at the University of Warsaw. He dealt with the application of remote sensing in the regional geological and tectonic research and the compilation of geological maps of Slovakia. He is the co-author of the first cosmotectonic maps of the Central and Eastern Europe. Together with the Polish geologists from the University of Warsaw he participated as an expert guarantor and guide of documentary series on the geological structure of the Carpathians in Slovakia. This successful educational project was implemented by the Polish Television; later during the years of 1999-2000 was aired also by the Slovak Television. Besides the teaching and publishing his research results, he worked on the text books for students, he was the author of numerous reviews and the expert's final assessments of research and survey reports and research projects as well the expertise and assessments of geological maps and explanatory notes. His research results were summarized in 65 scientific publications, 7 monographs, 6 geological maps, 3 notes to the geological maps. He actively worked in professional organizations and committees. He was the Chairman of the Slovak Geological Society (1981-2000), Secretary of KBGA tectonic commission (1983-1996), the member of the International Working Group CMEA for remote geological research methods using satellites and aircraft (1981-1986). He was a member of scientific councils of many Slovak geological institutions, the member of the editorial boards of leading scientific and professional geological journals.

For the occasion of his important jubilee Assoc. Prof. Dr. Peter Reichwalder was awarded by the Bronze Medal of Comenius University for his successful scientific and educational work in the field of regional and structural geology of Slovakia which thereby increase overall the scientific and educational credit of Comenius University.

Assoc. Prof. Dr. Jozef Michalík, is our third jubilant and the scientific community celebrates his jubilee of 70 years this year. He is the outstanding scientist of the Institute of Earth Sciences SAS and long-time collaborator of research team of the Department of Geology and Paleontology in Faculty of Natural Sciences. The main fields of his interest are palaeontology of marine macro- invertebrates, carbonate facies, carbonate sequence stratigraphy, palaeoceanography and palaeoclimates, Mesozoic biostratigraphy, facies and palaeogeography. He dealt with palaeoecological and palaeodynamic aspects of the Rhaetian sediments and life communities including dinosaur footprints, the first in the Slovak territory at all. Since 1976, he started to work in Lower Cretaceous sequences of the Western Carpathians, with a special emphasis to the Krížna and Manín Nappes. In eighties, Dr. Michalík was a secretary of a research project oriented on the Malé Karpaty Mts structure. He represents the Slovak geology by numerous of published scientific papers, monographs, by hundreds of oral presentations in conferences and workshops. Dr. Michalík acted as the director of the Geological Institute (1996-2002), the chairman of the Slovak National Committee (1996-2001), and the chairman of the National IYPE Committee (2006-2010). He is the Assistant Professor in the Department of Geology and Paleontology, Faculty of Natural Sciences of the Comenius University in Bratislava, where he gives since 1991 the lectures of Sequence stratigraphy, Palaeoclimatology, Palaeoceanology and Geodynamic development of the Western Carpathians. He is also an external teacher in the Department of Geology of the Masaryk University in Brno. He is the chairman of the Paleontological Group of the Slovakian Geological Society, and the Scientific Editor of the Geologica Carpathica. He is a member of the Editorial Boards of several international journals Open Paleontology Journal, Iranian Journal of Earth Sciences, Geological Quarterly, Mineralia Slovaca, Bulletin of Geology. In a position of the co-leader, he organized the IGCP UNESCO Project No 362 (Tethyan and Boreal Cretaceous). Dr. Michalík guided seven grant projects (Nos. GA-1081, 2035, 2074, 3135, 7215, VEGA-4076, 0196), he has been the member (or national coordinator, respectively) of the IGCP UNESCO Projects No 458, 463, 556 and 605, and he participated in several projects of cooperation with the Slovak Geological Survey. He is the Corresponding Member of the Triassic Subcommission of the IUGS International Stratigraphic Committee and the member of the Slovak Commission for UNESCO by Ministry of Foreign Affairs of Slovak Republic. He is active in organizing of geological excursions and scientific events (seminars, conferences, workshops). He deals with promotions geology in public-legal media. He supervised many of successful PhD students. For his important research work he has been awarded by several awards: awards of Jan Slávik, Medal of Dimitri Andrusov, Gold Medal of the Geological Institute and the Medal of academic B. Cambel.

For the occasion of his important jubilee Assoc. Prof Dr. Jozef Michalík was awarded by the Silver Medal of Comenius University for his successful scientific and educational work in the field of geology of Slovakia, for the cultivation of long-term cooperation, which contributes significantly to the development and reputation of the Comenius University in Slovakia and abroad.

During first day of the conference the best student presentation competition took place and involved 12 students. The oral and poster presentations were evaluated by international committee comprising from Assoc. Prof. Dr. Natália Hudáčková (Comenius University in Bratislava, Slovakia), Assoc. Prof. Dr. Orsolya Sztanó (Eötvös Loránd University, Budapest, Hungary) and Prof. Dr. Zdeněk Vašíček (Academy of Sciences, Czech Republic). The first place was awarded to MSc. Lilla Tőkés, the second place to MSc. Tomáš Klučiar and the third place to Bc. Peter Kiss.

Ophiolite from Osielec-Magura Nappe, Outer Carpathians, Poland – a new approach to the problem

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In the early fifties of 20-th century, in Osielec village located in Beskid Makowski Mts. between towns of Sucha Beskidzka and Jordanów, a block of igneous rock has been discovered in the Magura Nappe. It was studied and described by Wieser (1952) as ophiolite, and in petrologic approach classified as gabbro. New outcrops with large blocks of the discussed igneous rock (Cieszkowski et al. 2010, 2016) were found in Osielec, so detail studies of sedimentary rocks containing gabro blocks, their tectonic position, their petrological characteristics, as well as studies of gabbro's absolute age have been done.

The Magura Nappe in Osielec (Cieszkowski et al. 2016) consists mainly of the late Cretaceous-Palaeogene deposits represented by the Rača Subunit. There in the lithostratigraphic log of the Osielczyk Thrust-Sheet occur Łabowa Shale Fm. (red beds - Early and Middle Eocene), Pasierbiec Sandstone Fm. (Middle Eocene) and Beloveža Fm. (Middle and Late Eocene). The Pasierbiec Sandstone Fm. consists of thick-bedded sandstones and with occasional intercalations of thick-bedded Łącko Marls, as well as packages of thin-bedded Beloveža-like flysch and red shales. There was also identified olistostrome which is developed as chaotically defragmented sandstone layers with crumpled shales in between and debrites that consists of sandy-gravel matrix with number shally clasts and pebbles, boulders and blocks of different exotic rocks e.g. granitoids, gabbro, micaceous schists, quartz, limestones, marls, and glauconitic sandstones. Within others there occur large blocks of gabro, 0,5 m up to 3,5 m in dimension.

Studied gabbro, is a medium grained rock, dark green or green black in colour, showing massive texture. The rock is partly strongly dynamically altered and shows irregular pale green or pale yellow green zones (up to 5 cm thick). These zones consist of neogenic minerals, macroscopically visible, as chlorite, epidote and calcite. Microscopic study of thin section indicates that in dynamically deformed parts of metabasite cataclastic and mylonitic structures are formed. The phenomena of crushing mineral crystals, reduction of their size and abnormal optical properties of rock-forming minerals are observed. In undeformed parts of the rock studied some relics of primary poikiloblastic structure occur. Plagioclases and amphiboles are the main minerals of the rock studied. Plagioclases are represented by subhedral albite which is characterized by multiple twinning of albite law and undulatory extinction. Central parts of albite crystals are filled by small grains of neogenic minerals: epidote and zoisite. In deformed parts of the rock studied, albite crystals are crushed and strongly altered into aggregates of flakes a white mica. Amphiboles are represented by olive hornblende, showing strong pleochroism from yellow green to olive green in colour. Hornblende tends to form elongated crystals and is altered in various degree. This mineral is partially replaced by aggregates of secondary minerals: epidote, sphene, chlorite and opaque minerals. Accessory minerals, are represented by: apatite, ilmenite and zircon. In some blocks Gabbro rock cut calcite veinlets containing pyrite and chalcopyrite.

The zircon grain have been separate from the rock and tested at the age of absolute. Cathodoluminescence analysis of internal zircon structure revealed a single population with simple one stage growth. We conducted preliminary laser ablation ICPMS U-Pb dating on 10 randomly selected crystals which define mean ^{206}Pb-^{238}U age of 601+-10 Ma. This age is interpreted as reflecting zircon crystallization during gabbro formation. It means that these igneous rocks formed in Early Proterosoic since the Cadomian Orogeny. These results stop the hopes, according to Wieser's suggestions, discussed gabbro rocks emerged in the Alpine orogenic cycle, and could be remnants of supposed oceanic floor of the Magura Basin.

The source area of the exotic rocks with gabbro fragments, basing of the paleocurrent directions and distribution of lithofacies, were situated towards the north (estimated as southern part of the Silesian Ridge, or more probably of the Grybów Ridge *sensu* Cieszkowski 1992), south from the Bielsko-Biała Dome. It could represented an eastern prolongation of the Brno Massif composed besides of granites and granodiorites also of gabbros (Picha et al. 2006). That was probably also source of chromian spinel found locally within sediments of NE part of the Magura Nappe (Winkler & Ślączka, 1992).

Acknowledgement: This research has been financed by UJ ING grant K/ZDS/001463 and DS/MND/WBiNoZ/ING/12/2015.

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New occurrences of bauxite-filled paleokarst in Slovak Karst area near Čoltovo: The first report

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In the Slovak Karst area, close to the contact with Neogene filling of the South Slovakian Basin, three quarries are situated opposite to the Čoltovo village. The northernmost one is still active and two more southern ones are abandoned. In these three quarries, Triassic limestone succession of the Silica Nappe is outcropped. The southern quarry was excavated in the Anisian succession from Steinalm platform limestones, Zámostie black basin limestones and allodapic Harmanec limestones. The middle quarry is mostly formed by platform Wetterstein Limestone of Ladinian-Carnian age and the northernmost quarry reveals mostly Dachstein reefal limestone of Norian to Rhaetian age.

Recently, paleokarst clefts and cavities were revealed in the southernmost quarry. They contain yellowish sinter filling with flowstone draperies, small stalactites and stalagmites. The rest of sinter filling is followed by yellowish (in some clefts also whitish to redish) sedimentary material, which was first considered to be Lower Miocene schliers. However, first dating attempts revealed neither any presence of marine microfauna nor palynoflora. On the other hand, the analysis revealed that this material is non-calcareous.

One cleft was sampled for the sedimentary filling. The sample was subjected to the PXRD analysis (Powder X-Ray Diffraction), which indicated that the material is represented purely by diaspore, which is aluminium oxide hydroxide mineral, α-AlO(OH). This means that the yellowish material most likely represents a remnant bauxitic lateritic weathering crust.

Unlike in more southern countries, there have been only a few occurrences of bauxite revealed so far in Slovakia. They are situated mostly in the Strážovské vrchy Mts. (Mojtín, Domaniža, Pružina) within the Choč and Strážov nappe dolomites and limestones and at the toe of the Galmus Zone (in the vicinity of Markušovce village) which is formed by limestones Silicicum s.l. Some small occurrences were registered also in the Slovak Karst itself (Silica nappe, Silicicum s.s.), e.g. in the Miglinc Valley. All these bauxitic occurrences are invariably related to the emersion and karstification period that occurred after the main nappe thrusting phase in the West Carpathian internides, i.e. their age spans from the Late Cretaceous to Paleocene. In this time period there was the West Carpathian area was in the humid tropical climate zone, which was able to promote lateritic weathering. Later periods were not suitable for such a weathering.

Therefore, it is substantiated to presume similar age for the bauxites revealed at Čoltovo. However, it is not yet known, whether the bauxitic material rests in its original position or it was reworked and resedimented to younger clefts and cavities. The extent of Čoltovo bauxite occurrences also has not been verified yet. There are clefts in all three quarries, samples of which are now being analysed. Some of them are clefts filled with Terra-Rossa and similar materials, which are obviously younger, as revealed by mammal remnants. Further research is necessary to verify the age and extent of these newly discovered bauxite occurrences.

Acknowledgement: The research was supported by the VEGA agency grant No. 1/0095/14 and grants of APVV agency under the contracts No. APVV 14-0118, APVV 0212-12 and APVV 14-0276.

Late Miocene lacustrine deltaic deposits: the junction of the Danube-Kisalföld Basin and the Gerecse Hills, Hungary

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The Transdanubian Range played an important role in the Western Carpathians–Paleo-Danube (?)–Pannonian Basin source-to-sink system during the Late Miocene. This elevated basement block formed a barrier between the Danube-Kisalföld Basin (DKB) and rest of Lake Pannon basins to the S-SE until 9.2 Ma ago (Sztanó et al., 2016). Afterwards flooding started resulting in deposition of open-water clay marls in the northern foreland (Cziczer et al., 2009). As filling up of the DKB progressed, deltaic lobes developed above this flooded basement high. This depositional environment produced the successions located in the Gerecse Hills, near Neszmély. In a deep valley there are 11 outcrops within a 1 km distance.

The oldest strata are clays with intercalations of very fine cross-laminated sand with lenticular to wavy bedding and coarse mollusc-hash of hummocky cross-lamination. Higher up in the succession cross-laminated sandstone becomes dominant. Sand bodies are often cut by erosional surfaces, commonly paved by rip-up mud-clasts or marked by wedge-shaped silty-sandy fills with tabular and trough cross-bedding. The sandy sediments are overlain by mottled, oxidized siltstones with calcareous concretions or by an organic-rich to carbonaceous clay with carbonized wood trunks. These carbonaceous clays lead correlation of the sections and are overlain by the blue, fossiliferous clays again. For fossils of the succession see Magyar et al. (this volume). The exposed Pannonian succession was deposited in shallow water above storm-wave base to lower shoreface/deltafront and in delta plain channels. The sedimentary successions partly reflect cyclic changes of water depth and are interpreted as lacustrine parasequences indicating repeated rises of base level. The littoral shell debris may have been accumulated by storms or as a transgressive lag related to minor oscillations of lake level. Some of the fluvial deposits could be channels on the delta plain, but those of a more complex cut-and-fill structure are interpreted as small incised valleys, therefore may reveal minor drops of base-level.

A relation was found between thickness and abundance of various shallow lacustrine facies and locus of major faults of the area. Although the regional trend of palaeotransport directions is towards SE-E, unusual directions towards N and NE were measured, which indicate that the Gerecse block was not only a passive morphostructural feature, but its relative vertical motions may have actively influenced the locus of different sedimentary environments, incision of channels in particular, and sediment dispersal directions. The delta system finally progressed around/partly over the Gerecse Hills and reached the Buda Hills area to the south at about 8.6 Ma (cf. Magyar et al., 2013).

Acknowledgement: The research was connected to project TÉT-12-SK-HU-2013-0020 supported by the National Research, Development and Innovation Office of Hungary.

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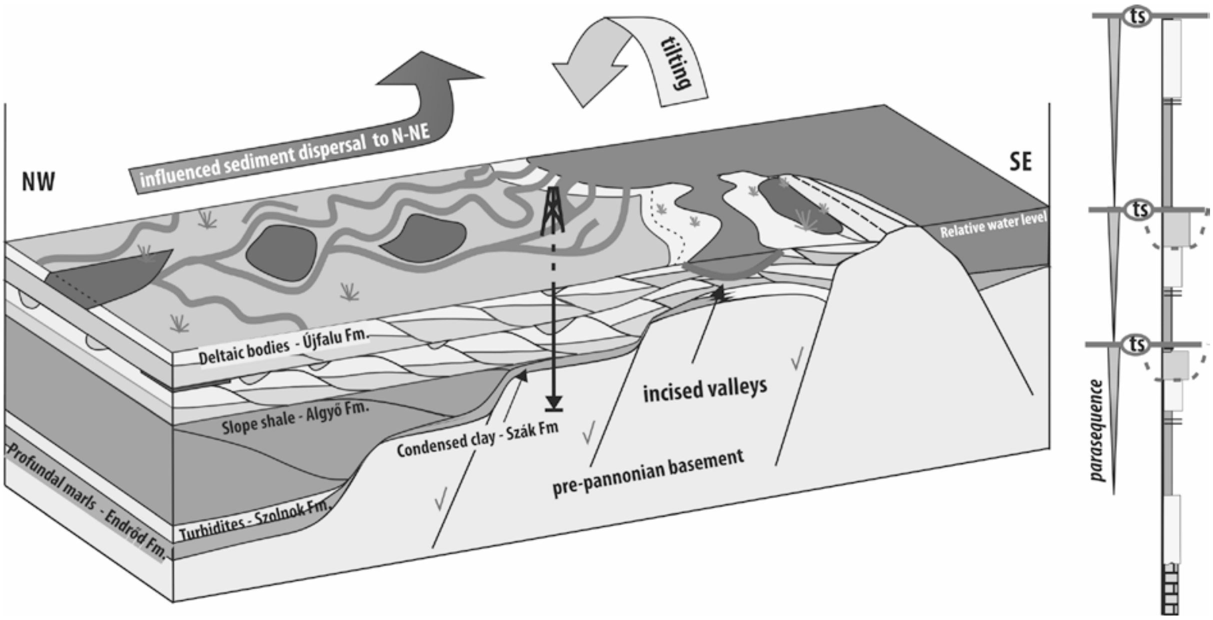

Figure 1: Conceptual block model of delta development and its structural control.

Channel deposits of submarine fan in abandoned quarry in Wielka Puszcza, Beskid Mały Mts. (Outer Carpathians)

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The Beskid Mały Mts. is a part of the Outer Western Carpathians, situated within the Silesian Nappe. This nappe is tectonically partitioned and consists of Upper Jurassic–Neocomian series with a large proportion of shales and Upper Createaceous–Paleogene series, in which sandstones dominate (Paul et al., 1996; Golonka, 2007). In the study area, the Silesian Nappe is divided into tectonic sub-units. The lower, Cieszyn sub-unit is folded and reveal in a small area. The upper, Godula sub-unit is characterized by predominance a part of sandstones (Konior, 1938; Książkiewicz; 1951, Nowak; 1957).

During Uppermost Turonian–Early Senonian sedimentation in the Silesian Basin was dominated by very thick–bedded, sandy flysch series of the Godula Beds (Godula Formation after Golonka et al. 2008). Within the Western Carpathians the Godula Formation is subdivided into three, lithologically different parts. The lower part is represented by coarse-grained conglomerates and thin–bedded sandstones intercalated by green and black shales. The middle part is developed as thick–bedded sandstones with green and black shales. The upper part is composed of thick-bedded, coarse–grained sandstones with locally developed horizons of conglomerates (Malinowska skała conglomerate). Complete thickness of the Godula Formation in the western sector of the Polish Carpathians is about 3000 m.

Analyzed outcrop is built of thick and medium bedded sandstones (S), muddy sandstones (SM) and conglomerate sandstones (SC) lithofacies (see Ghibaudo, 1992; Słomka, 1995). These lithofacies correspond to the Lower Godula Formation. The sandstones are gray or gray-green, silica–clay. Shales are steel gray, intercalated by cross-bedded, fine-grained sandstones.

Thick - bedded sandstones are usually massive, occasionally parallel laminated and cross bedded. Amalgamated surfaces and normal grading are common. The lower surfaces are sharp, usually uneven, with small load casts. Beds are laterally continuous. There are also a tendency to decrease in beds thickness (positive cycles) and the grain size toward the upper part of the outcrop (Bębenek 2011).

According to the classical theory (Lowe, 1982) these deposits were formed from high/low density turbidity currents. However, the grain size is too large to transport in the suspension, which is the main mechanism of turbidity current (Lowe, 1982). It may suggest that deposits from Wielka Puszcza are the result of sandy debris flow sensu Shanmugam (2006).

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Detrital chromian spinels from the Magura Unit (Western Carpathians, Eastern Slovakia): provenance implications

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Detrital chromian spinels in sedimentary rocks provide much information concerning the tectonics of their parent ultrabasic rocks. Chromian spinels occurring in the Eocene to Oligocene deposits from the Magura Nappe were examined to provide some constrains on the history of the Magura basin. The Magura Nappe is a part of the Flysch Belt belonging to the External Western Carpathians. The Magura Nappe is separated by a narrow zone associated with the Pieniny Klippen Belt and is divided into three principal tectono-lithofacies units (from the S to N): the Krynica, Bystrica and Rača units.

Cr-spinel is a common accessory mineral (2.3-5.9 vol% of heavy mineral spectra) in the siliciclastic rocks of the Rača and Krynica units. In terms of texture and chemical composition, two types of Cr-spinels were recognized: unaltered and altered. Unaltered spinels were found to contain silicate inclusions such as chromio-pargasite, enstatite, diopside, pargasite, plagioclase and forsterite. The Cr-spinels show wide variations in compositional parameters such as Cr# (0.3–0.7), Mg# (0.3–0.7), TiO_2 (<0.03–1.9 wt %) and Fe^{2+}/Fe^{3+} (2.5–13) whereas the differences between the Rača and Krynica units are insignificant. These parameters suggest a peridotitic and volcanic origin of the spinels, respectively. The ophiolite source consisting of harzburgitic mantle peridotites was developed mainly in a supra-subduction zone setting; volcanic spinels indicate an origin in mid-ocean ridge basalts, back-arc basin basalts and sporadically in ocean-island basalts (Lenaz et al., 2000; Kamenetsky et al., 2001).

Taking into account the geochemical characteristics of the Cr-spinels and palaeoflow directions (in the Eocene especially), we propose that during the Eocene to Lower Oligocene, the ophiolitic detritus in the eastern part of the Magura Basin deposits may have been derived from a source area located in the Fore-Marmarosh Suture Zone (Eastern Carpathians) that is considered an equivalent of the Black Flysch and Ceahlau units (e.g., Ślączka et al., 2006; Hnylko et al., 2015). Some Cr-spinels found in the Eocene sedimentary successions may have resedimented from older Late Cretaceous-Paleocene formations of the Magura Unit, which are considered as reworked sedimentary material from the Pieniny Klippen Belt.

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Epiphreatic development phases in the Ochtinská Aragonite Cave: Revision high-resolution magnetostratigraphy of cave sediments

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The complicated multi-phased genesis of the well-known Ochtinská Aragonite Cave (Revúcka Highlands, southern Slovakia) has still been the object of ongoing research. Revision high-resolution paleomagnetic sampling of the sedimentary profile in the Oválna Passage followed original pilot sampling of the profile in 1999 (only 5 samples; Bosák et al., 2002). High-resolution re-sampling by 40 samples in 2013 covered 60 cm thick profile. The Bunhes/Matuyama chron boundary (0.78 Ma) was more precise determined at 13 cm below the top of the profile. Newly, the short normal polarized magnetic zone at 33 cm below the profile top was interpreted as the Jaramillo event (0.99 to 1.07 Ma). The depositional rate between the Brunhes/Matuyama boundary and the upper boundary of the Jaramillo magnetic zone is about 0.09 $cm.ka^{-1}$ (19 cm long section deposited during 210 ka). The very slowly depositional rate resulted from slow water flow with only occasionally turbid water loaded only in extremely fine-grained material (clays; i.e. highly sieved material). If the depositional rate has been similar also in the lower section of the studied profile under the Jaramillo magnetic zone (28 cm long section deposited during 310 ka), the sedimentation on the bottom bedrock began ca 1.3–1.4 Ma ago. The prevailing NE–SW direction of magnetic lineation from the anisotropy of magnetic susceptibility measurements indicates uniform direction of water flow during the accumulation of sediments, i.e. from the Hlboký Dome through Oválna Passage to Sieň mliečnej cesty Hall. The age of flowstone covering the sedimentary profile is 177 ka (Bosák et al., 2002), therefore these sediments were eroded in the period from ca >780 up to 177 ka, most probably as a result of oscillations of groundwater table up from lower cave levels. The water table oscillation and its long-lasting stagnation resulted in the origin of the principle flat ceiling (Laugdecke) between the Oválna Passage and Hlboký Dome. This ceiling cut an older ceiling cupola-like form with aragonite and calcite fills. Based on their U-series dating (Bosák et al., 2002), the flat ceiling corrosion can be dated into the period between 405 and 177 ka.

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Quaternary climate reconstruction in the middle Tisza region based on VHR seismic images

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Based on very high-resolution (VHR) waterborn seismic profiles an ancient meandering river (Palaeo-Bodrog) with high discharge was reconstructed under the modern Tisza. The study verified the existence of the third hydrological axis (Gábris, 2002) of the Pannonian Basin during the Middle Pleniglacial. The catchment area of this river was the junction zone of the Western and Eastern Carpathians, thus the climate proxy resulted from the study of the alluvial sediments for the earlier part of MIS3 (Fig. 1) might be applicable for the nearby mountainous areas.

On the VHR profiles sedimentary structures of 20–30 m thick alluvial deposit were observed. Seven frequently occurring seismic units were analysed. The most spectacular, 300–3000 m-long series of inclined reflections appear consequently in the same depth level. This unit was interpreted as laterally accreted point bar complexes of a meandering river. Other seismic units in the same depth level were extended floodplain deposits, abandoned cut-off channel fills and large erosional scours. The Tiszaliget core revealed the medium sand to silty-clayey upward fining succession of the point bar and the overlying floodplain fines correlating well to the seismic interpretation. The OSL ages derived from the ancient point bars show Middle Pleniglacial (MIS3), 46–47 ± 4.6 ky (Cserkész-Nagy et al., 2012). The duration of meander development was about 2–3 ky.

The spatial and temporal variations of the point bar geometry were resurveyed by quasi-3D seismic profiling. The dip directions of series of inclined reflections and geometry of progressive development units helped to reconstruct natural meander migration. Channel-forming discharge (400 to 1800 m^3/s) curve was calculated from the width (350–520 m) and depth (6–7 m) data of the river. A primary trend in discharge variation was detected within the range of millennial-scale climatic fluctuations (Cserkész-Nagy & Sztanó, 2016). The undulation of the river-bed reflects the same trend. Increasing discharge was coupled with stepwise incisions in correspondence with meander migration phases, while continuous decreasing discharge resulted in slight aggradation of the river bed.

The alluvial history of the succession fits well into the glacial–interglacial climate model, and supports the deterioration of the climate described for the Carpathian Basin (Novothny et al. 2011). Sustained meandering of the high-discharge Palaeo-Bodrog proves a mild and wet climate at the beginning of MIS3. Subsequent aggrading storeys with meandering character reflect a decrease of discharge, which implies the aridification of climate.

Incising channels followed by rapid infill suppose a sudden cold period, but the subsequent meandering phase indicates climate re-amelioration. Towards MIS2, the transition of river pattern from meandering to braided may reflect the permanent deterioration of the climate.

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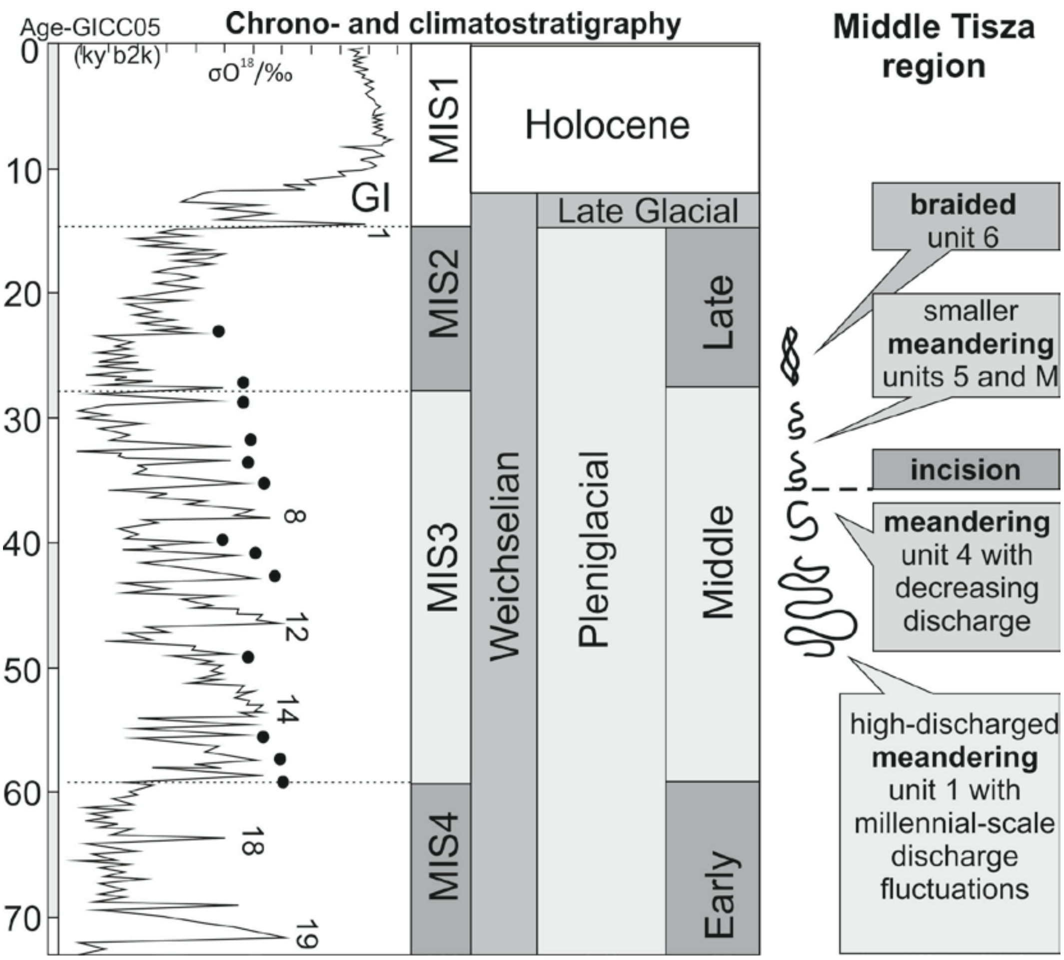

Fig. 1: Reconstructed alluvial history of the middle Tisza region (after GICC05, Svensson et al. 2008).

Geological and geophysical investigation of Havranická jaskyňa cave in Malé Karpaty Mts., Slovakia

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The Havranická jaskyňa cave (174 m long, -50 m deep) is situated in Malé Karpaty Mts., approximately 1 km northwest from town Smolenice. The entrance is located only few meters from the top of Havrania skala (599 m a. s. l.), which is part of hill Havranica (717 m a. s. l.). This area is include to the Považský Nappe, which is part of Hronic Nappe system (Polák et al., 2011). Within the karst regionalization we incorporating it into the Plavecký Karst Area (Stankoviansky, 1974).

The cave is mainly built of dark gray to black, layered Guttenstein Limestones with Middle Triassic age (Polák et al., 2011). However, it is not excluded, that to the cave system the Guttenstein Dolomites interfere. During the research it was taken 5 samples of limestones. These samples were subjected to XRD analysis and also were prepared thin sections. In three samples we observed in thin sections crystals of dolomite, and the XRD analysis confirmed the occurrence of partially dolomitizated limestones and dolomites. These three samples were taken from Zbojnická hall (-36 m), Michal's chamber (-40 m) and 5 meters above Michal's chamber (-45 m).

The cave was formed to subvertical discontinuities of N-S direction, which can be seen also at the surface around the cave entrance. Fractures based on these directions are characteristic of the whole area around the cave. At the inception of the cave origin was another important system of discontinuities - and areas bedding to bow northwards with inclination 36-76°. N-S subvertical direction discontinuities are not only dominating of Plavecká karst; they often occur in other karst areas of the Malé Karpaty Mts. The direction of cave passages have connection with N-S affinity to stab NW-SE form pair system faults. During the Middle Miocen compression was these fault reactivated in the form of slip faults. It is also a prerequisite for their reactivation in Plio-Quarternary stage (Marko, 2012). On these discontinuities occurred to karsting - dissolution of carbonate by atmospheric precipitation, and these activity was followed by the particularly corrosive activity. At present, we cannot find shapes created by erosion. This does not mean, that you do not have to located in the past. They could succumb to the corrosive activities of water percolating, or destruction of the walls related to younger tectonic processes. Examples of such processes can be the Zbojnická hall.

Below this hall Šmída (2010) assumes a greater corrosion hall, after which the neotectonic and gravitational movements collapsing. As a result of this event is the shape-wedge profile of Zbojnická hall. The cave system continues to the north, and the character of passages becomes more vertical (70-80°).

Geophysical measurements on this area were made in 2009 and 2010 (Lačný et al., 2012). By electrical resistance tomography (ERT) we want to find possible continuations of cave passages. The ERT method allows to obtain a sufficient density of data for further details of 2D and 3D modelling (Gambetta, 2009). On the base of these datas we can modelled a 3D model, where we add a polygonal traction points that show points the walls of cave. The latest discoveries in the cave are bound to a steep passages. Based on the new places we assume, that the digging depth of discontinuities is very significant. The deepest point of the cave is currently -50 m, and the speleologists continued into excavation works in vertical passages. According to the model, in the places of the greatest resistance is fiting with the polygonal traction points. These geophysical measurements confirmed the continuation into the deepest part. The depth range of 3D model is more than 70 m and the high resistance place are continued deeper. It means, the cave system will be at least -70 m deep. For relatively short cave system (174 m) is that depth exceptional, and it makes a karst phenomenon of Havranická jaskyňa cave in Malé Karpaty Mts.

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Structural evolution of the East Alpine-Pannonian junction area: from nappe stacking to extension

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The western part of the Miocene Pannonian Basin covers the transition from the Eastern Alps to the Pre-Miocene basement units of the Pannonian Basin. Structural evolution of this area was reconstructed from surface observations, borehole data, seismic reflection profiles and 3D seismic data sets. Fault-slip and geochronological data were collected at the Miocene basin margins, in the Pohorje-Kozjak Mts. (Slovenia) and in the Transdanubian Range (TR) in Hungary.

The area is characterized by NW or W-verging Cretaceous nappe stacking and internal folding and thrusting (Tari 1994, Héja et al. 2015) while SE-vergent thrusts in the TR are considered as back-thrusts. Detachment levels are postulated in the Carnian and Silurian levels. In the highest TR unit this deformation occurred before the Mid-Albian (before 108 Ma). In the underlying low-grade units the youngest K-Ar age is around 116 Ma, while in the lower medium-grade Koralpe-Wölz unit geochronological data scatter from 95 to 87 Ma (Árkai & Balogh, 1989; Thöni, 2002). The mid-Cretaceous thrust contact was reactivated or deformed by two phases of extensional deformation: few cooling ages indicate late Cretaceous exhumation of the medium-grade Koralpe-Wölz metamorphism in the Kozjak Mts. (Fodor et al. 2003, 2008). Major structures are a wide mylonitic belt, shear bands, folds related to low-angle normal shearing, and in map-scale, extensional allochtons: they are composed of Palaeozoic rocks and the non-metamorphic Permo-triassic sequence of the TR. This extensional deformation might have been connected to Senonian (Santonian to Campanian) basin formation in the hanging wall units (TR); such synsedimentary normal faults were in fact observed on seismic profiles.

Good parts of the geochronological data set indicate Miocene cooling of the Koralpe-Wölz rocks and the Miocene Pohorje pluton. The Miocene exhumation resulted in low-angle detachment faults and mylonitic shear zones in deeper structural level. Above these first-order structures, a series of half grabens and few strike-slip faults formed; the latter ones played as transfer faults and part of them presumably reactivated former strike-slip faults (e.g. Mid-Hungarian Shear Zone). Extension was oblique within these shear zones. Tectonic exhumation resulted in the formation of metamorphic core complexes.

Exhumation exposed different structural levels from the Cretaceous nappe pile: Koralpe-Wölz in the Pohorje Mts., Murska Sobota high and the Penninnic unit in the Rechnitz windows (Tari 1994, Dunkl & Demény 1997, Fodor et al. 2003). Extension affected the 18.6 Ma old Pohorje intrusion during its cooling through greenschist facies conditions between 18–15 Ma. Extension in the pluton was recorded by AMS data, crystal plastic and brittle deformation structures which have been observed in the pluton and related Miocene magmatic dykes of variable composition. This extensional deformation was connected to the opening of the Pannonian Basin from ca 18.5 Ma to ca. 15 Ma.

During the middle Badenian the extension direction gradually changed to ESE-WNW. However, few map-scale grabens were associated to this deformation, which could be much more important further to the north, in the Danube basin.

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Tectonic control on sedimentation pattern in the late Miocene of the western Pannonian basin, Hungary

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The Pannonian Basin system is due to late Early to Mid-Miocene lithospheric extension of the formerly thickened Alpine-Carpathian crust. The major crustal faulting occurred between 19 and 11.5 Ma which resulted in a dense network of normal and strike-slip faults of varying orientation. The faults bounded more or less isolated sub-basins, generally half grabens where a relatively modest sedimentary sequence (the so-called syn-rift sequence) deposited while the intermittent basin highs were marked by a reduced sedimentation.

At the beginning of the Late Miocene (Pannonian) ca. 11.5 Ma ago, the sedimentation patter has been changed and the former basin highs were progressively inundated by the brakish Lake Pannon. The initial transgressive phase of ca. 11.5–9.5 Ma was gradually changed and clastic input from fluvial network progressively filled the lake. In our research, we investigated the sedimentation pattern, facies relationship of the late Miocene sediments and the tectonic style, geometry and kinematics of Late Miocene structures and their influence on sedimentation by the help of surface structural, sedimentological and palaeontological observations, and by 2D and 3D seismic reflection data sets. Our research extended into the Transdanubian Range (TR), the largest high in the Miocene, and sub-basins west, south and east of it.

The initial transgressive phase inherited a dissected basin topography from the previous syn-rift deformations. The inherited structures and active deformation resulted in a variable facies pattern, which could be simplified as in the following: deep lacustrine marl-claymarl sequence ("basinal marls") accumulated in the deep sub-basins. This lithofacies changed to a slightly different marl along the margins of the basement highs, which was still deposited below wave base (ca. 50-80m), which we refer to as "basin-margin marls" (Szák Fm.). This lithofacies is characteristic along the western margin of the TR, during 9.5–9 Ma. The clastic input reached the basin from the NW and resulted in deltas of ca. 20–50 m thick dominantly sandy sedimentary packages (Újfalu Fm.). These shelf deltas changed to slopes of several hundred meter high in the deep sub-basins (Algyő Fm.), while slopes were missing from above highs. Deltas were prograding across all highs but with reduced sequences. The final stage of basin fill was a fluvial sedimentation (Zagyva Fm.).

Systematic mapping of clinoforms of the slope sediments clearly indicate the influence of basement highs which deflected slope progradation into a direction sub-parallel to highs. These basement highs were partly inherited from the syn-rift deformation. However, seismic sections clearly demonstrate active syn-sedimentary faulting during the transgressive phase, and partly during slope progradation, ca. between 11.5 and 8 Ma.

Surface measurements suggest an E–W to ESE–WNW extensional stress field in agreement with seismic fault mapping. Fault-controlled abrasional gravels and fault breccias formed the margins along the TR which probably changed rapidly to “basin-margin marls” toward basin centres. Map-scale normal or oblique-slip faults characterize most sub-basins around the TR. On the other hand, the ca. E-W trending Kilimán High represented contractional features already at the early basin marl deposition, ca. 11.5-8.8 Ma. The last stage of deformation affected the deltaic sequences near the Rechnitz windows (Kovács et al., 2015) and in the north-westernmost Gerecse (Bartha et al., 2014) around 9–8.6 Ma.

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Geological research of caves in Slovakia – a review

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Caves are considered by many geologists as unsuitable for geological research on the score of speleothem occurrence. Nevertheless many caves cut across bedding sequences, uncover significant faults and folds, contain various fossils in cave walls or in sediments and hide many types of minerals. More than 7,100 caves are known in Slovakia in the present. The most of them were created in carbonate rocks, but about 200 non karstic caves occur in granite, gneiss, andesite, basalt, tuff, sandstone, siltstone, quartzite and conglomerate.

Only after World War I, it is possible to talk about targeted geological research in Slovakian caves. Geological research in caves before war was sporadic and accidental (for example description of Demänová Ice Cave by D. Štúr in 1868, find of first tree mold caves by A. Kmeť in 1902 or compilation of cave list in Slovak karst by G. Strömpl in 1912). After World War II successful investigation has been performed by Czech geologist in Domica Cave headed by R. Kettner from 1933 to 1938. Important geologic researches were made in caves of Slovak Karst by J. Seneš (1950, 1954, 1957), V. Homola (1951) and F. Skřivánek (1957, 1966). Systematic geologic research of Slovakian caves has started Slovak Karst Museum and Slovak Caves Administration, which was oriented mainly to lithology, stratigraphy, tectonic, mineralogy and hydrogeology of caves. The most important results are the following.

Stratigraphy and lithology of cave bedrock was researched in Driny Cave with documentation of Lower Cretaceous profile (Michalík et al., 1992). Very interesting was the detection of Miocenian abrasion caves in Malé Karpaty Mts. (Mišík, 1976; Lehotský, 1994; Aubrecht, 2015). In Ochtiná Aragonite Cave the genesis of Devonian reef limestones with the unique variscian fold structures was clarified (Gaál, 2004). Detail micro facial analysis was performed by J. Mello (2004) in Domica Cave and in Liskovská Cave some faults parallel with Subtatric Fault were detected (Psotka et al., 2006). Complex geological investigation and sedimentological studies was realized in Dobšinská-Stratenská cave system (Tulis & Novotný, 1989) as well as in others caves of Slovenský raj Mts. (Novotný & Tulis (2005). In Bystrianska Cave 5 tectonic blocks in Reifling limestones were distinguished (Gaál & Psotka, 2006). Beside numerous geological researches of further caves (e.g., Perlová, Brestovská, Hrušovská, Gombasecká, Čertova, Milada, Malužinská Cave (Vlček & Psotka, 2007; Vlček, 2006, 2007; 2008, 2009; Gaál & Vlček, 2009, Bella et al., 2014) the finding out of Anisian initial reefs with Silicispongiae in Demänová Cave System was significant (Gaál, *in press*).

Stratigraphy and dating of cave sediment was realized in Demänovský Cave System with the continuous Pliocene and Quaternary sequence (Hercman et al., 1998, 2005; Bella et al., 2011, 2012, 2013). Also from Ochtinská Aragonite Cave and Važecká Cave was obtained valuable data with paleomagnetism (Bosák et al., 2002; Pruner et al., 2002; Bella et al., 2016). In Domica Cave and Dobšinská Ice Cave the Pliocene allochtonous sediments were dated by cosmogenic nuclide (Bella et al., 2014, 2015). Valuable datas were obtained from Upper Cretaceous paleokarst cave filling in Včeláre quarry (Gaál et al., 2007) and Jurassic cave filling in Dachstein limestones near Bretka (Gaál, 2008).

Tectonic study of Drienovská and other caves of eastern part of Slovak Karst by M. Zacharov (1985, 2008, 2012, 2013) markedly contributed to genesis of this region. In Domica Cave the NW-SE and NE-SW fault system was detected (Gaál & Vlček, 2011). The Zápoľná Cave was created on the base of Choč nappe along some significant tectonic lines (Littva et al., *in press*) however the important fault system was detected in Važecká Cave too (Bella et al., 2016). Tectonic activity and recent limestones block movement are followed by inbuilt dilatometer in several caves in Slovakia (Briestenský & Stember, 2008; Briestenský et al., 2010, 2011). A new term cavitonics was created by Littva et al. (2015) which is encompassed all aspects of active tectonic using caves.

The gravitation slope deformation with crevasse and boulder caves was described in basalt of Cerová vrchovina Mts. (Gaál & Gaál, 1995) and in limestones of Tisovec karst (Gaál, 1997). The origin and typology of boulders caves was described too (Bella & Gaál, 2010).

Paleontological remnants in more than 300 caves were found in Slovakia till now. It belongs to 330 taxons, which testify the high diversion of fossils of flora and fauna in caves of Slovakia (Gaál et al., 2013). Their bigger part (82 %) were found in cave sediments, while smaller part (18 %) in bedrock of cave. Extra propositional researches were realized by V. Ložek (1955, 1958, 1962, 1965 and others) oriented to Quaternary malacofauna of caves in main karst regions of Slovakia. Paleontological remnants – mainly cave bear and cave lion – were studied by Z. Schmidt (1965), Schmidt & Chrapan (1970), P. Holec (1985, 2000, 2007) and M. Sabol (1998, 1999, 2001).

Among many minerals in Slovakian caves we can mention about the some first finding as brushit in Domica Cave (Kašpar, 1934), gypsum in Demänovský Cave System (Pavlarčík, 1986), viseite and apatite in Domica (Cílek, 1999, Cílek et al., 2001), cryogenic crystals in several caves of Low Tatra (Orvošová, 2005; Orvošová & Hurai, 2008; Orvošová et al., 2010), taranakite in Domica (Sejkora et al., 2004) or first explanation of origin of aragonite in Ochtiná Aragonite Cave (Homza et al., 1970).

References will be published on the poster.

Central Carpathians–North European plates suture zone in Poland

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The goal of this research was interpretation of the deep structure of the Pieniny Klippen Belt (PKB) in the area between Czorsztyn Lake and Biały Dunajec River in Poland. The authors utilized the Czorsztyn 2D seismic survey, the first high-resolution deep seismic reflection survey within PKB in Poland. The investigation of the geological structure of three main Carpathian tectonic units: Central Carpathians, PKB and Outer Carpathians in the suture zone was one of the goals of this survey. Analysis of the seismic activity in the Czorsztyn Lake region was also the important objective of this research (Golonka et al., 2016). The knowledge of the PKB structure in Poland was based on the geological and geophysical surveys as well on the deep drillings. The geological investigations included mapping, stratigraphic, sedimentological and structural studies. The geophysical research included among the others. Deep Seismic Survey based on the refraction seismic method applied in the CELEBRATION 200 project, particularly CEL04 seismic profile (Janik et al., 2009; Janik et al., 2011 as well as magnetotelluric investigation The following deep bore-holes: Bańska IG-1, Bańska PGP-1, Maruszyna IG1, Nowy Targ PIG-1, Bukowina Tatrzańska PGP-1, Biały Dunajec PGP-2 Biały Dunajec PAN-1, were drilled in this region, however outside the Czorsztyn 2D seismic survey lines. Input data for this study come from 2D seismic survey "Czorsztyn" (lines 01-01-15K, 02-01-15K, 03-01-15K and 04-01-15K) which was generated in 2015 by Geofizyka Kraków SA for the Institute of Geophysics, Polish Academy of Sciences (IGF PAN) and four archival profiles (24A-5-87K, 24-5-87K,26-5-87K and 28-5-87K) generated in 1987 by the same company.

The great continental plate, known as North European Platform, forms the basement of the Northern Carpathians. This plate consists of Proterozoic, Vendian (Cadomian) and Lower Paleozoic (Caledonian) fragments, deformed and metamorphosed. The Paleozoic, Mesozoic, Paleogene and Neogene strata cover the crystalline, metamorphosed basement (Golonka et al., 2011).The PKB mark the suture zone between the Central Carpathian Plate and the North European Platform. The Central Carpathian Paleozoic and Mesozoic rocks crop out in the Tatra Mountains. Between the Tatras and PKB, they are covered by the Central Carpathian Paleogene and known only from boreholes and geophysical data (Golonka et al., 2005). The PKB is limited by two major faults (PKB_S and PKB_N), linked to the strike-slip zone.

The seismic lines show the Central Carpathian Paleogene rocks covering the Tatric units south of PKB. The Sub- Tatric cover High Tatric autochthonic and allochthonic rocks cover the Paleozoic Central Carpathian Basement. The crystalline Central Carpathian rocks are thrust over the sedimentary rocks belonging perhaps to the North European Platform cover. The North European Platform basement is visible below these sedimentary rocks. The Central Carpathian Plate is thrust over the North European Plate in the Podhale region.

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Changes in oxic regime in the Turonian of the Úpohlavy section (Czech Cretaceous Basin)

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The class Ostracoda has been studied at the Úpohlavy quarry, which is an important paleontological site of the Turonian in the Czech Cretaceous Basin with abundant and well-preserved invertebrate and vertebrate fauna. Twenty samples from marl and limestone of Jizera and Teplice formation were collected in which 36 marine Upper Turonian ostracods species have been identified. Ostracods of the studied profile are characterized by gradual increase of species richness and decline in dominance of *Cytherella cf. ovata* (Roemer, 1840). The lowest diversity is observed in the dark marl of the Jizera formation and the highest diversity in the limestone and marl of the Teplice formation. The order Platycopida prevails on the order Podocopida in the Jizera formation, in which percentages of Platycopida specimens is in the range 67-89%, while its percentage in the Teplice formation is lower, in the range 25-59%. Using the Platycopida Signal Hypothesis in a sense of Whatley et al. (2003), which compares percentages of Platycopida and Podocopida, a low O2 content in Jizera formation and in the Coprolite bed (monotonous dark marl) of Teplice formation is supposed. This is in accordance with low number of species (5-11 per sample) and with higher TOC content (0.34-0.74 %). With the beginning of limestone and marl sedimentation of the Teplice formation a number of species increases (6-27 per sample), the TOC content decreases (0.11-0.38%) and a sedimentation reflects the oxic conditions with diversified ostracod fauna.

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Sedimentary environment and development based on palynofacies and fluorescence analysis in samples from the Uhryński river section (Bystrica zone, Magura Nappe, Polish Outer Carpathians)

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The Magura Nappe is the innermost nappe of the Outer Carpathians of Poland, between the Pieniny Klippen Belt in the south and the Submagura Nappe and Silesian Nappe in the north (Oszczypko, 2006). In the Magura Basin five clearly defined sedimentary cycles can be distinguished. The opening of the basin in the middle Jurassic was followed by pelagic sedimentation with turbiditic sedimentation at the end. Based on lithological differences the turbiditic succession is divided into 3 stages: late Cretaceous-Paleocene, Paleocene-middle Eocene and late Eocene-Oligocene. The last sedimentary cycle in the Magura basin, is made of marine sediments of the piggy back basin stage, developed in the early Miocene (Oszczypko, 1992 a, b).

The studied samples were taken from Uhryński river section (Bystrica zone, Magura Nappe, Polish Outer Carpathians), assigned to the second and third turbiditic cycle based on nannofosil stratigraphy. The organic matter isolated from these samples can be divided into three groups, based on fluorescence colors of the marine plankton (dinocysts): (1) well preserved dinocysts with intense, bright yellow fluorescence colors, (2) well to moderately preserved dinocysts with less intense, dark yellow to orange fluorescence colors and (3) poorly preserved non-fluorescent dinocysts. The different type of fluorescence within one palynomorph group gives evidence of the different origin of this material, mainly based on differences in thermal history (maturation). Group 1 dinocysts indicate organic matter deposited in-situ in this basin. Group 2 dinocysts represent allochthonous, slightly more mature organic matter redeposited into this basin, while the dark coloured dinocysts of group 3 represent highly mature organic matter, related to strong tectonic overprint or multiple redeposition of the sediments. Therefore the detailed analysis of palynomorph assemblages gives clear evidence of different types of sediment redeposition within the turbiditic cycles of the Magura basin.

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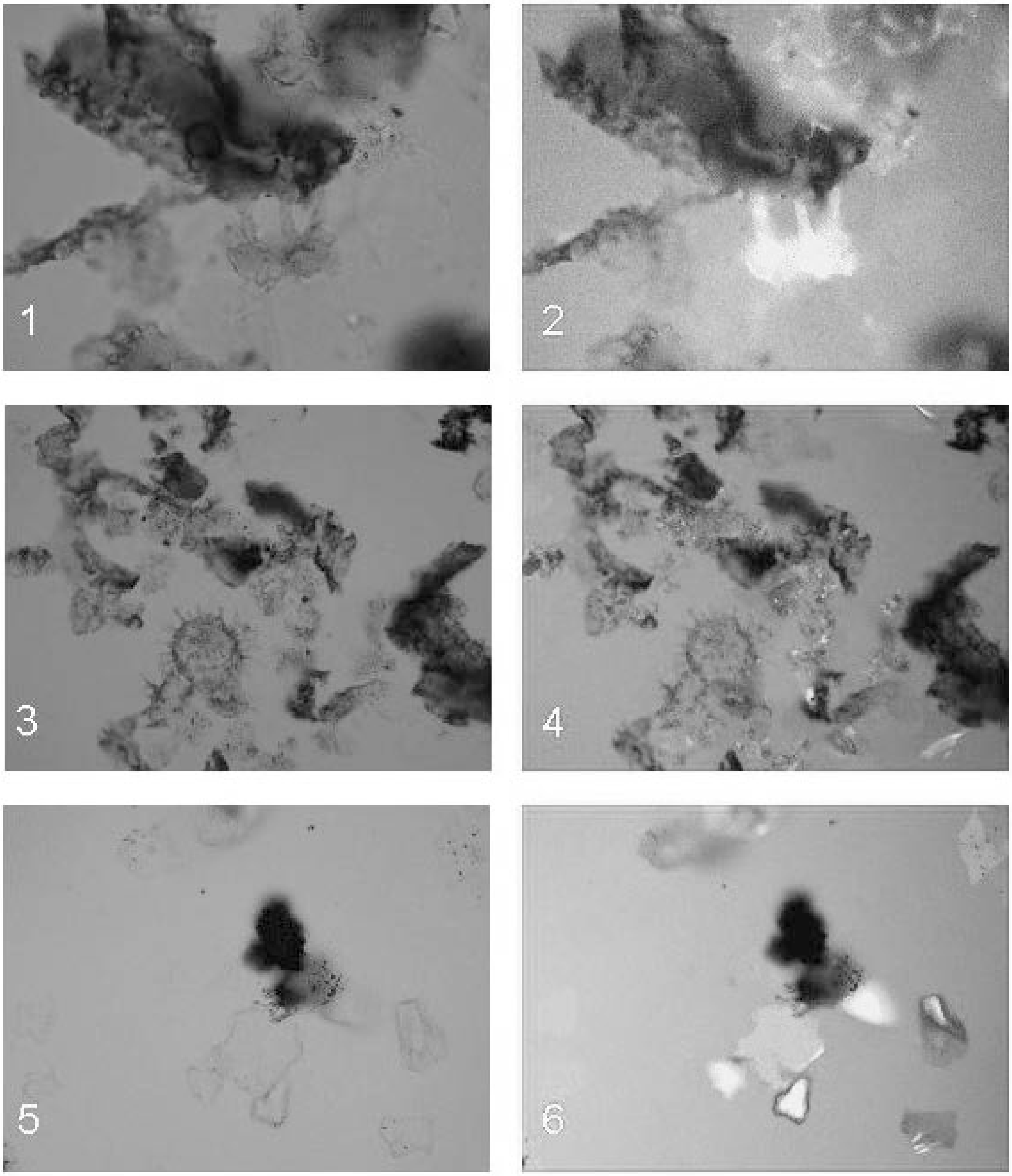

Table 1: Dinoflagellate cysts from samples from Uhryński river section (Bystrica zone, Magura nappe, Polish Outer Carpathians). **1, 2** - Well preserved dinoflagellate cyst, WP280 sample 7 - Uhryński stream: 1 - polarized nicols, 2 - fluorescence; **3, 4** – Moderately preserved dinoflagellate cyst, WP280 sample 7 - Uhryński stream: 3 - polarized nicols, 4 - fluorescence; **5, 6** - Poorly preserved dinoflagellate cyst, WP356 sample 10 - Uhryński stream: 5 - polarized nicols, 6 - fluorescence.

Image classification with unconventionally applied GIS methods in the fault related rocks from the Western Tatra Mts. grain size distribution: preliminary results

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Analysis of a grain size distribution and grain shapes in the fault-related rocks is a relevant tool in a reconstruction of a mechanisms and conditions leading to a development of these rocks (e.g., Heilbronner & Keulen, 2006; Berger et al., 2011). A data can be obtained from a thin sections: manually (like in Kania, 2014) or using an image analysis procedure. A YAGBSE imagery was used and an image classification methods derived from the remote sensing and GIS methodology were applied (see e.g., Tarquini & Favalli, 2009) to improve grain sized distribution data on the Western Tatra Mts. fault rocks. Such an extended method allowed to get definitely better data sample to performing statistical analyses.

The analyses were proceeded in 5 samples taken in typical for the Western Tatra Mts. crystalline core cataclasites from the Długi Upłaz–Wołowiec area, as well as one protomylonite from the Wołowiec massif. The characteristic feature of this region is abundance of a sub-horizontal brittle-ductile shear zones, composed of a shearing-related rocks: cataclasites and mylonites. The protholites are so called leucogranites and Roháče-type granodiorites. The following procedure was applied: (1) YAGBSE SEM imaging, (2) noise reduction, (3) determining training areas for a maximum likelihood classification, (4) maximum likelihood classification, (5) generalization of the raster, (6) vectorization, (7) data selection, the quartz grains were taken into consideration,) statistical analyses. In some stages decision steps with visual evaluation of the results were included. The ArcGIS software was applied to perform a crucial steps – supervised image classification.

The results of the grain size determination are shown on the Figure 1. The area and perimeter of the grains have generally unimodal distribution with right-side skewness, resembling the gamma distribution in most cases. The unique rocks have different kurtosis, stronger for the rocks of more advanced cataclasis.

The range of a variation in size parameters is narrowest for the mylonite. In the cataclasites, narrow range of the variation occur in the smaller grain dominated rocks.

The method applied here with additional shape indicators seems to be a powerful tool in quantitative analysis and interpretation of the fault rocks textural features.

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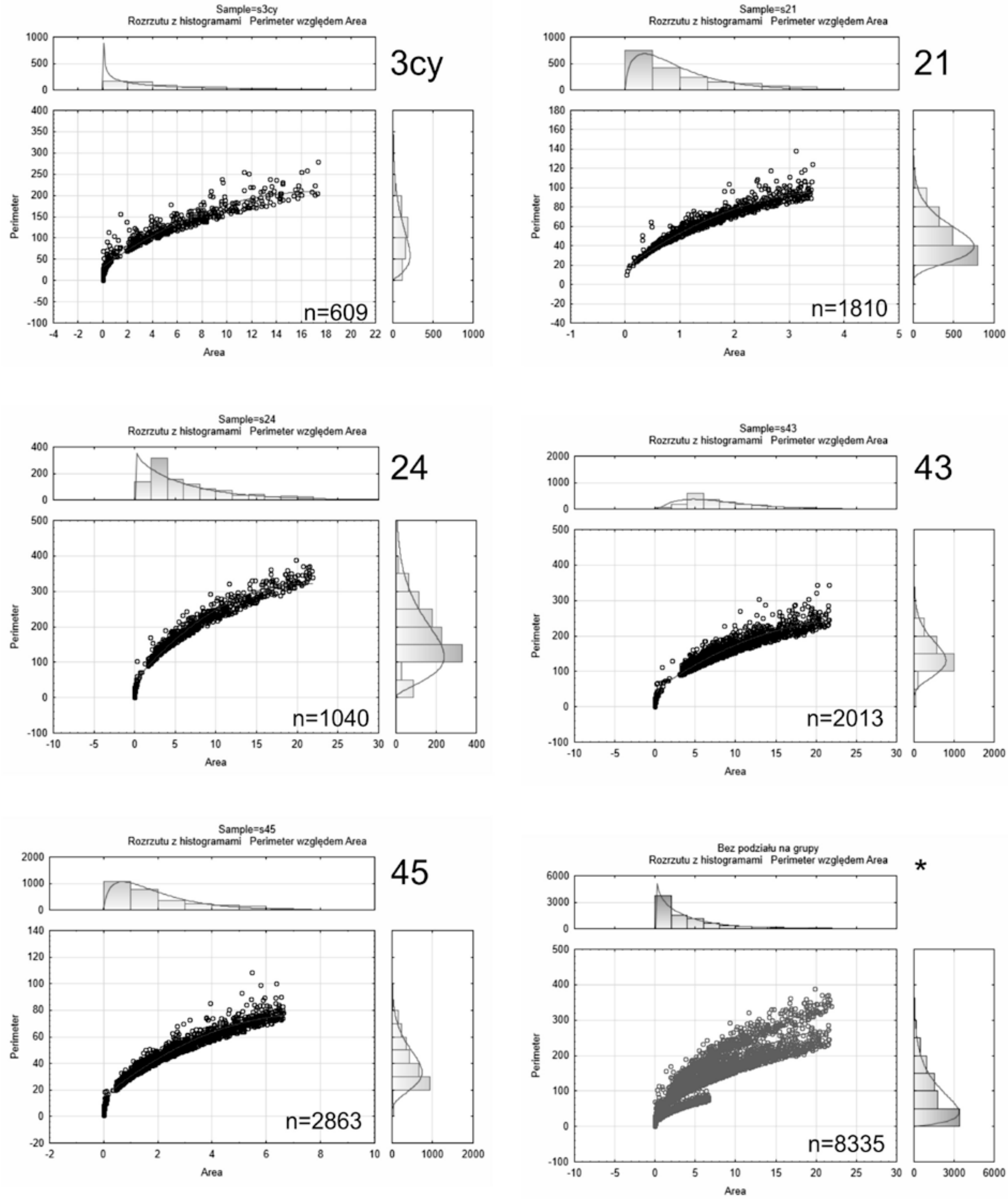

Figure 1: Grain size distribution: histograms of an area (upper, µm2), a perimeter (left, µm); perimeter (Y axis) vs. area (X axis) scatter plot. The last plot–aggregated data of all of the samples.

Morphological change during the ontogeny of *Orbulina suturalis* from the Danube Basin

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The ontogenetic studies of species *Orbulina suturalis* have been the subject of much speculation since their first describe by d´Orbigny in 1839. Research on their ontogeny is difficult due to the lack of preservation of ontogenetic stages in fossil record. Despite of it, genus *Orbulina* provide us an excellent material for ontogenetic studies and by using X-ray tomographic microscope, from an adult shell, we can reconstruct their complete ontogenetic evolution. The growing of the shell is gradual; each successive stage represents a part of the growing structure. It means, that they entire ontogenetic history is preserved within their test (Hembleben et. al., 1989; Caromel et. al., 2015).

Our specimen was studied using X-ray micro-tomography SkyScan 1172. The effective pixel size was ca. 0.56 µm. Tube voltage was set to 40 kV, current source was 250 µA. Data were acquired with angle step 0.120 degree. The acquired data were processed using flat field correction and reconstructed by supplied software N Recon (Bruker).

Generally, among the spinose planktonic foraminifera, we can distinguish 5 ontogenetic stages: prolocular, juvenile, neanic, adult and terminal. It is called the five stage model (Hembleben et. al., 1989). The determination and morphological describe of these stages allow us to understand the mechanism of shaping adult morphology and final morphological disparity. Recent studies and systematics concepts are based on the morphology of the adult stages. The identification of the complete ontogeny is difficult and limited in the fossil record. Despite of it, genus *Orbulina*, provide us an excellent material to distinguish the five stage model of ontogeny by using X-ray tomographic microscope.

The ontogeny begins with the first compressed chamber, which is the not calcified proloculus. The second stage is initiated by the addition of the deuteroconch. This is the first multi-chambered morphology during the life cycle of *Orbulina suturalis*. The biggest morphological changes take part in between the juvenile and the adult stage, which is the neanic stage. This stage is marked by chamber inflation, wall thickening, pore development and spine creation. The adult stage of species *Orbulina suturalis* starts with the growing of the terminal, spherical chamber, which is enveloping the previous compressed chambers. The last stage of ontogeny is marked by reproduction, gametogenesis (Hembleben et. al. 1989).

Researches on ontogenetic stages help us to understand the environmental influences on evolutionary processes. Environmental influences affect differently juvenile ontogenetic stages compare to an adult specimen. On the other hand, it could help us to understand mechanisms, such as heterochrony. Through the ontogeny planktonic foraminifers require different environment. By studying grow of the shell attributions we could make more accurate paleoecological reconstructions (Hembleben et. al., 1989; Caromel et. al., 2015).

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The Hurbanovo–Diösjenő Fault: boundary between the Central Western Carpathians and Northern Pannonian Domain

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The boundary between the Central Western Carpathians and the Northern Pannonian Domain – two crustal fragments with a different geodynamic provenance is represented by the Hurbanovo–Diösjenő Fault. The fault itself is located in the northern edge of the Transdanubian Unit and is covered by the relatively thick Neogene to Quaternary fill of the Danube Basin. The nature of this tectonic boundary is explained very contradictory because it is known only from several boreholes drilled in the 1950–70s. Moreover, interpretation of the seismic profiles is missing. The description of aforementioned boreholes often displays an old-fashioned biostratigraphy and outdated tectonic explanation of the Hurbanovo–Diösjenő Fault activity. Re-evaluation of the deep borehole cores penetrating the fill of several different Neogene and Palaeogene basins located above or near the Hurbanovo–Diösjenő Fault supported by structural analysis allowed a new interpretation of the Cenozoic activity along this fault zone: (1) during the Oligocene collision of the Eastern Alpine–Western Carpathian orogenic system with the European Platform, latter replaced by the Early Miocene formation of the ALCAPA microplate and its successive tectonic escape eastward required a dextral strike-slip movement along the fault; (2) a sinistral strike-slip movement along the fault is documented during the Middle Miocene evolution of the Danube and the Novohrad–Nógrad basins; and (3) a tectonic extinction of this crustal weakness zone was confirmed for the Late Miocene, when the Lake Pannon was formed. The renewed activity of this tectonic boundary as a normal fault is expected as a result of the Central Western Carpathian tectonic inversion phase in the Early Pliocene.

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The Miocene basin opening related to CCW rotations measured in the crustal wedge of ALCAPA domain

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In the Early Miocene (23–20 Ma), the ALCAPA microplate individualization and its following north-eastward escape was coupled with ~50° counter-clockwise (CCW) rotation of the Central Western Carpathians together with the Outer Western Carpathian accretionary wedge and the Northern Pannonian domain. Compression perpendicular to the front of the orogenic system led to a gradual closing of residual flysch troughs and growth of the accretionary wedge. Later on, the deep subsurface load of the sinking slab caused the subsidence of foredeep basins flanking the European Platform margins. Simultaneously, compression controlled disintegration of the forearc basin and opening of new wedge-top basins at the prograding northern edge of the microplate (~20–17 Ma). Along the southern boundary of the escaping ALCAPA, the subsidence of basin depocentres in the orogen rear part reflected initial rifting of the hinterland basin system in a transtensional tectonic regime. Pull-apart depocentres of the Eastern Slovakian Basin opened due to the dextral wrenching compensating the rotation of the microplate at the end of this period (~17 Ma).

The following Middle Miocene movement of microplate toward north-east led to disintegration of the Early Miocene wedge-top basins and to the opening of the Vienna Basin pull-apart depocentres (~16 Ma). This sinistral wrenching event was probably coupled also with ~30° CCW rotation in the outermost unit of Outer Western Carpathians, the Ždánice Unit. Simultaneously, shortening of the prograding accretionary wedge took place with widening of the Western Carpathian foredeep. The foredeep basin extended towards the platform with documented advance of the maximal subsidence from south-west to north-east. The Middle Miocene tectonic escape of ALCAPA resulted in double ~30° CCW rotations and associated with stretching of the orogenic system. The first ~30° CCW rotation (~15–13 Ma) led to opening and synrift subsidence of basins with depocentres west- and east-ward from the Central Western Carpathian stable core. Development of the Danube, composite Southern Slovakia–Northern Hungary, and Eastern Slovakia basins was forced by extension perpendicular to the orogen and associated with voluminous volcanic activity along the margins of the hinterland (back-arc) basin system. The second ~30° CCW rotation (~12 Ma) led to a late synrift phase above the stretched microplate in NW–SE oriented transtension. Shift of maximal subsidence from west to east is documented as well. Beside the hinterland basins, also intramontane basins of the Central Western Carpathians subsided again.

The Late Miocene development is characterized by termination of sedimentation in the foredeep on the one hand, and opening of the new – Pannonian Basin System in the orogen hinterland (~11–10 Ma) on the other hand. This process was accompanied by stretching of both ALCAPA and Tisza-Dacia microplates due to the subduction pull in front of the Eastern Carpathians. Filling up of the hinterland basins associated with thermal subsidence and was followed by the Pliocene tectonic inversion and consequent erosion of the basin system margins.

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Late Miocene – Pannonian ostracods from the southwestern Transylvanian Basin (Romania)

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Study of the Paratethys Neogene ostracods has substantially contributed to the stratigraphic, ecological, and paleogeographic understanding of this huge and complex marine to lacustrine depositional system (Danielopol et al., 2008). Of the large brackish lakes that repeatedly formed during the history of the Paratethys, the Late Miocene-Early Pliocene Lake Pannon was probably the longest-lived (Magyar et al., 1999). As a consequence this lake incubated a perplexingly diverse lacustrine biota (Magyar et al., 1999). In particular, the Transylvanian Basin (TB), representing the easternmost part of the early Lake Pannon, lacks modern and well-illustrated documentation of the endemic ostracod taxa. The objective of this contribution is to present the Late Miocene (Pannonian) ostracod faunae from 7 outcrops (LopadeaVeche/ Oláhlapád, Gârbovița/Középorbó, Gârbova de Jos/Alsóorbó, Mihalț/Mihálc, Oarba de Mureș/Marosorbó, Tău/Székástóhát, Cunța/Kunca) of the southwestern TB, and to explore their paleoecological, paleobiogeographical and biostratigraphic context. The fauna, consisting of 30 taxa, is dominated by species endemic to the brackish Lake Pannon. The overall paleoecological interpretation of the investigated ostracod faunae is difficult; probably much more samples would be required to understand the ecological significance of these endemic species. In general, the assemblages indicate a mixture of deep-water and shallow-water species. Thin-shelled, smooth Paratethyan Candoninae occupied the sublittoral to profundal zones of Lake Pannon, from the wave base down to the foot of the slope. The littoral zone was inhabited by forms with thicker and ornamented shells, such as, for instance, *Cyprideis*, *Loxoconcha*, *Amnicythere*, and *Hemicytheria*. In our samples, the deep-water and littoral taxa occur in various ratio.

Three ostracod biozones: *Hemicytheriahungarica* Zone (Lopadea Veche and Gârboviţa); *Hemicytheriatenuistriata* Zone (Gârbova de Jos, Oarba de Mureş, and Mihalţ) and *Propontoniellacandeo* Zone (Tău and Cunţa) are represented from the southwestern part of the TB. All these zones belong to the lower Pannonian Slavonian Substage, but the oldest Pannonian ostracod biozone, the *Hemicytheria loerentheyi* Zone was not identified in any of the samples. This interpretation is roughly supported by the mollusc fauna. The age of the outcrops is thus approximately between 10 and 11.3 Ma (cf. Vasiliev et al., 2010).

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Alpine low-thermal evolution of the Western Carpathian basement rock complexes: inferred from zircon and apatite fission track data

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Zircon and apatite fission track analyses have been used in order to refer quantitative constraints on the Mesozoic to Cenozoic low-thermal evolution of the Internal Western Carpathians immediately after the Eo-Alpine nappe stack and metamorphosis. For a case study on the low-thermal evolution, the Variscan consolidated crystalline basements of the Tatric, Veporic, and Gemeric tectonic units were chosen. The thick-skinned tectonic units provide a coherent natural laboratory where exhumation and burial processes controlling low-thermal and landscape evolution can be studied. New zircon and apatite fission track ages together with all available data enable to identify Alpine low-thermal phases of the Variscan crystalline basements. The Gemeric Unit, an upper most thick-skinned thrust sheet of the orogen inner part, cooled from depth levels of ~10 up to 2.5 km (temperature interval of ~250–60°C) about ~88–64 Ma ago, after the collapse of the overlying Meliata-Turňa-Silica Mesozoic accretionary prism. The middle and lower thick-skinned thrust sheets, so-called Veporic and Tatric units, cooled from the depths of ~10 up to 2.5 km about ~110–40 Ma ago. The process of exhumation was controlled by unroofing of footwall from beneath the Gemeric Unit and the Meliata-Turňa-Silica accretionary prism. The internal portion of the Tatric Unit was gradually exhumed to the depth less than ~2 km and some parts of the unit appeared at the erosional level and remained cold. However, this exhumation was replaced by the burial beneath the irregular in thickness Eocene to Lower Miocene (~45–20 Ma) strata that caused fully reheating of apatite single grain fission track ages in predominantly external part of the Tatric Unit close to the Pieniny Klippen Belt. According to apatite fission track data of ~21–8 Ma, the middle Miocene collision of Internal Western Carpathian orogen wedge with the European continental margin led to final exhumation of the most external horsts formed by the Tatric Unit ('Tatric core mountains'). Based on geomorphological markers, the final mountain morphology of the most external part of the Tatric Unit was formed since the Pliocene.

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Volcano-sedimentary sequences in the Carpathian orogenic system (Ukrainian/Romanian transborder zone) versus volcanogenic deposits in Alpine (Italy) and Caledonian orogens (Poland): similarities and differences

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The geological record of the Alpine belt preserves the whole Permian-Mesozoic history of the Tethys Ocean and constitutes the base for palaeogeographic-geodynamic reconstruction of this ocean. Pre-orogenic period of the Jurassic-Cretaceous deposits in the Carpathians (Ukrainian-Romanian transborder zone) and Permian-Mesozoic deposits in the Dolomite Mts. document perfectly a long oceanic history of the northern and central part of the Western Tethys.

The Ukrainian Carpathians form a connecting link between the West and East Carpathians, but the structure of this connection is disputable. Accumulation of the ancient accretionary prism, which turned into the Flysch Carpathian nappes – was caused by the subduction of the Carpathian Flysch Basin basement beneath both the ALCAPA and Tisza-Dacia terranes. Outer Carpathian Flysch is divided into inner and outer flysch nappes. Inner Flysch Nappes of the Outer Eastern Carpathians (Fore-Marmarosh flysch prism) was formed in the front of Tisza-Dacia terrane during the Cretaceous-Paleogene times. The Kamyanyi (Kaminnyi) Potik, Rakhiv and Burkut suture units (Transcarpathian Ukraine) were developed in the frontal part of the Marmarosh basement nappes (Crystalline Massif) of the Central East Carpathians and correspond to the Outer Dacides-Severinides. Volcano-sedimentary complex of the Kamyanyi Potik Unit (Chyvchynian Mountains) is represented by: basalts and volcanic breccias, debris-flows and volcano-sedimentary breccias (with olistoliths of the limestones and basalts) within volcanic/tuffitic matrix and coral limestones with basalt fragments and pyroclastic intercalations, and thin-bedded micritic limestones with cherts interbedded by coarse/fine-grained calcareous pyroclastic turbidites (flysch). These associations were formed in the Early Cretaceous (Berriasian) times generating several different parts of the Outer Dacides-Severinides Carpathian basin. These facies have continual transition from very proximal type of debris flows through flysch-type facies of coarse- and fine-grained pyroclastic turbidites up to flow of massive basaltic pillow lavas on the other side in our reconstruction. The present stage of investigations provide arguments that the volcanogenic formation of the Chyvchynian Mts was formed on the presumable oceanic crust and can be attributed to the Fore-Marmarosh suture zone.

On the other hand, the Triassic units in the Dolomite Mts, are tripartite, from Werfen-type clastic-carbonate Early Triassic units, through Mid-Triassic carbonate platforms with volcanogenic-carbonate deposits up to Late Triassic prograding and aggrading carbonate platforms. The Late Anisian–Ladinian Magmatic Cycle in this region, which had produced large amounts of volcano-sedimentary sequences, is a very well documented geodynamic event in the history of the Dolomites and, moreover, of the Alps. Our preliminary recognition of these deposits/units in several places in the Dolomites (syn-volcanic subaqueous deposits – pillow lavas, pyroclastic density current deposits, lahar deposits – and post-volcanic subaqueous deposits – volcanoclastic mass flow deposits) indicates absolutely unique chance to reconstruct these spectacular volcanogenic event(s) and especially in their geodynamic and geotectonic regimes, which are the base to wider palaeogeographical reconstruction of this part of the Western Tethys. Our comparative studies between Carpathians and Dolomites indicate very similar, almost identical, volcanogenic-sedimentary sequences. Such comparative studies, the most probably of syn-rift in origin sequences, analyzed in different, independent both in space and time selected parts of the Western Tethys, could help to understand similar geodynamic/geotectonic regimes in separated parts of the Tethys Ocean.

Finally, we can compare these Mesozoic Alpine volcanogenic units, both from sedimentological and geodynamical point of view, with some Caledonian examples from southern Poland (Sudety Mts and Holy Cross Mts). In the Sudety Mts whole Early and Middle Cambrian history of the so-called Stronie basin (Stronie Formation) indicate more similarities than differences, although all rocks of this formation were strongly metamorphosed [they are represented now by: amphibolites with marbles (as olistoliths?), mica schists/metapelites, mafic metavolcanogenic rocks, metabasaltic pillow lavas etc.]. On the other hand, the Late Silurian (Ludlovian) pyroclastic and greywacke flysch-type deposits in the Holy Cross Mts (so-called the Prągowiec, Niewachlów and Wydryszów beds) indicate strong volcanic activity in this part of the Iapetus Ocean as well, during syn-orogenic episode of this ocean history.

In conclusion, we would like to suggest, that such type of volcanogenic and sedimentary consortium usually occur together in several oceans independently in space and time, both in such old as Palaeozoic and younger as Mesozoic ones, but geotectonic/geodynamic regimes have probably been very similar.

Occurrence of brecciated crystalline carbonate in association with deep-marine metamorphosed sediments of the Turnaic Unit

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In the Revúcka vrchovina highland, north of Hrušovo village (N 48°31’12,5”; E20°02’55,9”) about 15 km north of Rimavská Sobota town, condensed horizon of metamorphosed carbonate breccia and deep-marine sediments of the Turnaic Unit with the thickness of about 18 m occurs. Stratigraphically, the rocks lie directly on the Honce Limestone (Anisian) and upper limit of this formation is restricted by rauhwacke.

The base of the study horizon is formed by brecciated crystalline carbonate and clasts of predominantly fine-grained recrystallized limestone with the clast size up to 4 cm. Therein rarely alochems and uniserial foraminifera (Nodosaria sp.) without any further stratigraphic importance. Breccia gradually pass to finer grained layers. Matrix is formed by submicroscopic detritic redeposited dolomite (< 25 µm) which is cemented by Fe-Mn oxides and calcareous mud. During diagenesis and metamorphosis of dolomite a substitution of Mn^{2+} for Mg^{2+} occurred which resulted in the formation of zonal carbonates. The cores are formed by dolomite relics that are flanked by Mn-Ca-Mg carbonate and the rims are composed of Mn calcite. In the matrix (formerly a very fine-grained cement) the paragenesis of greenschist facies metamorphosis is presented with albite, quartz, chlorite, biotite, sericite, Fe and Mn oxides ± apatite and ± monazite mineral association.

A principal part of the study horizon consists of very fine-grained (below 25 µm) macroscopically red-brownish metamorphosed deep-marine sediments very similar to radiolarite. The original major components of deep marine sediments were: *(a)* – calcareous ooze; *(b)* – siliciclastics (predominantly quartz, mica, kaolinite, zeolite, and occasionally also zircon) which represent formerly heavily weathered pyroclastic (ash) material from acid/intermediate rocks; *(c)* – Fe and Mn oxides. These main constituent alternate in a different quantitative ratio and in a different thickness of sedimentary layers. Toward the upper strata siliciclastic material in sediments increasing. A part of the study horizon is composed of grey to black graphitic-muscovite-sericitic schist with intercalation of kaolinite and analcime which were metamorphosed to albite. Such an association of deep-marine sediments is typical for the sedimentary environment at a continental rise.

We suppose that breccia is related to the increased tectonic activity during the Pelsonian riffing and opening of the Meliata Ocean (synrift sedimentary breccia?). The sedimentary record reflects a chaotic deposition of clasts of varying size and composition up to very fine-grained deep-marine sediments that subsequently underwent lithification, diagenesis, and metamorphosis under the greenschist facies condition.

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High-diversity chitinoidellid associations from the West Balkan (Bulgaria) correlated with their record in the Western Carpathians

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Borza (1969) firstly documented diverse chitinoidellids from the West Carpathians in Slovakia. Later Pop (1997, 1998a), Reháková (2002) and Sallouhi et al. (2011) introduced additional genera and species belonging to the Family Chitinoidellidae Trejo, 1973. Then these highly diverse associations were also reported from Morocco (Benzaggagh et al., 2010).

The biostratigraphic significance of chitinoidellid diversity and vast geographical distribution is related to direct calibration of chitinoidellid zonations and bioevents to calcareous nannofossils and calcareous dinocysts in the Tithonian, as well as with magnetostratigraphy. Thus, the base of Chitinoidella boneti Subzone correlates quite well with Microcanthum ammonite zone, i.e with the Lower/Upper Tithonian boundary.

Recent chitinoidellid studies in Tithonian pelagic and hemipelagic carbonates of the West Balkan tectonic unit in Bulgaria revealed high-diversity chitinoidellid association comparable with the extensive results in the West Carpathians in Slovakia (see Petrova, 2011, Lakova & Petrova, 2013). All known genera from the West and South Carpathians and Tunisia occur in the West Balkan of Bulgaria*: Longicollaria*, *Daciella*, *Dobeniella*, *Borziella*, *Carpathella*, *Almajella*, *Popiella*, *Chitinoidella* where they were studied in Gintsi, Komshtitsa, Barlya and Dragovishtitsa sections. The Dobeni Subzone includes the species *Longicalaria dobeni*, *Daciella svinitensis*, *D. almajica*, *D. danubica*, *Dobeniella tithonica*, *D. colomi*, *Borziella slovenica*, *Carpathella rumanica* and *Popiella oblongata*. The Boneti Subzone is characterized by larger-sized species, such as *Chitinoidella boneti*, *Ch. elongata*, *Ch. popi*, *Ch. hegarati*, *Dobeniella cubensis*, *D. bermudezi*, *Longicollaria insueta*, *Almajella cristobalensis*.

The largely accepted pre-Crassicollaria Tithonian chitinoidellid zonation consisting of Dobeni and Boneti subzones (Grandesso, 1977; Reháková & Michalík 1997, Pop, 1998b) is pretty applicaple to the chitinoidellid vertical occurrence in Bulgaria. Grün & Blau (1997), however, proposed a bit “approved” zonation of the same part of Tithonian additing the Bermudezi Subzone above the Boneti Subzone. One can see that *Dobeniella bermudezi* FO is at different levels of Boneti Subzone, but we consider two allocated chitinoidellid subzones as sufficient. It is a rare species which makes not sence in terms of direct correlation with magnetic chrons.

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Carbon isotope record on the Triassic-Jurassic boundary

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Measurement of carbon isotope composition is widely applied to provide information on the carbonate deposition and/or on global C cycle perturbation.The uppermost Triassic is marked by a pronounced negative excursion near the system boundary that is linked to significant biotic turnover. Causes of the δ13C excursions at the Triassic-Jurassic (T/J) systems boundary remain under investigation. Outgassing during volcanic activity, changes in productivity, greenhouse climate and ocean anoxia, and seafloor methane releases – all have been suggested as mechanisms explaining perturbed global C cycle and accelerated biotic extinction. Negative excursions in the C isotope curves in the Veľká Furkaska and the Kardolina sections in the Tatra Mts (Michalík et al., 2007, 2010, 2013, Lintnerová et al., 2013) were documented and used to spatial correlation. All data - carbon isotope ($\delta^{13}C_{carb}$, $\delta^{13}C_{org}$), oxygen ($\delta^{18}O_{carb}$) and strontium isotope ($\delta^{87}Sr_{carb}$) ratios, total organic carbon (C_{org}) and other geochemical and mineralogical results from sections studied have been revised. Accumulation of C_{org} (0.5 to 3 %) and high negative $\delta^{13}C$ excursions ($\delta^{13}C_{org}$ in interval from -20 to -30 ‰VPDB) locate T/J boundary interval and enable correlation with the Kuhjoch stratotype section (Ruhl et al., 2010). The Kardolina section, where integrated stratigraphic data collected in the last decade suggest tight correlation of benthic biota extinction with the C- cycle perturbation, could be of a special importance. Lithology of both the Kardolina and the Veľká Furkaska sections (mainly stop of carbonate sedimentation on the T/J boundary) indicates decrease in carbonate production due to high CO_2 saturation and acidity rise in the water column. Greenhouse monsoonal climate accelerated weathering of the emerged land rocks, transport of terrigeneous matter and carbonate production demise in adjacent marine basins. The terrigenous input to the basin also suggested character of the $^{87}Sr/^{86}Sr$ curve (data), palynological data and documented the (enriched) kaolinite weathering crust in the High Tatra Mts area (Lintnerová et al., 2013).

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Pannonian molluscs and their localities in the Gerecse Hills, Transdanubian Range

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Gerecse Hills, representing the northeasternmost part of the Mesozoic-Paleogene Transdanubian Range, is surrounded by an Upper Miocene-Pliocene (Pannonian) lacustrine to fluvial sedimentary cover to the west and to the north, i.e. towards the Danube–Kisalföld Basin of Slovakia and Hungary. The oldest reports on fossil molluscs from these sediments were published almost 150 years ago. A systematic mapping of the area by the geologists of the Geological and Geophysical Institute of Hungary between 2010 and 2014 revealed a number of natural and artificial outcrops of fossiliferous Lake Pannon sediments.

The Upper Miocene deposits near the Gerecse Hills comprise the Szák and Újfalu Formations, each having its characteristic mollusc fauna. The Szák Fm is exposed in brickyard clay pits within the town of Tata, in the western foreland of the Gerecse Hills. This formation consists of homogeneous, bioturbated, bluish-grey clay and argillaceous marl, deposited from suspension in quiet offshore conditions. Characteristic mollusc species include large dreissenids (*Congeria czjzeki, C. partschi, C. ungulacaprae*), a wide variety of cockles (*Lymnocardium tegulatum, L. triangulatocostatum, L. majeri, L. apertum, L.* aff. *brunnense, L.* aff. *rogenhoferi, „Pontalmyra" otiophora, Paradacna* sp.), and deep-water-adapted pulmonate snails (*Valenciennius reussi, Radix kobelti, Gyraulus* sp.). This fauna lived in a nutrient-rich and well-oxygenated sublittoral environment, at a few tens of meters water depth.

A highly atypical facies was discovered in one of the northern valleys of the Gerecse Hills (Ivánhalála, Dunaszentmiklós). A poorly-sorted conglomerate consisting of cobble- and boulder-sized clasts with sandy-clayey matrix overlies directly the Cretaceous basement. The imbrication of the clasts indicates N to S transport direction i.e. from the open lake towards the dry land. The matrix contains abundant molluscs fauna, including articulated valves of *Congeria simulans trurgida, Dreissenomya arcuata*, and ?*Paradacna* sp. This sediment package is suspected to have been deposited by a tsunami on the rocky coast of Lake Pannon.

The Újfalu Fm is exposed in the northern valleys of the Gerecse Hills (see Bartha et al., *this volume*). This formation consists of few meter thick, shallowing up sedimentary cycles, starting with sublittoral clays (formed below wave base on the prodelta) and ending with littoral sands (deposited on lower shoreface, deltafront or delta plain channels) or even paludal huminitic clays (delta plain marshes or abandoned channel fills). Molluscs reflect this cyclicity and the overall fauna is very different from that of the Szák Formation. The dreissenids are more diverse (*Congeria ungulacaprae, C.* cf. *balatonica, C. simulans turgida, C. czjzeki, Dreissena auricularis, Dreissena sp., Dreissenomya arcuata, Dreissenomya* sp.), and in addition to the rich cockle fauna, dominated by *Lymncoardium penslii* and including *L. ponticum, L. vicinum, L. majeri, Euxinicardium schreteri, Caladacna steindachneri* and *Paradacna wurmbi,* the freshwater-origin *Unio mihanovici* and plant-grazing prosobranch gastropods like *Theodoxus radmanesti, Melanopsis caryota, M. pygmaea, M. decollata, M. sturi, M, kupensis,* and *Viviparus* sp. are common. They indicate shallow water within the photic zone and strong influence of freshwater in accord with the delta environment.

Although superposition of the Szák and Újfalu Fms in this area is well known from boreholes, a direct contact of the two units was not observed in outcrops. An apparently„reverse" succession was recorded in the central part of the Gerecse Hills, at 375 m elevation (Vályúskút, Tardos). In this sequence, lignite-bearing black clay and variegated clays with freshwater molluscs (*Theodoxus radmanesti, Melanopsis sturi sturi, M. sturi tortispina,* Planorbidae sp., Unionidae sp., *Valvata oecsensis, V. obtusaeformis, Oxychilus* sp.) are overlain by clay and silt with *Congeria czjzeki, Lymnocardium majeri,* and other brackish species. This superposition indicates flooding of paludal areas, deepening, and development of intense connection with the sublittoral offshore environment of Lake Pannon.

The Pannonian sediments and their fossil molluscs in the Gerecse hills reflect gradual flooding of the Mesozoic block, locally either producing a transgressive lag (Tata) or a paludal-lacustrine transitional sequence (Vályúskút) before the sublittoral clay with *Congeria czjzeki* (Szák Fm) draped probably much of the recent hills. Sedimentary infilling up to lake level took place in several cycles represented by deltaic parasequences (Újfalu Fm), each displaying faunal changes from open lacustrine bivalve-dominated to paludal snail-dominated assemblages.

Biochronostratigraphic correlations suggest that the age of the entire Pannonian sequence in the Gerecse hills is between 9.7 and 8.7 Ma. Accordingly, reverse magnetic polarity in the lowermost 10 m interval of the Tata outcrop suggests correlation with C4Ar, restricting the age of the flooding of the Gerecse hills to the 9.6-9.1 Ma interval.

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Ditrupa-Nummulites transitional facies in the Eocene shallow-water carbonates of the Tatra Mountains (Poland) as an indicator of episodic mesophotication

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The Middle-Upper Eocene shallow water carbonates crop out along the northern margin of the Tatra Mountains in Poland. These deposits are unconformably overlying the older Mesozoic basement and pass upward into the Central Carpathian flysch. They represent a transgressive sequence, which is characterised by distinct facies variability, great units thickness and lateral facies changes which can be followed over a great distance.

Generally, the Eocene succession starts with conglomerates, which contain clasts of the Mesozoic rocks. The conglomerates are covered by littoral detritic carbonates of the Early Bartonian age, SBZ 17 according to the Shallow Benthic Zonation (Serra-Kiel et al., 1998). Although these deposits show a distinct facies variations, usually they are extraclastic packstones with larger benthic foraminifera (LBF) as bioclasts. At the beginning of the succession, tests of *Nummulites brongniarti* d'Archiac & Heim prevail among bioclasts, upward nummulitid tests and tube worms (*Ditrupa-Nummulites* facies) are dominant, while at the end of this part of succession (*Nummulites* bank facies) the robust tests of *Nummulites perforatus* (Monfort) are the most abundant. These deposits are covered by *Discocyclina*-bearing facies (*Nummulites-Discocyclina* bioclastic packstone and *Discocyclina* rudstone), which are overlain by glauconitic marls with planktonic foraminifera. The uppermost part of the succession is formed by organodetritic limestones, flora beds limestones and upper conglomerates, attributed to the Priabonian. The carbonates are succeeded by a thick complex of the Oligocene turbiditic deposits.

The studied *Ditrupa-Nummulites* facies represent bioclastic wackestones, with great diversity of macro- and microfossils. The assemblage contains tubes of serpulid polychaete of *Ditrupa*, fragments of thick-walled bivalve shells (*Ostrea* sp., *Pecten* sp.) and LBF (flat tests of *Nummulites puschi* d'Archiac, and robust and spherical tests of *Nummulites perforatus*). The contact imbrications and linear accumulation of foraminiferal tests are the most conspicuous textural characteristics. Tests of nummulitids bear evidence of physical and biological alternations, like being encrusted by foraminifera (*Miniacina* sp., *Haddonia* sp.) or having truncated test's poles or showing exfoliated outer surface of the youngest whorl. The defined taphonomic category 1 *sensu* Beavington-Penney (2004) supports seawards transport of LBF tests over a short distance either by the action of storm-driven currents, internal waves or sediment gravity flows.

Abundance of LBF suggests shallow, warm and well illuminated, oligophotic waters with low nutrient level (Hottinger, 1983). The episodic great occurrence of semi-infaunal ditrupas (suspensions-feeders), suggests a short period of an increasing organic influx to the sea-bottom. The co-occurrences of LBF, ditrupas, ostreas, and ecrusting foraminifera may indicate somewhat dwindling light conditions, typical for meso-oligophotic conditions (Pomar et al., 2014). The distribution of facies implies that some environmental changes took place in depositional setting during the Middle–Late Eocene. The development of *Ditrupa-Nummulites* facies is a result of the influx of organic matter to the sea-bottom, indicating the local instability within studied sedimentary environment.

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Neo-Alpine evolution of the Inner Western Carpathians controlled by strike-slip faulting and block rotations

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Neo-Alpine tectonic evolution of the Carpathians has been described in many, more or less similar geodynamic models. All of them are constrained by knowledge concerning migration of active orogene front in time and space (from the west towards the east; Jiříček, 1979) as a result of oblique collision after the subduction of quasi-oceanic crust (Doglioni et al., 1991). Morpho-structure of the Western Carpathians was formed at the beginning of gradual occupation of foreland embayment by orogene – by units consolidated during the Meso-Alpine processes. From paleogeographic restorations follows that the Inner Carpathians, disintegrated to several segments were during the Neo-Alpine evolution removed to a long distances and even rotated. The Western Carpathians crustal segments invasion into the foreland embayment created by weak crust was driven by processes of its subduction and controlled by strike-slip tectonics, volcanic activity and block rotations. While in the front of north to east propagating Inner Western Carpathians were sediments of the Magura basin scrabbled to an accretionary wedge, the rigid crust of the Inner Carpathians was broken to independently moving blocks allowing to fill oceanic embayment of complex shape. Herein the attention is focused to the evolution of the western, Slovakian part of Carpathians. The kinematic model of Inner Western Carpathians propagation is proposed, using as an important block boundaries known map-scale faults, shear zones respectively, where the dominant role play strike-slips (Marko et al., 2014). The Neo-Alpine evolution is described by succession of several tectonic events. Their dating (in time span ca 22 Ma – recent) is based on superposition of structures, e.g. fault offsets, taking into account geochronological and other relevant data as well. The best documented are the latest stages of tectonic evolution, when the blocks were close to their recent position. Description of the Early stages of tectonic evolution faces to usual palinspastic problems with correct restoration of position of structures and terranes in current geographic coordinates. Magnitudes of block movements use to be in geodynamic models only roughly estimated. In herein submitted model, as a criterion to measure exact magnitude of shift and shape of movement trajectory of eastwardly extruding crustal segment was applied a concept of migration of volcanic products. It is expected, that all volcanic apparates (Vepor, Poľana, Javorie, Štiavnica) had the the same source, fixed and deep seated magmatic chamber (hot spot). This approach led to calculation of 85 km east-north-eastward shift of the Inner Western Carpathians crustal segment during the Badenian-Sarmatian. A model of strike-slip controlled eastward extrusion of the Western Carpathians crustal segment explains different tectonic style of the western and eastern part of the Pieniny Klippen Belt, isostatic unbalance of the Vienna basin, origin and situation of external core mountains belt, Neo-Alpine passivity of the Muráň fault and more.

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Time relation of the internal deformations and the large scale rotations of the Magura and Silesian rootless nappes during the Cenozoic as manifested in the paleomagnetic declinations and in the magnetic fabrics

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The paleomagnetic and magnetic anisotropy results interpreted in this presentation in terms of tectonics were obtained on the fine grained members of the flysch. A common feature of all sampled sediments is the low susceptibility (in the range of 10^{-4} SI or lower), weak remanence and the presence of pyrite. AMS measurements point to a relatively strong and probably repeated deformation in the Magura nappe, and the remanence is of-post-folding age. The AMS of the Silesian nappe indicate weaker deformation, the orientations of the AMS lineations reflect compression. The remanence is of pre-folding age in the western and central segments of the Silesian nappe while some localities in the eastern segment have pre-folding, others post-folding magnetization. The rotation suggested by the paleomagnetic declinations of pre and postfolding remanences are about 50° in the CCW sense. These observations suggest that:

1. Magura and Silesian nappe stacks rotated together with the PKB and the northern part of ALCAPA microplate.

2. There was no change in general orientation of the Western Carpathian front from the late Cretaceous till the end of the deposition of the Paleogene (early Miocene) flysch of the Magura and Silesian units.

3. As the magnetizations of prefolding and postfolding ages suggest similar CCW rotation, we can conclude that the compressional deformation resulting in AMS lineations and in folds took place before the general CCW rotation.

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Parental rocks of Carpathian keuper sandstone clastics as inferred from heavy mineral spectra and monazite dating (Malá Fatra Mts., Slovakia)

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Carpathian Keuper Formation occurs in three West Carpathian units: Fatric, Tatric and in restricted extent also in the Pieniny Klippen Belt. Its facies variability is obvious mainly in the Krížna Nappe (Fatric). The Carpathian Keuper Formation consists of pale-grey, fine-grained dolomite beds (rarely with silicite concretions), beds of carbonatic breccias, variegated claystones, aleuroliths and sandstones (litharenites, subarcoses and quartz arenites). The sandstones are generally dominated by quartz; less common are feldspar grains and lithoclasts (mainly carbonates and claystone, rarely also lithoclasts of plutonic rocks). Subject of our research was represented by sandstones occurring in the Kriváň part of the malá Fatra Mts., from the localities situated between the Párnica and Zázrivá villages (600 m SE and 1600 m SSE from the Čierťaže elevation point), on the slopes of Tržinovo Valley. On the top of the studied formation in the Krížna Nappe rests Rhaetian Fatra Formation. Therefore, based on superposition, the Carpathian Keuper Formation is ranked to the Norian. The lower boundary of the formation is not clearly dated because of the absence of stratigraphically important fossils. The Carpathian Keuper sandstones are fine- to medium-grained, dominated by monocrystalline, subangular to angular quartz and quartz with undulatory extinction. Rarely, polycrystalline quartz grains appear, too. The sandstones also contain sericitized K-feldspars, plagioclases, carbonates, (dolomite, calcite), micas, clay minerals and heavy minerals (HM). HM are generally dispersed within the sandstones, but rarely they can form laminated accumulations. From HM, rutile, apatite, zircon, monazite-(Ce), xenotime-(Y), Ti-magnetite, ilmenite and tourmaline were identified. The HM spectrum indicates that the source area was dominated by acidic plutonic rocks (granitoids).

In the HM laminae, oval monazite grains are numerous (up to 50-100 µm in size). The monazites were analyzed by EPMA microprobe analyser. Results of the chemical (EMPA) U-Th-Pb dating of monazite-(Ce) from (22 analyses) indicates quite an uniform age 306±3.2 Ma (ages calculated by statistical method of Montel et. al., 1996). The HM spectrum, together with monazite dating indicate that the source area of the detritic material might be presented by the Moldanubian Zone of the Bohemian Massif (Upper Carboniferous to Lower Permian Plutonic Suite).

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How our planet fate is governed by "stars" - geological record of cosmic impacts on terrestrial processes

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Material cycling on the Earth surface is controlled by extraterrestrial physical forces – the effect of planetary motion vector, the gravity effect of the moon and nearby planets, and energy input fluctuations from our nearest star - the Sun. Their recognition in the past supports clarification of both the astronomical time scale and more detailed knowledge on forming process of the Earth and of the life on it.

The lithosphere, which is produced by the constant interplay of internal and external forces acting on its surface, recorded billion years long history of our planet. Tens of thousands meters thick sediments represent the record of geological time. It is not enough to read this record to follow the development of our planet, as our stone archive is stirred, containing many often unknown data, records are incomplete, and even a large parts of them are totally absent, so instead of a solid chronicle, the nature offers a lot of decayed, incomplete pages, often in mixed order.

Ancient interpretation of rock massifs led to a conclusion that the surface of continents is mutable, that the past still constantly undergoing radical changes. A detailed study of rocks and their arrangement come to knowledge of periodic repetitions of individual texture and structural composition of sediments. Thus, the formation of sediments involved a periodic repetition of environmental factors.

Hutton (1788) considered periodic uplift, erosion and accumulation of sediments in basins. Goethe assumed that the Earth climate is undergoing through changes and that the Europe overcame through era of a great cold in the geological past. Similarly, Agassiz (1840) argued that moraines in Alpine valleys have been covered by massive ice sheets (such as the Greenland of today). MacLaren (1842) recognized a link between glaciation and sea level fluctuation. Adhémar (1842) supposed that glaciations are triggered by a precession of the Earth rotation axis. Croll (1889) related eccentricity of the Earth's orbit with the precession of the Earth rotation axis and with resulting length of seasons. Based on carbonate content changes in Cretaceous hemipelagites from Colorado, Gilbert (1895) found that irregularities in the planet circulation may affect the amount of solar energy adopted by its surface. Penck and Bruckner (1929) suggested that four separate interglacial fluctuations of temperature took place during the Quaternary glaciation. Bradley (1929) recognized repetitions corresponding to precession cycles in oil shales from the Green River Valley of western USA.

Complex and increasingly recognized interpretation of astronomical factors ruling our planet has been given by Serbian mathematician Milutin Milankovitch (1941). It justifies climate impacts on the planet's surface through changing insolation and through mechanisms governing the energy transition through the atmosphere (Kneźević 2010). Secular eccentricity, precession and inclination changes of the Earth's orbit, of its rotation axis are the most important astronomical mechanisms that stimulate insolation changes. The eccentricity of Earth circulation over time changes due to gravitational pull of other planets. Changes are quasi-periodic, with different amplitude and events in different time slices.

From the beginning, the Milankovitch theory met skepticism of practical geologists. Later, Emiliano (1955) stated frequency of the isotopic record in Pleistocene marine sediments. Then, Hays et al. (1976) accepted the term “Milankovitch cycles” (with a frequency of 104 to 105 years) and its use as a tool for the interpretation of orbital periods.

The sun is the dominant factor in Earth's climate system: These cycles are driven by periodic changes of solar radiation. The intensity of sunspots fluctuates in short-term (11 years Schwabe- and 22 years Hale-) solar cycles that modulate ten- or/and millennial climate changes. Their geological record, however, is rare and limited by a special preservation. Formation of microlaminated sediment has been controlled by the solar activity cycles which ruled rates of microbial growth, biomass production, rainfall, temperature, redox, etc., leading to variations in elements (Ca, Fe, Br ...) concentrations during deposition and early diagenesis (Tang et al., 2014).

Rotational movement of the Earth's axis is changing in precessional cycles with a periodicity of 23.7 ky (thousands of years). Thus, rotational axis describes a cone with a top angle of 23.44°. If the precession cone angle changes to 54 °, average tropical temperatures will not change dramatically, but the climate in polar regions gets warmer (like 99 My ago during Mid Cretaceous; Michalík, 1999). The actual precession changes were defined already in Hipparchos sky map (150 y B.C). Copernicus (1543) correlated these changes with changing position of the Earth rotational axis. Change of its inclination to ecliptics (from 23.5° by about 3°) at intervals of about 41 (39.7 to 56.3) ka causes obliquity cycles. Sha (2015) came to the conclusion that higher latitudes of the Earth before 200 My (during Triassic / Jurassic interface) were influenced by orbital cyclicity, managed by obliquity (40 ka), while the obliquity record at lower latitudes is indistinct.

Quaternary ice ages were associated with eccentric cycles (interference with the Jupiter in periods of 100 ka and 405 ky). Eccentricity variation affects the distance to the Sun: the amount of solar radiation reaching the Earth is inversely proportional to the square of this distance. Thus, astronomically induced signal is recorded in continental and marine sediments in cycles that correspond with climatic changes. Martinez and Dera (2013) concluded that Early Jurassic transgressions and regressions and resulting productivity changes may reflect changes in sea-level driven eccentric cycles. The same authors

(Martinez et al., 2015) identified Early Cretaceous eccentric cycles (405 ky) in the Vocontian-Subbetic basins.

Depending on the degree of sensitivity to global climate turnover in a given period of time, each component is capable to cause significant climate change. Global seasonality is low in times of low obliquity (when the planet's rotational axis is almost perpendicular to the ecliptic plane), called as the “climatic optimum”, when long eccentric cycles are recorded in sediments. Conversely, when beveling the Earth's axis, temperature gradients and increasing seasonality are marked, polar regions became cooler. During this time, called as the “climate minimum”, short-term periodicities record is dominating. If a continent is in a polar position, equatorial oceanic current is blocked and seaway for circumpolar currents opens, atmosphere is depleted of greenhouse gases, solar activity is reduced starting the albedo effect, a way to glaciation is open.

Global oceanic/atmospheric currents that control humidity, rainfall and temperature are the main control element of the climatic regime. Atmospheric current system consists of Hadley, Ferrel and polar jet cells. Where circulation given by these three cells collides with the Earth's surface, constant atmospheric currents (the trade winds) will stabilize. Atmospheric upwelling is characterized by higher humidity caused by adiabatic phenomena that control air saturation. Regional atmospheric circulation is triggered by different heat capacity of land and sea-level. Changed position of circulating cells during seasons leads to seasonal flow changes (monsoons). Sea winds bring moisture that condenses in lifting flow over the coast. Therefore, windward slopes tend to be more humid and the climate of eastern and western coasts can be diametrically different.

Hedley and Ferrel cells interface runs between 15° and 35° latitude, where hot deserts with high evaporation form during climate minimum (when the Earth's axis is oblique to the ecliptics). Monsoon belts are few moving during seasons, limiting the input of precipitations into the area. Hadley/Ferrel downwelling zone moves to the poles and desert zone shifts to 35-40 during climate maximum (reduction of the axis tilt). The monsoon cycle is more efficient and humidity is rising in the zone between 10°-35°. Upwelling arms of both Ferrel and Polar cells shift to 70°, enabling the origin of non-glacial cycles (Miall, 1997). De Boer and Smith (1994) stressed the effectivity of precessional cycles at low latitudes, modulated by Earth's orbit eccentricity. They shift caloric equator and borders of climatic zones. Orbital changes affect relative length of seasons, winter and summer contrasts, and monsoon intensity in mid-latitudes. At high latitudes, the effect of changing obliquity is more evident.

Milankovitch major claim to fame was to demonstrate the phase difference on basis of laborious and lengthy time slices calculations (today they can be mastered relatively easy by standard computer). Calculation of orbital changes (based on interactions between sediment, climate and stimulated orbital insolation) are now combined with the geometry measuring cycles, sedimentological assays, mineralogy of clays, analyzing the C and O isotopes and spectrum of organic residues. Exceptionally well-preserved series of astronomical signals gave rise to a method known as "cyclostratigraphy" and build the model of the solar system dynamics in a continuous sequence called the "astronomical time scale" (Martinez et al., 2015).

The use of cyclostratigraphy and compilation of astronomical time scale unprecedently specified dating of geological boundaries, especially of the Cenozoic and Mesozoic era (from the existing uncertainty of ~ 0.5 My to ~ 40 to ~ 20,000 years). Neogene astronomical time scale has been prepared with an accuracy of 0.02 My. The resolution towards the Oligocene (prior to 30 My) decreased to 0.04 ka and Eocene - Paleocene strata (50-60 My ago) to 100,000 ka. So far, development of dating is limited by uncertainties related to the diffusion of the solar system (Hinnow and Ogg, 2007). Tolerance of the Mesozoic astronomical time scale is currently about 0.4 - 0.5 My, that is roughly equivalent to the accuracy of biostratigraphic method. Paleozoic cyclostratigraphy, over 250 My provides sufficient appropriate data, but relating astronomical time scale is hampered by the lack of astrodynamical model of this period, which is quite different (e.g., different duration of precession and obliquity). A development of settled astronomical time tends towards improved distinctiveness of the geological time scale at least an order of magnitude. As noted by Hinnow and Ogg (2007), the solution of detailed chronically thorny problems associated with lithospheric plate tectonics, global geochemical cycles, paleoclimate, sea level changes, or biotic processes depends on it.

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Diversity of animal trace assemblages in recent lowland river sediments (Dunajec River, SE Poland)

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In the course of evolution, fauna inhabiting river banks has developed adaptations helping it to colonize and survive in this dynamic environment. One of them is a specific distribution of animals in the vertical profile of bank deposits, that reflects their susceptibility for disturbances. The studied fauna inhabits sandy to muddy, overbank deposits of a well-drained, non-vegetated or partly vegetated and rarely flooded alluvial plain of the Dunajec River (Sandomierz Basin, southern Poland). The most frequently observed animals in the alluvium include four species of ground beetles (*Carabidae*), European mole (*Talpa europaea*), common earthworm (*Lumbricus terrestris*), and solitary bees (*Ammophila*).

The abundance and distribution of the studied burrows within the overbank deposits of the Dunajec River reflect sensitivity of particular animals to disturbances and the position of ground water table. The frequency of *Bembidion quadrimaculatum* burrows ranges from 5 to 100 per m^2. *B. stephensii* burrows occurred less frequently (up to 5 per m^2) and were observed farther from the contemporary river bank. The burrows of *Harpalus rufipes* and *Melolontha melolontha* were most scarce (less than 1 per m^2) and occurred highest above water table.

The *Melolontha melolontha* burrows occur in the most distal places and are limited to the elevated Pleistocene terrace. As this is a breeding chamber, larvae need to burrow deeply during all phases of ontogenetic development, also during winter, when the ground can be frozen down to 1 m depth. Moreover, in this part of the alluvial plain, soils are more mature, with more variable vegetation and hence food availability related to roots (Hembree & Nadon, 2011). The burrows of *Harpalus rufipes* occupy an intermediate position. This fits well with the herbivorous activity of the tracemaker, as vegetation is better developed at some distance from the river channel. The bembidionid burrows are present on the contemporary floodplain, but the burrows of *Bembidion stephensii* occupy more distal position, while those of *Bembidion quadrimaculatum* are located closer to the river. As very mobile carnivores, bembidionids are better adapted to stress conditions, which increase towards the river channel.

Water-level fluctuations are the main factor disturbing river-bank burrowing biota and controlling their diversity and abundance (Buatois & Mángano, 2004). Changes in the river bank ecosystem of the Dunajec, caused by summer and winter floods, were examined during the last three years. The highest diversity of the river bank fauna, especially beetles, occurs under a moderate level of disturbances. With a low intensity of disturbances, large, long-living species dominate, whereas with high-intensity disturbances, small, short-living forms prevail (Fernandes *et al.*, 2002). A large majority of the small organisms inhabiting the alluvial deposits are not adapted to survive floods. On the contrary, European mole and bank swallow (*Riparia riparia*) build their burrows beyond the range of flood waters. Burrows of the latter are long enough to enable nesting during the progressive erosion of the banks. However, a major flood can completely modify river banks, making them unsuitable for quick re-colonisation until the next year.

Earthworms and solitary bees occur in the whole profile of the overbank deposits, but they are the most susceptible to flooding, so their populations can be almost completely destroyed in the case of a major flood. On the other hand, they have the greatest re-colonisation potential among the Dunajec River bank animals. This adaptation allows them to colonize the parts of the alluvial plain nearest to the river channel and be the first animals colonizing sediment after flooding.

Most of the organisms inhabiting river banks are well equipped to survive unfavourable environmental impact. Rapid changes in alluvial environment increase interspecies competition and stimulate growth of biodiversity. Major flooding can completely destroy most of the river animal assemblies but after this event, species richness increasing in freshly deposited sediment more rapidly than before the flood.

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The Early Miocene residual Magura flysch basin at the front of the Central Carpathians and its paleogeographic implications (Magura Nappe, Poland)

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There is a common understanding that the closing of the Outer Carpathian basin took place gradually in accordance with traditional Alpine model from internides to externides, i.e. from the south to the north (Książkiewicz, 1977; Birkenmajer, 1986, 1988; Oszczypko, 1992, 2006; Golonka et al., 2000). However, the discovery of the Oligo/Miocene sediments of the Magura Nappe near Stara Lubowna (Oszczypko-Clowes et al., 2005) and near Szczawnica, at the front of the Pieniny Klippen Belt (PKB) (Oszczypko & Oszczypko-Clowes, 2010, 2014) requires a revision of existing views.

In 1992 Cieszkowski described the Middle Miocene deposits of the Magura Succession in the Stare Bystre and Rogoźnik sections (Podhale region). Simultaneously more or less the same deposits were drilled in the Nowy Targ PIG-1 borehole (Paul & Poprawa, 1992), at the northern boundary of the PKB. All of these st rata revealed multiple layers of reworked foraminifera and calcareous nannoplankton from the Cretaceous and Palaeogene ages (see Oszczypko-Clowes, 2012).

Similar results were achieved near Stara Ľubovňa (East Slovakia). In this area within the contact zone of the Magura Nappe and the Pieniny Klippen Belt, Stranik and Hanzlikova (1968) described the ”Kremna facies” (Paleocene to Early Eocene previously known as the ”Nordliche Granz Flysch Zone” (Uhlig, 1898). These deposits were redefined as the Kremna Fm. of the Early Miocene age (Oszczypko et al., 2005). The calcareous nannoplankton studies of this formation showed a predominance (60%) of reworked species, mainly of Middle-Late Eocene age, while the youngest species that were identified belonged to Early Miocene (NN1 and NN2 zones, see also Oszczypko-Clowes, 2012). During recent years the Kremna Formation was recognized also in the Krynica facies zone in the Muszyna and Jaworki areas (Oszczypko & Oszczypko-Clowes, 2010, 2014) as well as also in the “Magura Autochthonous Paleogene” in the tectonic windows of the PKB (Oszczypko & Oszczypko-Clowes, 2010; 2014, Oszczypko et al., 2010). These deposits up to 1000 m thick are strongly tectonized and sometimes can be regarded as to kind of the “broken formation”. These deposit are extended to the Eastern Slovakian sector of the Magura basin (Maťašovský & Andreyeva-Grigorovich, 2002).

During the Burdigalian at the front of the PKB and the Central Western Carpathians still existed synorogenic, residual Magura marine basin, which was at least 300-400 km long and up to-100 km wide (see also Kováč at al. 2016). This basin was supplied with detritic material from SE as well as from uplifted parts of the PKB and Magura Nappe.

The discovery of the Early Miocene flysch deposits of the Magura succession significantly modifies existing views on the structural evolution of the Outer Western Carpathians and Pieniny Klippen Belt.

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New views on the genesis of the carbon dioxide in the Polish Outer Carpathians

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In the Polish sector of the Magura Nappe have long been known and exploited carbonate mineral waters, saturated with carbon dioxide, known as the "shchava (szczawa)".

These waters are characterized by low mineralization and the content of free carbon dioxide by at least 1 g/dm^3. The total mineralization of these waters is formed by infiltration and circulation of atmospheric waters into the Magura flysch deposits (Oszczypko et al., 1981). Another factor which causes the increase in total mineralization of these waters is the dissolution of rocks involving aggressive, endogenous CO_2.

The origin of carbon dioxide in the "shchava" type of waters is still not clear. Traditionally it held the view that the CO_2 is of volcanic origin, associated with intrusions of the Miocene andesites, in the Szczawnica–Krościenko area, at the front of the Pieniny Klippen Belt (PKB) (see Świdziński, 1972; Birkenmajer, 1956; Rajchel, 2012 and references therein). This hypothesis is not confirmed by isotopic studies (e.g., Leśniak, 1998; Zuber and Grabczak, 1985; Oszczypko and Zuber, 2002), which suggested rather diagenetic or "metamorphic" origin of CO_2. An interesting view on the genesis of CO_2 in the Outer Carpathians expressed Nowak (1924, 1938), which tied them with the oxidation of hydrocarbons. Hydrocarbon chains, kerogen and bitumen are thermally degraded during catagenesis at about 50°C to 160°C. This process corresponds to the cracking stage (breaking of C–C bonds), which produces oil and thermogenic gas, also CO_2 (Tissot and Welte, 1978).

These waters occur mainly between the Dunajec and Poprad rivers in the Krynica facies zone of the Magura Nappe. The exception, are the mineral springs occurring in the Szczawa tectonic window, west of the Dunajec valley. This window belongs to the Grybów Unit and is composed predominantly of Late Eocene-Oligocene deposits, linked the Silesian and Magura successions. Characteristic feature of the Grybów Unit is the presence of dark deposits of bituminous shales, analogous to the Menilite Beds of the Silesian Succession. These deposits generally are considered as the source formations for generation of hydrocarbons in the Outer Western Carpathians (Curtis et al., 2004; Kotarba and Koltun, 2006; Wójcik-Tabol, 2015). The total organic carbon content of the Grybów Unit samples is 0.15–6.16 wt.%. The T_{max} values vary between 436 and 454°C. Kerogen is a mixture of type II and III that is prone to oil and oil/gas production.

The Grybów Unit is situated below the Magura Nappe at different depths, from about 250 m a.s.l. on the north to 2000 m– 5000 m b.s.l. along the boundary with PKB. At same time at the base of the Carpathian flysch over thrust south of the Rabka- Nowy Sącz line temperatures are greater than 150°C. Further south on line Szczawnica-Piwniczna-Krynica these values transgress 300°C.

Mineral composition of the Grybów Unit sediments includes quartz, calcite, dolomite, Na-rich plagioclase, muscovite and clay minerals distinctive on the XRD patterns of whole-rock samples. Share of smectite in mixed-layers I/S ranges from 10 to 30%, reflecting palaeotemperatures >165–140°C. The highest illitization was recognized in the Szczawa tectonic window that correspond with the pattern of temperature at the base of the Carpathian flysch over thrust mentioned above. In terms of chemical composition, samples of the Grybów Unit are depleted in major, minor and trace elements, with the exception of CaO. Some samples are enriched in Fe_2O_3 and MgO. In the samples, Nb/Ta and Zr/Hf ratios almost maintain UCC ratios of 13.33 and 36.42, respectively. Ratios of Y/Ho are about the UCC value of 27 and Th/U ratios of samples are mostly <5 typical to UCC. The most scattered values of these ratios describe the Szczawa tectonic window samples. The REE distribution shows light REE (LREE) sloping down to heavy REE (HREE) on UCC normalized plots (Oszczypko-Clowes et al., 2015). Dolomitization, K-addition (associated with illitization) and fractionation of trace elements are mainly explicit in the Szczawa tectonic window and suggest that rocks were infiltrated by brines, possibly being the "shchava" type.

Paleoecology and sedimentology of the Miocene marine and terrestrial sediments on the Devínska Kobyla hill and Hainburg hills (Vienna Basin)

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Dramatic tectonic and sea level changes of the Central Paratethys realm during the Middle Miocene (Late Badenian to Early Sarmatian) resulted in the coastal morphology and seabed changes affecting marine association composition and distribution of the facies along the coast. Three different episodes in the environmental evolution were interpreted in localities on the Devínska Kobyla hill and Hainburg hills spaced 8 km apart.

Lower marine episode (Late Badenian; Serravallian) was dominated by coarse grained sandy carbonatic and siliciclastic deposits derived from the crystalline rocks and Mesozoic sedimentary cover of the Malé Karpaty Mts. what point to the uplifted position of the source area. Still active tectonic movement of the region was documented by presence of clastic dikes. The sequence is characterized also by organodetritic sedimentation on and around the algal bioherm. Maërl facies (with unattached algal protuberances) typical for high energy "rhodalgal" environment evolved on the top of algal mound. On the slopes "rhodechfor" rim separated the bioherm from the rest of the bottom with seagrass cover and crustacean burrows. In the study area, this high energy rhodechfor is the most abundant environmental type. It is composed mostly of coralline algae (*Mesophyllum*, *Lithothamnion*, *Spongites*, *Lithophyllum*), benthic foraminifers (*Elphidium crispum*, *Neoconorbina terquemi*, *Miniacina* sp., *Borelis melo*), echinoids (cidaroid, spatangoid and diadematoid group), bivalves, bryozoans, serpulids and ostracods. Coralline algae form unattached protuberances and less praline rhodolith growth forms. Rare "echinofor" skeletal assemblage is characterized by the dominance of irregular echinoid fragments. "Bimol" skeletal assemblage with high amount of bivalves formed also in greater water depths was identified in couple of sites.

On the basis of fossil assemblages the studied sediment can be correlated with recent Mediterranean infralittoral biocenoses of „*coarse sands and fine gravels mixed by waves*" and „*coarse sand and fine gravels under bottom currents (SGCF)*" and circalittoral "*coastal detritic (DC)*" composed of organodetritic gravel with terrigenous sand and mud.

Shallow marine non-tropical rhodechfor, rhodalgal, echinofor and bimol skeletal assemblages are described from the Central Paratethys realm for the first time. Sparce solitery corals which did not form greater accumulation point to the non-tropical conditions. Warm temperate climatic zone where melobesioid algae associated with mastophoroids and lithophylloids was interpreted. Most of the studied sediment accumulated predominantly in the sublittoral zone influenced by waves and currents in the laguna or shelf with maximum water depth of 25 m.

Overlying terrestrial sedimentation sequence is represented by regolith, paleosoil and channel body sediments set discordantly on the top of the lagunal deposits. In the studied area this sediment is documented only from the "Medieval quarry" situated on SW slope of Devínska Kobyla hill.

Subsequent transgressive marine sequence (Lower Sarmatian; Serravallian) is characterized by coarse pebbly sediment with provenance in uplifted pre-Neogene basement.

Serravallian (Upper Badenian to Lower Sarmatian) age was inferred on the basis of the benthic foraminifera, calcareous nannoplankton and bivalve assemblages. *Titanoderma pustulatum* (Lamouroux) Nägeli point to the communication between Central and Eastern Paratethys realms.

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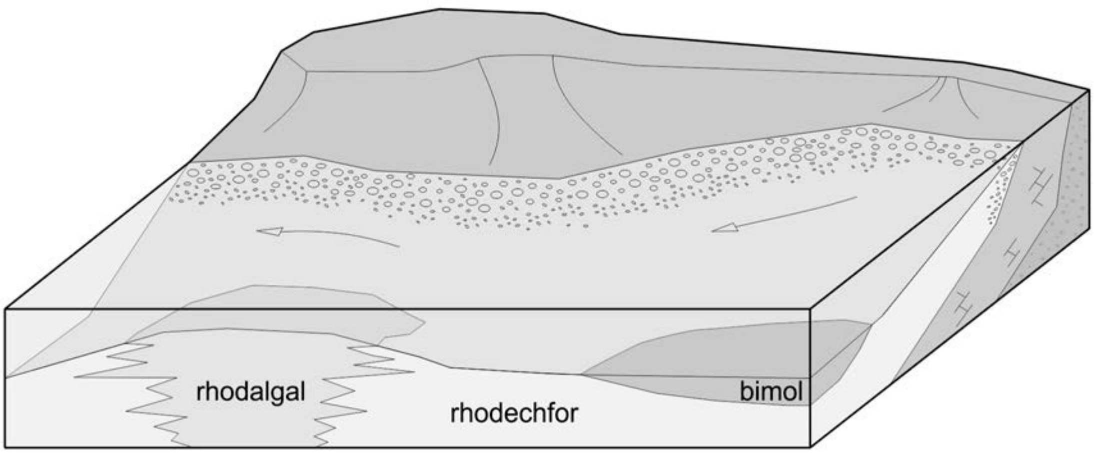

Figure 1: Block diagram of Middle Miocene environment with skeletal assemblages in Devínska Kobyla hill and Hainburg hills.

Structure of the eastern part of the Varín sector of the Pieniny Klippen Belt – unravelling the puzzle

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The studied area occurs in the borderland of the Kysuca and Orava regions in northern Slovakia, west of the N-S trending "Zázrivá sigmoid", between the villages of Lysica, Terchová and Zázrivá. The area was mapped already in 1930-ies by Andrusov (1938) and later by Haško & Polák (1979). The latter authors distinguished the Klippen Belt (PKB) units, namely the Kysuca and Orava, which are overlain by the Manín Nappe (nowadays correlated with the Klape Unit). The area is dominated by the highest mountain of the entire PKB – the Pupov Hill (1090 m a.s.l.) composed of Senonian marls and calcareous turbiditic sandstones correlated with the Klape Unit (Pupov Beds – Potfaj ed., 2003). The southern, W–E trending margin of the PKB is followed by imbricated lenses of the "peri-Klippen Paleogene" (Gosau-type, Paleocene–Middle Eocene Myjava-Hričov Group).

We performed detailed geological mapping, structural analysis and biostratigraphic investigations for foraminifers and dinoflagellates of various, mostly shaly and marly formations. Relying on the current concept of the PKB structure (Plašienka et al., 2012; Plašienka & Soták, 2015), we have distinguished three main Oravic tectonic units – the Šariš Unit (Plašienka & Mikuš, 2010), Subpieniny and Pieniny units (Uhlig, 1907) from bottom to top with various, partly differing successions and formations, and two nappe units of possibly Central Carpathian (Fatric) provenance – the Klape and Orava units. Overstepping post-nappe formations are represented by the Gosau-type Senonian Pupov Fm. and Lower Paleogene Myjava-Hričov Group.

The extraordinarily complex structure of this PKB part can be characterized as a synclinorium with almost all beds and successions overturned and steeply N-dipping. In general, the Oravic units are mostly rimming the PKB along its northern and southern margins, while the Klape and Orava nappe units occur in the centre and at the eastern part, respectively. The latter are associated also with the Senonian deposits of the Pupov Fm. However, there are numerous exceptions from this scheme and some formations sometimes occur in a very strange position. In consequence, our tectonic interpretation can merely be a preliminary one reflecting the present state of knowledge.

The Šariš Unit is only represented by fragments of its succession, e.g. by the Middle Jurassic "Black Flysch" and radiolarites (Szlachtowa, Opaleniec, Sokolica and Czajakowa fms) and variegated shales and sandstones of the Upper Cretaceous Malinowa Fm. Some characteristic members, like the calcareous flysch of the Jarmuta-Proč Fm., have not been recognized. Due to close lithological and spatial relationships to the Middle Jurassic formations, we associate the Lower Jurassic quarzitic sandstones occurring on the Jedľovinka Hill with the Šariš Unit, too.

The Czorsztyn Succession, as a typical representative of the Subpieniny Unit, crops out in patches along the northern PKB margin. Czorsztyn-type blocky klippen are mostly formed by Middle-Upper Jurassic sandy-crinoidal and red nodular limestones surrounded by Aalenian black shales and Upper Cretaceous variegated marlstones of the Púchov facies (e.g. Kopčeky near Lutiše, Holešova skala, Janíkov vrch, Erdúdsky kostol – see Jamrichová et al., 2012). The "transitional" Czertezik Succession is represented by one small klippe near Zázrivá village (Haško, 1976).

The Pieniny Unit is composed of the deep-water Kysuca Succession – its prolongation from the westerly located "Kysuca Gate" type area (Rochovica and Brodno klippen – see e.g. Michalík et al., 2009 and references therein). In the investigated area, the incomplete and dismembered succession lacks Jurassic members and consists of Lower Cretaceous bedded cherty limestones (Pieniny Fm.) and spotted marly limestones of the Fleckenmergel facies (Kapuśnica and/or Tissalo Fm.), followed by the Cenomanian–Santonian, upward coarsening-and-thickening synorogenic sequence of dark-grey marly shales, siliciclastic turbidites and bodies of conglomerates and pebbly mudstones containing also the "exotic" material (Snežnica and Sromowce fms, respectively).

The Orava Unit (Haško, 1978) is also a deep-marine succession, but with some special members (e.g., the Adnet Fm.) and with flysch sedimentation starting already during the Albian. According to Maheľ (1990), it likely represents a frontal element of the Krížna nappe system incorporated in the PKB. It builds two large klippen in the easternmost part of the area (Kozinec and Havranský vrch hills), separated by a distinct WNW-ESE trending dextral fault, named here as the Ráztoky Fault.

The Klape Unit consists mostly of thick prisms of mid-Cretaceous terrigenous flysch deposits that overlie the Kysuca Succession in the western part of the area. It is not to be excluded that a long stripe of klippen with Lower Cretaceous cherty limestones north of Lysica village, having been interpreted as a window of the Kysuca Unit, also belongs to the Klape Unit.

The up to thousand metres thick Pupov Formation occupies the central position in the PKB synclinorium and consists of several members. The lower part is composed of Coniacian–Santonian calcareous turbiditic sandstones with marly intercalations, followed by Campanian grey and variegated marlstones. The uppermost part is composed of probably Maastrichtian shallow-water gritty sandstones used as a sharpening stone. Although not definitely clear, we consider the Pupov Fm. as an element of the post-thrusting, wedge-top basins associated with the Gosau Group (cf. Plašienka & Soták, 2015 and references therein).

New structural and stratigraphic data from the Súľov conglomerates (Middle Váh Valley, Slovakia)

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The Súľov conglomerates are situated in the Middle Váh Valley area in basal formation of the Súľov-Domaniža Basin. They represent poorly sorted coarse breccias and conglomerates accumulated along scarps of synorogenic basin (Marschalko & Samuel 1993). This wedge-top basin (Plašienka & Soták, 2015) overlain the frontal parts of the Centrocarpathian and Peri-Klippen Units. In Súľov area the conglomerates are lying discordantly (from 20° to 60°) on the Cretaceous sediments of the Manín Unit. Sedimentary sequence in the NW of the Súľov village (in course towards to „Lúka pod hradom“) gradually changed from basal coarse-grained conglomerates through fine-grained conglomerates to calcareous sandstones and siltstones with very steep dip (from 68° to 86°) striking in NNW-SSE to NNE–SSW direction. In this part the Súľov conglomerates are interbedded by layers of yellow-brown claystones with rich microfauna of planktonic foraminifers, which were discovered for the first time. Foraminifers from the Súľov formation consists of species Acarenina praetopilensis, A. pentacamerata, Acareninacollactea, Turborotalia frontosa, Morozovelloides bandyi, Morozowella subbotinae, Subottinalina perta, S. senni, S. yeguaensisand Catapsydrax unicavus), which provide an evidence for Late Ypresian to Early Lutetian age. Considering that, the described sequence of conglomerates with claystones could be correlated with organodetritic limestones and sandstones, which superposed the Súľov conglomerates and underlain below the Domaniža Formation (Lutetian; Mello et al., 2011).

Súľov conglomerates are strongly tectonically deformed, in Súľov area having steep dip between 50° to 68° in SE direction. The first tectonic phase belongs to the Upper Paleogene (Upper Eocene to Oligocene), is recorded by compressional axis in NW-SE direction and by compressional to transpressional tectonic regime. During this event the Paleogene sediments of Peri-Klippen zone and Rajec and Turiec Basins were deformed, too (Hók et al., 1998; Rakús & Hók, 2003; Šimonová, 2011; Bučová, 2013). Next deformational event was changed from transpressional to transtensional tectonic regime. That is the reason why sinistral strike slips related to transtensional regime can be observed in the studied area. This kinematic change of deformation started during the Middle Miocene. The youngest recorded tectonic phase led to extensional tectonic regime with gradual rotation of extensional axes from NW–SE to NE–SW direction. The change to extensional tectonic regime is dated to the Upper Miocene to Pliocene.

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Metamorphosed sources of the Late Cretaceous flysch in the Infratatric Albian-Eocene accretionary wedge: impact on large-scale tectonics

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The Infratatric (IFTA) Unit (Putiš, 1992) of the Central Western Carpathians is exposed in Miocene horst of Považský Inovec Mts. in tectonic window below the Tatric Unit overlain with the Mesozoic Fatric and Hronic Nappes. Plašienka et al. (1994) consider the IFTA Belice Unit Late Cretaceous flysch as a trench flysch above the inferred subducted Vahic (~South-Penninic) Ocean crust. Putiš et al. (2006) consider the Aptian–Cenomanian Klape flysch in trench position, while the IFTA Jurassic to Early Cretaceous succession formed on a thinned passive, and Couches Rouges marls and the Late Cretaceous flysch on an active continental margin wedge due to inferred southward subduction of the Vahic/Penninic crust.

The Alpine evolution of the IFTA Unit is bound to a Variscan micaschist basement as a source of variable sedimentary rocks from the Late Carboniferous to Late Cretaceous. The Permian to Albian *Humienec Succession* was reconstructed from the anchimetamorphosed clasts, olistoliths and olistostromes in the late Santonian to Maastrichtian flysch. Pre-flysch hemipelagic Cenomanian to early Santonian Couches-Rouges type marls and upwards (with a hiatus?) continuing flysch define the *Belice Succession* in our scheme (Putiš et al., 2006).

The IFTA Unit records an inferred Jurassic–Early Cretaceous *Humienec Basin* closure and an accretionary wedge formation in late Early Cretaceous constrained by metamorphic white mica $^{40}Ar/^{39}Ar$ plateau ages between 115 and 100 Ma (Putiš et al., 2009), occasionally older (138±3 Ma and 130±3), found in very low-grade medium-pressure metamorphosed rocks of the higher IFTA *Inovec Nappe* which were the source of the Late Cretaceous flysch. The presence of illite–phengite with (K+Na) values from 0.7 to 0.9 pfu and K_2O from 8 to 10 wt.% in the IFTA accretionary wedge indicates anchimetamorphic conditions of 200–250°C at minimum medium pressure of 5–6 kbar (Sulák et al., 2009) or burial to 16–20 km depth.

The Eocene tectono-metamorphic overprint and subsequent cooling is constrained by the white mica $^{40}Ar/^{39}Ar$ plateau age of 48±2 Ma (Putiš et al., 2009) from the hanging wall blastomylonites of the Tatric Unit, K/Ar age of 46±3 Ma from an olistostrome basalt block in flysch (Putiš et al., 2006) and Zrn FT ages of 47–37 Ma (unpublished). The Cenomanian to Maastrichtian *Belice Basin* closed and the lower IFTA *Belice Nappe* has formed most likely due to *Biele Karpaty (Magura s.l.) Unit* oceanic crust subduction in the foreland. The lower anchimetamorphic conditions (150–200°C) were achieved in the Belice Nappe underthrust below the higher IFTA Inovec basement/cover and the Tatric Nappes.

The Early Cretaceous metamorphic event is consistent with the Aptian to early Cenomanian Klape flysch formation. The blueschist pebbles (Mišík & Marschalko, 1988) blue amphibole was $^{40}Ar/^{39}Ar$ dated at 155 Ma (Dal Piaz et al., 1995) resembling the Meliatic Bôrka Nappe „phengite" ages of ca. 170 to 150 Ma (Dallmeyer et al., 1996; Faryad and Henjes-Kunst, 1997). Despite some differences in blueschist protoliths and temperature subduction gradients (Faryad, 1997; Ivan et al., 2006), the Meliatic type Late Jurassic–Early Cretaceous subduction zone is inferred along the northern IFTA margin. The remnants of the sheared subducted slab below the Infratatricum and Tatricum at the depths of ca. 15–20 km are recognizable in seismic profiles (Leško et al., 1988; Tomek, 1993; Kytková et al., 2007). The inferred Late Jurassic–Early Cretaceous subduction mélange with HP rocks might have been resedimented in the Klape flysch in Albian during the mid-Cretaceous stage of the wedge formation.

The IFTA wedge formation was controlled by the subduction and slab erosion processes in front of the Infratatric nappes. The younging flysch strata from the Aptian in *Klape Succession* to Santonian up to Maastrichtian in *Belice Succession* may be related to roll-back of the subducted slab. Good evidence of subduction erosion of the upper plate is rare material in the flysch with older white mica ages of ca. 140 and 115 Ma, although the zircon FT ages of ca. 125–90 Ma (Kissová et al., 2005) were determined from the pebbles of A-type Permian granites (274±13 Ma, convential U/Pb method; Uher & Pushkarev, 1994). Plašienka (1995) proposed the north-Veporic (Fatric) origin of the Klape flysch, but the northern Veporicum was in exhumation after Turonian (Ar/Ar ages from 93 to 80 Ma; Putiš et al., 2009).

The South-Veporic–Gemeric–Meliatic accretionary wedge (170–130? Ma) (Putiš et al., 2014 and references therein) is timely overlapping with the northern part of the Infratatric–Tatric–North-Veporic (Fatric) wedge (ca. 150?–50 Ma) before the mid-Cretaceous. Do the Meliatic type fragments of the wedges belong to the same Tethyan Triassic–Jurassic Basin?

Triassic ophiolitic and related deepwater rocks (Ladinian and Lower Carnian red cherts with N-MOR- and E-MOR-type basaltic rocks, respectively) also occur in the Eastern Carpathians in external position to the Central W. Carpathians as blocks ranging from few metres to a few kilometers in size and as centimetre-sized in breccias, similarly embedded in the late Barremian–early Albian Wildflysch formation (Săndulescu, 1984; Höck et al., 2009) tectonically included in the Bucovinian Nappes of the Median Dacides after the pre-Vraconian (pre-105 Ma) orogeny. The Wildflysch Nappe is bordered by the Ceahlău unmetamorphosed Cretaceous flysch of the Outer Dacides (Săndulescu, 2009). Infratatricum may correspond to an enigmatic block derived from continental margin of the Main Tethyan Oceanic Domain rooted in the Main Tethyan Suture traced between the Pienides (Magura Nappes and the Pieniny Klippen Belt; Maramureş Zone of the Inner East Carpathians) and a Pre-Apulian Domain grouping the Northern Apusenides, Central W. Carpathians and Austroalpine Nappes (Săndulescu, 2009). The HP pebbles in the Infratatric Klape flysch could be a remnant of the same Tethyan Triassic–Jurassic Ocean as detected in the Dacides.

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Monazite chemical dating of acidic and intermediate volcanic rocks from the Permian sedimentary cover and dykes of the Infratatric Inovec Nappe in the Western Carpathians

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The Infratatric (IFTA) Unit (Putiš, 1992) of the Central Western Carpathians is composed of the higher Inovec and the lower Belice Nappes, exposed in Miocene horst of Považský Inovec Mts. The Inovec Nappe is overthrust with the Tatric Unit overloaded with the Mesozoic Fatric and Hronic Nappes. The Inovec Nappe micaschist basement is covered by the Late Carboniferous to mid-Triassic sedimentary rocks (Putiš, 1983). The Permian siliciclastics contain lensoidal km-size bodies of basic and acidic volcanic rocks exposed in wider area of Hôrčanská Valley in middle part of the mountains. Smaller bodies of both types occur in Javorí Hill area in the north, and as olistoliths in the Late Cretaceous flysch sediments of the Belice Succession. The basement and cover rocks show a distinct anchi-metamorphic overprint (Putiš, 1986; Korikovsky and Putiš, 1999; Sulák et al., 2009) which was dated by white mica (illite-phengite; 3.3 Si pfu) $^{40}Ar/^{39}Ar$ plateau age at 101.2±2.9 Ma (Putiš et al., 2009) from a Permian meta-sandstone (sample PI-4, Hôrka Valley, 1km NW of dated meta-rhyolite sample PI-R11). The Tatric Unit hanging wall blastomylonites record a similar older newly-formed white mica age of 102.3±1.9 Ma, and an overprint plateau age of 48±2 Ma (Putiš et al., 2009). The older age is related to mid-Cretaceous underthrusting of the IFTA Inovec Nappe below the north-Tatric nappes. The younger one is most likely related to closure of the Late Cretaceous Belice Basin and formation of the lower IFTA Belice Nappe underthrust below the higher IFTA Inovec and Tatric Nappes. The exhumation ages of the Tatric hanging wall blastomylonites following the mid-Cretaceous metamorphic event occurred from 90 to 70 Ma in Považský Inovec, Malé Karpaty and Malá Fatra Mts., or at ca. 50 Ma at Hrádok–Zlatníky thrust-fault dividing the IFTA and Tatric Units in Považký Inovec Mts. in the Eocene accretionary wedge.

The mid-Cretaceous anchimetamorphosed rocks were the source of the flysch overlying the Couches-Rouges type marls, the clayee matrix of which shows only diagenesis to lowest anchimetamorphic recrystallization, with still well preserved fossil remnants (Putiš et al., 2006, 2008). The inferred frontal Humienec tectonic slice (micaschists and the Permian to Early Cretaceous anchimetamorphosed sedimentary cover) of the Inovec Nappe yielded the most of material for the late Santonian to Maastrichtian flysch, including the Permian volcanic rocks and siliciclastics.

Meta-rhyolite (sample PI-R11, 72–77 wt.% SiO_2) from area of Hôrka Valley belongs to Permian cover of the IFTA Inovec Nappe. It has well preserved porphyritic texture of quartz, feldspars and biotite in fine grained recrystallized matrix with newly formed celadonite-rich muscovite („phengite“) aggregates. The dated monazite has suitable content of Th (1.4–4.2 wt-%) providing an age of 283±17.4 (2s).

Meta-dacitoandesite (57 wt.% SiO_2) north of Inovec Hill (sample PI-RD-1) occurs as a dyke crosscutting the Inovec Nappe basement micaschists, which are included as microxenoliths in the dyke. A few occurrences were found on western slopes of Inovec Hill. They have well preserved porphyritic texture of feldspars and biotite, less quartz in fine grained aggregate of lath shape sodic plagioclase, partly to totally replaced by newly formed very fine-grained white mica. In comparison with the meta-rhyolites from Hôrčanská Valley, they are richer in plagioclase that dominate in groundmass. Kalifeldspar occurs only as phenocrysts. The dated monazite has suitable content of Th (1.8–5.6 wt.%) providing an age of 257 ± 6.8 (2s).

The acidic to intermediate composition and different age of volcanic rocks could indicate two timely postponed Permian volcanic phases in the Infratatric pre-Mesozoic basement: 1) The early Permian acidic, and 2) Late Permian intermediate one. Anyway, association of intracontinental within-plate type basalts to basaltoandesites with rhyolites, trachyrhyolites and dacitoandesites (Putiš et al., 2006, 2008) indicate a distinct Permian extension tectonic regime in the IFTA Unit that is not characteristic for the Tatric pre-Mesozoic basement, including the overlying north-Tatric Panská Javorina Nappe.

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Calpionellid tests malformations recorded in Upper Jurassic and Lower Cretaceous pelagic carbonates of the Western Carpathians and Western Balcan - a tool for paleoenvironmental interpretation

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Characteristic morphology and assemblage composition of ancient planktonic ciliate protozoan loricas made of them a favourable tool for interregional correlation. They are playing a key role in the biostratigraphy of Upper Jurassic/Lower Cretaceous sequences not only in areas lacking in ammonites. Detailed comparative analysis of calpionellid associations along all the Tethys shows variations in relative species abundance, variability, diversity changes and also in variability of their lorica structure. As oligotrophic organisms, they were sensitive to environmental perturbations such as change of the water temperature, chemistry, salinity and the nutrient supply. Mass occurrence of these microfossils was associated with shallow basins and with intrashelf elevations. These enviroments were characterized by a permanent current regime positively influencing the nutrient input. It is worth to mention, that the abundance and size of calpionellid loricas decrease towards the open sea - they are less frequent in deep basins, being very rare or seldom in reefal and lagoonal settings or in proximal settings with permanent river-influenced elevated nutrient level and with changes in surface water chemistry. Two diversity maxima were recorded within the Intermedia and the Oblonga subzones and two crisis were observed at the end of the Colomi Subzone and at the beginning of the Murgeanui Subzone. During the last mentioned events, deformations (aberrant morphology) were documented in *Crassicollaria*, *Tintinnopsella* and *Praecalpionellites loricas* (Reháková, 2000; Benzaggagh et al., 2012; Lakova and Petrova, 2013; López-Martínez et al., 2013; 2015). Teratological (malformed) tests may coincide either with metal poisoning or with salinity changes. Global climate changes could have been evoked by active volcanoes noted at this time (Casellato and Erba, 2015). Oxygen isotope data signalized late Tithonian cooling followed by a warming at the beginning of the Berriasian (Weissert and Erba, 2004). Huge portion of siliclastic input which was documented during the Late Tithonian and Valanginian could indicate tectonic activity combined with rised humidity and with the eustatic sea-level drop (Michalík and Reháková, 1997; Michalík, 2007). Rapid decrease of oligotrophic nannoconid abundance correlable with the extinction of calpionellids has been interpreted as the Cretaceous first biocalcification crisis (Erba and Tremolada, 2004). Thus, thinning and deformation of calpionellid loricas could have been associated with distant volcanic effusions producing metallic contaminants and salinity variations.

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Alternation of Miocene facies and sediment entry points in the Blatné depression of the Danube Basin

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Deep petroleum wells drilled in the Blatné depression of Danube Basin penetrated a Cenozoic sedimentary record with a total thickness of ~ 3500 meters. The fill is composed from a narrow strip of the Inner Central Carpathian Paleogene sediments which occur in the northern part of the depression. These sediments are discordantly overlain by lower Miocene deposits (Biela 1978; Kováč 2000; Vass 2002). A short hiatus follows and the majority of sediments is then composed from Langhian (Lower Badenian) and Serravallian (Upper Badenian-Sarmatian) strata (Rybár et al. 2015, 2016). Deposition during the lower Miocene prerift stage was dominated by local fan-deltas and alluvial fans. The provenance analysis indicates erosion of pre-Neogene basement which entered the depression mainly from the SE and NW. In the central part a small but deep depocenter allowed sedimentation of offshore to possibly bathyal mudstones. The early synrift sedimentation began during the Burdigalian/Langhian transtensional opening of the Blatné depression. Conglomerates and sandstones were deposited and material entered the juvenile depocenters from all directions. During the Langhian synrift stage the accommodation space continued to grow and offshore environment developed in the central part of the depression. The offshore environment was surrounded by shoreface and deltaic environments that occurred on the depression margins. Provenance analysis confirmed ongoing erosion of basement rocks and erosion of some additional Miocene volcanic material that started to enter the depression form the SE. Nonetheless the main sediment entry points are in the W and NW parts. The whole depression is flooded for the first time during the early Serravallian late synrift stage and the depocenter shifts towards the East, what can point to an active sediment entry point in the NW. Offshore environment still prevails in the center of the depression, but the rest of the area is dominated by shoreface and deltaic environments. The late Serravallian postrift stage is connected with pronounced normal regression. River dominated deltas and vast coastal plains occupied the area. The main sediment entry points were in the W and NE. According to Šujan et al. (2016) these environments are later replaced by shallow lake, deltaic and alluvial plain conditions that prevailed during the Tortonian - Pliocene interval.

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Heavy mineral assemblages and garnet chemical composition as tools in discerning deep-sea Cretaceous-Miocene formations of the Skole Nappe (Polish Flysch Carpathians)

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Heavy mineral assemblages in the Cretaceous-Miocene deep-sea flysch formations of the Skole Nappe in the Polish Flysch Carpathians have been analyzed. The study area is located SE of Rzeszów. The formations studied include the Ropianka Formation (Senonian–Paleocene), the Kliva Member of the Menilite Formation (Oligocene: Rupelian), ”Transitional Beds” (Jutna Member of the Menilite Formation; Chatian–Aquitanian), and the Krosno Formation (Miocene). The Ropianka Formation and the Kliva Member in the northern part of the Skole Basin were supplied form the foreland located to the north-west. The Krosno Formation and probably a part of the Transitional Beds display evidence of palaeocurrents flowing from the south and south-east. For geology the mentioned units see Kotlarczyk (1966, 1978); Kotlarczyk & Leśniak (1990); Kotlarczyk et al. (2006).

The investigations carried out so far reveal differences of heavy mineral assemblages (within 0.06–0.25 mm fraction) between the formations. The older lithostratigraphic members, i.e. the Ropianka Formation and the Kliva Member, are zircon, rutile and tourmaline dominated (ZTR index = zircon + tourmaline + rutile up to 95% and 80%, respectively), which are accompanied mostly by staurolite, kyanite, lesser amounts of apatite and in some places by andalusite. Contrary to them, the younger sediments of the “Transitional Beds” are garnet dominated (up to 70%), whereas zircon, tourmaline and rutile occur in lesser amounts (ZTR up to 33%). The youngest sediments, represented by the Miocene Krosno Formation, display diverse heavy mineral composition depending on the area of sampling. In the southern part of the Skole Nappe, the heavy mineral assemblages resemble in composition the garnet-dominated “Transitional Beds” (garnet up to 67%; ZTR up to 28%). Towards the northern part of the nappe, where the lower part of the Krosno Formation was deposited probably later than in the south, the assemblages are garnet and amphibole dominated (up to 51% and 31%, respectively), accompanied mainly by apatite, staurolite, kyanite, epidote, zircon, tourmaline and rutile. The characteristic feature of the Krosno Formation in general is the significant contribution of apatite (up to 25%), while the additional specific feature of the garnet and amphibole dominated part of the Krosno Formation is the presence of single grains of a blue sodic amphibole.

Garnet from the Ropianka Formation and the Kliva Member displays composition typical of medium- and high-grade metamorphic conditions. Composition of garnet from the Krosno Formation points to their provenance from amphibolite, mainly medium-grade facies rocks, which is in agreement with composition of the heavy mineral assemblages. The garnet population of the Krosno Formation nearly lacks grains formed in high-grade granulite facies conditions.

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Determination and analysis of rock densities in the Carpathian-Pannonian lithosphere: based on the CELEBRATION 2000 experiment

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One of the most important goal of the CELEBRATION 2000 project was to research the structure and the dynamics of the lithosphere in the Carpathian-Pannonian region. In addition, the goal was to broaden the knowledge of deep-seated structures and the geodynamics of the complex continental lithosphere and to study the relationships between the main tectonic units of Central Europe.

The aim of this contribution is to determine and analyze densities of rocks in the Carpathian-Pannonian lithosphere. We present a density analysis based on the seismic interpretation along suitable seismic refraction profiles of the CELEBRATION 2000: CEL01, CEL04, CEL05, CEL06, CEL09, CEL11 and CEL12 (Janík et al., 2011). To these profiles we applied transformation of seismic P-wave velocity v_p to densities ρ by using Sobolev and Babeyko's (1994) and Christensen and Moony's (1995) formulas for crustal rocks, and Lachenbruch and Morgen's (1990) formulas for the lower lithospheric rocks. This contribution presents the determined densities in different depth, which depend on the pressure and temperature conditions in the crust and lower lithosphere. These results are shown for seismic refraction profiles CEL01, CEL04, CEL05, CEL06, CEL09, CEL11 and CEL12 crossing tectonic units of the Pannonian Basin, Transdanubian Range, Central Western Carpathians, Outer Carpathian Flysch, Carpathian Foredeep, Paleozoic Platform including the Lysogóry and Malopolská Units, East European Craton with Lublin Trough, and Bohemian Massif. Seeing that some of the seismic refraction profiles cross the same tectonic units, we were able to create graphical display range of depth and densities in the upper and lower crust, and lower lithosphere in individual tectonic units. A simplified chart is shown in Table 1.

These results provide significant input data for the density modelling of the Carpathian-Pannonian lithosphere.

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Tectonic Units		h [km]	v_p [km•s^{-1}]	ρ [g•cm^{-3}]
Pannonian Basin	Upper Crust	2 - 21	5,95 - 6,2	2,61 - 2,78
	Lower Crust	9 - 30	6,35 - 6,65	2,84 - 2,97
	Lower Lithosphere	21 - 100	7,85 - 8,4	3,29 - 3,47
Transdanubian Range	Upper Crust	0 - 20	5,9 - 6,25	2,69 - 2,8
	Lower Crust	17 - 30	6,5 - 6,65	2,89 - 2,94
	Lower Lithosphere	30 - 110	7,9 - 8	3,3 - 3,37
Central Western Carpathian	Upper Crust	2 - 25	6,05 - 6,25	2,66 - 2,8
	Lower Crust	13 - 36	6,55 - 6,7	2,9 - 2,97
	Lower Lithosphere	25 - 140	7,9 - 8,4	3,32 - 3,51
Outer Carpathian Flysch	Upper Crust	3 - 25	5,3 - 6,3	2,4 - 2,82
	Lower Crust	23 - 42	6,3 - 6,8	2,76 - 3,05
	Lower Lithosphere	35 - 170	8,08 - 8,05	3,33 - 3,45
Carpathian Foredeep	Upper Crust	3 - 25	5,55 - 6	2,56 - 2,71
	Lower Crust	23 - 42	6,1 - 6,8	2,68 - 3,01
	Lower Lithosphere	35 - 170	7,9 - 8,15	3,32 - 3,4
Paleozoic Platform	Upper Crust	3 - 27	5,5 - 6,3	2,54 - 2,82
	Lower Crust	20 - 44	6,65 - 7,05	2,94 - 3,13
	Lower Lithosphere	30 - 180	8,1 - 8,15	3,36 - 3,43
East European Craton	Upper Crust	4 - 22	5,2 - 6,2	2,41 - 2,78
	Lower Crust	10 - 51	6,45 - 7,15	2,83 - 3,13
	Lower Lithosphere	34 - 240	8,15 - 8,25	3,37 - 3,44
Bohemian Massif	Upper Crust	0 - 20	6 - 6,3	2,73 - 2,82
	Lower Crust	15 - 38	6,7	2,96
	Lower Lithosphere	30 - 140	8,05	3,36 - 3,38

Table 1: Thicknesses, seismic P-wave velocities and determined densities.

Paleostress evolution of the Manín Unit in western Slovakia: reconstruction based on kinematic analysis of multiple fault structures

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Our investigation was focused on the kinematic analysis and palaeostress reconstruction of the brittle structures of the Manín Unit cropping out in the Middle Váh River Valley in Western Slovakia. This originally Central Carpathian unit has become a part of accretionary prism of the front of Central Carpathian block where it was incorporated into the Pieniny Klippen Belt. Later, it was deformed again during the younger phases of the Alpine Orogeny together with the Outer Carpathians. Paleogeographically, the Manín Unit is considered to be the most external part of the Tatric sedimentary area, on an individual paleogeographic zone between Tatricum and Klippen zone (Andrusov, 1972). Alternatively, it is a nappe of Fatricum affiliation in the Vysoká development (Mahel', 1978). Structural analysis of brittle deformation that affected the Jurassic–Lower Cretaceous rocks of the Manín Unit at five main localities (Butkov, Tunežice, Mojtín, Manín and Skalica) was carried out based on the interpretation of palaeostress states. We have employed the program Win_Tensor for the computation of stresses and the separation of the faults into homogenous groups. Relative superposition of individual paleostress states was derived from field structural relationships; their stratigraphic age was estimated mainly by comparison with other published data from the adjacent south-western parts of the Western Carpathians (e.g., Fodor, 1995; Kováč et al., 1994; Králiková et al., 2010; Pešková et al., 2009; Vojtko et al., 2010). Palaeostress analysis in the Manín Unit revealed the existence of six different palaeostress fields acting in the period from the Palaeogene to Quaternary. The oldest deformation phase (pre-late Eocene) is characterized by compression in the W–E direction that was generated during the strike-slip to dextral transpressional tectonic regime. This event was accompanied by the formation of the dextral faults trending in the SW–NE and dominating over the sinistral faults. N–S trending oblique-slip reverse faults generated in a pure compressive regime, are superimposed on older fault structures. Next deformation stage (Egerian–Eggenburgian) is characterized by the WNW–ESE oriented SHmax, recorded by a great number of SW–NE striking oblique reverse faults. The strike-slip faults are mostly dextral features oriented SW–NE, whilst the sinistral strike-slip faults trend NNW–SSE. The third deformation stage (Ottnangian–Early Badenian) is represented by faults generated by a compressional regime with the NNW–SSE maximum horizontal stress axis SHmax. It resulted in formation of the conjugate strike-slip faults, including the NNE–SSW oriented sinistral strike-slip faults that predominate over the dextral faults. For this event the formation of multiple reverse faults is typical. Compression continued during the Middle–Late Badenian with SSW–NNE oriented SHmax axis. Generally, the number

of reverse faults decreased and the number of normal faults increased. The sinistral strike-slip faults oriented ENE–WSW prevail over the dextral strike-slip faults as a result of the next transtensional tectonic regime combining strike-slip movement with oblique extension. The fifth deformation stage (Sarmatian–Pannonian) reflects the next change of the tectonic regime that occurred during the WSW–ENE compression, where dextral N–S faults are dominating. The numerous normal faults indicate a primary role of NW–SE oriented extension. The last deformation phase (Pliocene-Quaternary) is characterized by a number of conjugate normal faults as the result of a purely extensional tectonic regime with the NW–SE oriented Shmin axis. The existence of many normal faults is likely caused by the relaxation of compressive tectonic stresses in the area. The reconstructed history of the palaeostress field orientations and rotations, partitioned into six principal deformation stages in the Manín Unit, is largely corresponding to the palaeostress reconstructions performed in neighbouring areas, and in fact in the entire Western Carpathian segment of the ALCAPA microplate.

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Foraminiferal event-stratigraphy and paleoenvironments across the K/T boundary sections in the Western Carpathians

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K/T boundary has been constrained in the Western Carpathian sections several times (see Salaj et al., 1978, Samuel et al. 1967), but its existence is still uncertain due to erosion connected with the Laramian tectogenesis. The sections promising for K/T boundary has been revised with some constraints, pointing out to the absence of lowermost P-serie biozones (P0-P1). New evidences of the K/T boundary has been gathered from the study of the stratigraphic drillings near Veľké Kršteňany, Žilina-Hradište and Krásno nad Kysucou - Čadca.

K/T boundary is most properly marked in the Kršteňany KRS-3 borehole, and that by LO of Abathomphalus mayaroensis and FO of *Parvularugoglobigerina eugubina*. Transitional interval is also well dated by microperforate species like *Globoconusa daubjergensis*, *Eoglobigerina simplicissima*, etc. The section grades upward to the Selandian formation with *Praemurica inconstans* and *Morozovella angulata*, Thanetian formation with predominance of conicate acarininids (*A. wilcoxensis*, *A. coalingensis*, *A. pseudotopilensis*, etc.), Ypresian formation with abundant and diversified morozovellids (*M. formosa*, *M. subbotinae*, *M. aragonensis*, *M. lensiformis*, etc.) and Lutetian formation with *Morozovella gorrondatxensis*, *Turborotalia frontosa*, *Acarinina topilensis*, *Globigerinatheka kugleri*, etc. Considering that, the Kršteňany section provides a most complete stratigraphical record from the K/T boundary up to the Zone E10, that corresponds to the Late Middle Lutetian.

K/T boundary in the ZA-2 borehole near Žilina (Hradisko) is developed in plankton-rich sequence, which allows to obtain a high quality stratigraphic record. The sequence begins with silty marls, which is Maastrichtian in age by presence of globotruncanid and heterohelicid foraminifers like *Contusotruncana*, *Racemiquembelina*, *Ganserina*, etc. This formation passes into dark bioturbated marls with impoverished microfauna, which higher up abruptly changed to *Parasubbotina*- and *Subbotina*-rich associations of the lowermost Paleocene formation. Middle Paleocene sequences is significantly enriched in large-sized foraminifers like angular and discoidal morozovellids (e.g., M. *angulata*, *M. acuta*, *M. conicotruncana*), numerous species of globanonalinids (e.g. *G. pseudomenardi*, *G. compressa*), muricate acareninids (e.g. *A. strabocela*, *A. soldadoensis*), and others. Marly sequence also contains an intercalations of coralgal limestones, that remind the so-called Kambühel Limestones.

New indications of K/T boundary has been also found in the Outer Western Carpathians in Kysuce region. Deep-water sequence of the Beloveža (Ráztoka?) formation of the Magura unit contains a rich microfauna of guembelitrids, which indicates

Guembelitria bloom at the K/T boundary. Herein, this stress microfauna is well documented by species *Guembelitria cretacea*, *G. danica* and *Woodbringina hornerstownensis*, which correspond with the P0 biozone of Arenillas et al. (2000). Paleocene sediments above *Guembelitria*-bearing formations differ by appearance of *Parasubbotina* species.

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Source rock geochemistry and sedimentary environments of the Oligocene mud-rich deposits of the Huty Formation (Prešov JT-10 borehole, Eastern Slovakia)

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Provenance and sedimentary environments of the Huty Formation have been inferred by using major and trace element geochemistry and foraminiferal and nannoplankton study. The Prešov section is formed by homogenous dark calcareous mudstones (50–34 m), which higher up pass to weakly calcareous claystones, laminated claystones, and fish shales.

The claystones of the Huty Formation are markedly depleted in Ba, Nb, Sr, and Tb relative to upper continental crust. Further, the rocks exhibit light rare earth element (REE) enrichment (La_N/Yb_N = 8.48–10.00), flat heavy REE, and significantly negative Eu anomalies (Eu/Eu* = 0.62–0.70) in chondrite-normalized REE patterns, similar to post-Archean average Australian shale (Taylor & McLennan 1985). Low Zr concentrations as well as various discriminant plots (for instance Th/Sc–Zr/Sc and Al_2O_3–TiO_2–Zr) indicate unimportant mineral sorting or recycling of these shales. The bulk chemistry and selected trace elements preserve the signatures of an intermediate igneous and quartzose sedimentary provenance, and thus suggest an immature continental margin magmatic arc to passive continental margin tectonic setting of the source areas for the Huty Formation shales. The Chemical Index of Alteration (CIA) (Nesbitt & Young 1982) values obtained from the shales studied range from 72 to 94 and suggest that the degree of weathering at the source areas was intensive. Such strong chemical weathering indicates a warm and wet paleoclimate.

Foraminiferal microfauna comprises of the large planktonic species in the lower part of the formation (*Globoturborotalita ouachitaensis*, *G. gnaucki*, *Globigerina praebulloides*, *G. officinalis*, "*Dentoglobigerina*" *venezuelana*, and *Paragloborotalia opima*). These cool-water foraminiferal species are associated with the planktonic pteropods, i.e. cold-adapted epiplanktonic molluscs indicating an influence of cold-water masses (Báldi 1984). Pteropoda-rich sediments of the Prešov section provide a correlative horizon with the Pteropoda beds of the Paratethys (Tard clays – Báldi 1984, Majkop Group – Popov et al. 2008). Diatoms also indicate a cool-water productivity and eutrophic conditions.

The most important foraminiferal bioevent is recorded by the appearance of *Globigerinoides primordius* in the upper part of the Prešov section (12.8 m).

This species with supplementary apertures occurred in the Late Oligocene (Zone O6), and is constrained as an ecological response of warming waters (Jenkins 1973).

Calcareous nannofossils from the lower part of the Prešov section (36.4 to 49.5 m) indicate the Early/Late Oligocene age (Zone NP23 and NP24), based on the species *Reticulofenestra lockeri*, *Isthmolithus lockeri*, and *Reticulofenestra ornata* (Martini 1971, Perch-Nielsen 1985). The upper part of the Prešov section between 10.5 to 36.4 m belongs to the Late Oligocene, based on the species *Cyclicargolithus abisectus* and *Helicosphaera recta* (Zone NP24). Calcareous nannofossils indicate a change of paleoenvironmental conditions in the interval of 36.4 m by decreasing of eutrophic and cold-water species from the lower part of the section, and by increasing of warm-water species towards to the higher part of the section.

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Mélange deposits in the Skrzydlna and Wiśniowa tectonic windows (Outer Carpathians) – preliminary results

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The deposits traditionally linked to the Subsilesian Unit occur in the Lipnik, Wiśniowa and Skrzydlna area, Polish Outer Carpathians. This region belongs to the larger Lanckorona–Żegocina tectonic zone. This zone was interpreted as a series of tectonic windows, where the Subsilesian Unit rocks crop out from the overlying Silesian Nappe (Książkiewicz, 1953, 1972; Skoczylas-Ciszewska, 1960; Burtan, 1978). Burtan (1978) distinguished Wiśniowa and Skrzydlna windows.

Burtan (1978) as well as Skoczylas-Ciszewska (1960) indicate difficulties in unravelling the geological structure of this zone, caused by strong tectonic deformations. Książkiewicz (1972) regarded Lanckorona–Żegocina tectonic zone as anticlinal structure originated by folding of both Subsilesian and Silesian nappes. According to Golonka et al. (2011) the diapiric-type migration of the less competent formations of Subsilesian nappe along the strike-slip fault forms these so-called tectonic windows.

The field observations indicate that the Subsilesian Unit is built of strongly deformed mélanges that is soft plastic claystones containing fragments of harder rocks. The Lower Cretaceous Grodziszcze, Verovice, Lgota formations are main components of this blocks. Węglówka and Frydek marls of Subsilesian Unit are also present in these blocks (Książkiewicz et al., 1962; Burtan, 1978; Waśkowska-Oliwa, 2005). The Czerwin sandstones (Burtan, 1978; Leśniak et al., 2005) are also characteristic for this zone. These sandstones are absent in the other Subsilesian Unit areas.

Two types of mélanges were distinguished: The deposits „blocks in matrix type" that is *de facto* breccias with mixture of clayey-sandy matrix and coarse material, which includes clasts differentiated by size and lithology and strongly deformed shales with layers of sandstones displaying budinage. The blocks in matrix type mélanges represent olistostromes according to Cieszkowski et al. (2011)

The mélange deposits age was established using micropaleontological investigations. The content of micropaleontological assemblages and samples biostratigraphy is linked to the type of sediments. The dark non-calcareous claystones contain Early Cretaceous microfauna, while gray marls and mudstones, contain microfauna's characteristic for Paleocene and Eocene.

The Early Cretaceous assemblages are dominated by agglutinated forms containing typical Early Cretaceous species *Glomospirella gaultina* Berthelin, *H. nonioninoides* (Reuss), *H. depressa* Vasicek, *P. variablis* (Vasicek), *T. neocomiensis* Geroch, *A. carpathicus* Geroch, *A. infimus* Bornemann, *P. troyeri* (Tappan), *C. crassa* (Geroch), *G. oblonga* Zaspelova, *T. vocontiana* Moullade, and *V. subfiliformis* Bartenstein. The Albian was estimated, however quite often the forams assemblages do not allowed the precise estimation and the longer Hauterivian-Albian interval was assumed.

The Paleocene samples contain extraordinary rich forams' assemblages (70 recognized species). The typical Paleocene *Rz. fissistomata* (Grzybowski) is present. The more precise age estimations were established by analysis of plankton containing acarinas (*A. nitida* Martin, *A. soldadoensis* (Brönnimann)), globigerins (*G.* cf. *primitiva* (Finlay), morozovellas (*M. subbotinae* Renz et Morozova, *M.* cf. *aequa* Cushman et Renz), subbotinas (S. *triangularis* White, *S. triloculinoides* Plummer, *S. velascoensis* Cushman, *S. triloculinoides* Plummer), and parasubbotinas (*P*. cf. *variospira* Belford, *P. varianta* Subbotina) suggesting middle Thanetian age.

The Eocene assemblages are dominated by planktonic forams. The subbotinas are most frequent. *S. corpulenta* (Subbotina), *S*. cf. *criociapertura* Blow, *S. eocaena* (Guembel), *S. linaperta* (Finlay), *S. yeguaensis* (Weinzierl & Applin), as well as acarinas (*A. bullbrooki* Bolli, *A.* cf. *collactea* (Finlay), *A.*cf. p*raetopilensis* (Blow)) suggest Lutetian age of the analyzed deposits. *R. amplectens* (Grzybowski), *E. propinqus* (Brady) and *C.* cf. *praelo-pjanicus* Mjatliuk represent early Lutetian benthic forms.

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Late Miocene to Quaternary evolution of the alluvial landscape in the northern Danube Basin: interplay of sediment supply and forming of accommodation space

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The Danube Basin represents northernmost subbasin of the Pannonian Basin System, which was formed by several distinct subsidence phases during the Neogene. The last major period of accumulation of up to 4500 m thick column of deposits is associated with filling of Lake Pannon depocenters during the late Miocene. The deposition in the Danube Basin occurred dominantly in alluvial environment after ca. 9.0 Ma, when the high sediment supply from the Eastern Alps and Western Carpathians led to regression of the water body (Kováč et al., 2011; Magyar et al., 2013; Šujan et al., 2016). This large portion of the alluvial strata was studied using an extensive dataset of several thousand boreholes, with the aim to recognize a detailed interplay between the rate of sediment supply and the forming of accommodation space.

A dominant part of the deposits is represented by the Volkovce Fm. accumulated by meandering to anastomosing rivers between ca. 6.0 and 10.0 Ma. The formation is generally highly fine grained, with floodplain facies content in the range 70-90% and low frequency of sandy channel bodies. Exceptions appear locally on the basin margins, where rivers from the Western Carpathians entered the basin (NE margin) or where low rate of forming of accommodation space led to stacking of the meandering channel belts (foothills of the Transdanubian Mountain Range).

The Volkovce Fm. is overlain discordantly by the Kolárovo Fm., which was deposited in an environment of braided rivers in the until now poorly constrained time span 2.6 to 4.1 Ma. The formation consists dominantly of gravelly and sandy channel facies, which resulted from decrease of subsidence rate and increase of sediment supply. This change was associated with a compression phase of the Pliocene basin inversion, characterized by synchronous uplift of basin margins together with subsidence of the basin central depression (Horváth & Cloetingh, 1996). This led to forming of erosional surface below the Kolárovo Fm. dominated by an incised valley in the northern part of the basin. The paleo-Váh river is the most favourable candidate for this incision. At least five phases of the high frequency cycles were recognized in the fill of the canyon. Each cycle is composed of gravelly low accommodation rate system tract with dominance of sandy-gravelly channel facies, followed by high accommodation rate system tract with channel belt - floodplain facies ratio ca. 1:2. The cycles are preceded by incisions drived by minor base level fall episodes, which are marked by concave bases. The content of coarse layers in the Kolárovo Fm. decreases towards the basin centre, where the incised valley opens towards the Gabčíkovo depression.

The last phase of evolution of alluvial systems is characterized by dominance of high sediment supply of the paleo-Danube river during the Quaternary and forming of up to 300 m thick gravelly succession. The apex of the large fluvial distributary system is situated in the Devín Gate between Malé Karpaty Mts. and Hundsheim Hills, on NW margin of the basin. The high sediment supply led to overwhelming of the tributaries and their orientation sub-parallel to the major stream on the basin margins. This phase is connected with (1) low subsidence of the central depression (possibly induced by compaction of underlying sequences), (2) by stagnation or very low uplift of the basin margins and (3) by uplift of marginal mountains mediated by fault activity and forming of river terrace staircases. Low accommodation rate probably resulted in amalgamation of gravelly channel belts across the basin.

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Nannofossil record across the Jurassic–Cretaceous boundary interval, Kurovice Quarry, Carpathian Flysch Belt: state of the art

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Jurassic–Cretaceous marine sequences of the Tethyan realm at the locality of Kurovice, Czech Republic were choosen for the multidisciplinary study of the J-K boundary. Tithonian–Valanginian strata, Kurovice Limestone and Tlumačov Marl respectively, are represented by whitish grey allodapic limestones intercalated with marlstones and belong to the Magura Group of Nappes, Carpathian Flysch Belt. Reháková (in Eliáš et al. 1996) mentioned here calpionellid zones ranging from the Crassicollarila to Calpionella elliptica including bloom *Calpionella alpina* that confirms the J-K interval.

Calcareous nannofossils were investigated in the fraction of 1-30µm separated by decantation method using 7% solution of H_2O_2. At first, hard rocks were disintegrated for finely powder. The first phase of works brought the following preliminary results:

- Strata provided poorly preserved calcareous nannofossils. Overgrowth and etching is extensive, making identification of some specimens difficult.
- Generally, assemblages are characterized by dominance of Ellipsagelosphaeraceae. Other placoliths are rare, usually fragmented and cannot be identified. The quantitative predominance of genera *Watznaueria* and *Cyclagelosphaera* may indicate strong etching and secondary post mortem modification of nannoflora association.
- Nannofossil record depends on the lithological character of strata. This phenomenon may affect final stratigraphic and paleoenvironmental interpretations.
- Calcarenites contain extremely poor nannofossils. In the finely ground detritus scarce nannofossil fragments (1-3 specimens per 10 fields of view of the microscope) are found represented exclusivelly by Ellipsagelosphaeraceae: *Watznaueria barnesiae* forms almost 80%, *Cyclagelosphaera margerelii* reaches up 11%.
- Homogenous limestones contain poorly preserved nannofossils with abundance ±1 up 10 specimens per 1 field of view of the microscope. Assemblages are represented by high numbers of genera *Watznaueria* and *Cyclagelosphaera* accompanied by rare *Conusphaera mexicana mexicana* and *C. mexicana minor*, *Polycostella beckmanii*, *Zeugrhabdotus cooperi*, and fragments of outer rims

of genera *Retacapsa*, *Helenea*, etc. Specimens of *W. barnesiae* reach up to 70% and *C. margerelii* up to 13%.

- Marlstone intercalations contain highly abundant (±50 specimens per 1 field of view of the microscope) and more diversified nannofossils. Although *W. barnesiae* quantitatively prevails, it is accompanied by higher number of other species of genera *Watznaueria* and *Cyclagelosphaera*, and by rare specimens of genera *Conusphaera, Nannoconus, Polycostella, Retacapsa, Helenea, Diazomatolithus, Zeugrhabdotus*, and others.
- For the present, following succession of the first (FO) or last (LO) occurrences of nannofossil species was observed: FO *Helenea staurolithina*, FO *H. chiastia*, LO *Polycostella beckmanii*, FO *Micrantholithus sp.*, FO *Umbria granulosa* and *Hexalithus noeliae*, FO *Watznaueria cynthae*, FO *Nannoconus ex gr. globulus*.

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Structure of the Pleistocene dammed lakes in the Kamienica River Valley in Gorce Mts. Magura Nappe, Outer Carpathians Poland: key study

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In Gorce Mts. a few traces of Pleistocene dammed lakes were found. The Gorces is a part of Beskidy Mts. Range, located north of the Tatra Mountains and Podhale region in western part of the Polish Outer Carpathians. Whole the massive presents characteristic morphology – para-radial arrangement of mountain ranges and valleys, radiating from the highest peak which is Turbacz Mt. (1310 m.a.s.l.). During detailed geological and geomorphological investigations in Gorce Mts. authors found a traces of Pleistocene and Holocene dammed lakes. The most spectacular lakes were found in source part of Kamienica River valley. Studied segment of the valley is located between Jaworzyna Kamienicka Range on south and Kudłoń Range on the north. Here on the distance of a few kilometers it has west-east extension.

The Gorces are formed on the area of the Magura Nappe, most inner tectonic unite of the Outer Carpathians. In the Gorces are represented two facial-tectonic subunits of the Magura Nappe. Its southern part is built of the Krynica Subunit and northern of the Bystrica Subunit. Source part of Kamienica River is located on the area of the Krynica Subunit. The Krynica Subunit is built of the Upper Cretaceous and Paleogene flysch deposits. In the studied area the Paleogene deposits are represented by the Zarzecze Formation and the Piwniczna Sandstone Member of the Magura Formation. The southern part of research area is built of the Early Eocene deposits of the Zarzecze Formation, which is represented by the thin- and medium-bedded, rhythmic flysch. Within the Zarzecze Formation occur thick-bedded sandstones and conglomerates called Krynica Sandstone Member. In the northern part of studied area occur Middle Eocene deposits of the Piwniczna Sandstone Member representing lower part of the Magura Formation. The Piwniczna Sandstone Member is represented by tick-bedded sandstones and conglomerates, in some places with packages of thin-bedded Beloveža beds-like flysch. In the studied area is formed an anticline, with the Zarzecze Formation in core and the Magura Formation in limbs. An axis of the anticline extends along the northern slope of Jaworzyna Kamienicka Ridge. While the valley adjusted to the orientation of the anticline structure.

A morphology of the analyzed part of Kamienica River valley marked very clearly segments with steep gradient, high and steep banks, and low gradient river segments with extensive terraces. Slops of the Kudłoń and Jaworzyna Kamienicka Ridges surrounding the valley in lower parts have larger declination, while in ridge-zone slopes have much more lower declination. It is very clearly visible on southern slopes of Kudłoń massive. Common elements in present morphology of investigated area are landslides, which origin in light of the research is connected with occurring here fault zone on NW-SE orientation. Detailed analysis on high resolution digital elevation model allowed to note, that the northern slopes of Kudłoń Mt. is located a large landslide. Morphology of the landslide in later periods was transformed by forming here smaller landslides. Some landslides deposits were accumulated in Kamienice River valley and now in this place where landslide toes were cut by the river is observed steep gradient of river and narrowing of the valley. Above these parts are visible valley's fragments are wide with low gradients. Its genesis connected with dammed valley by landslide. There the flat area is resulted of forming dammed lakes, and filling them by alluvial deposits. During fieldtrip researches in flatting part of the valley have been found sediments filled dammed lakes represented by silts, sandy-silts and grits. The found sediments proved, that hypothesis of existence here dammed lakes in past is true. Actually conducting palynological research, which will get for more detailed age dating of the dammed lakes.

Acknowledgement:
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Correlation of Late Miocene–Pliocene lacustrine to fluvial lithostratigraphic units of the Danube–Kisalföld Basin (Slovakia, Hungary)

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The northwestern subbasin of the Pannonian Basin System is crossed in the middle by the Danube river which marks the international boundary between Slovakia to the north and Hungary to the south. The basin is called “Danube basin” in Slovakia and “Kisalföld” in Hungary. The lithostratigraphic subdivision of the more than 4 km thick Upper Miocene to Pliocene sedimentary succession of the basin, deposited in Lake Pannon and in the adjacent fluvial environments, has been developed independently in the two countries. A careful study of the sedimentary formations across the entire basin, however, led us to claim that these formations are identical or similar between the two basin parts to such an extent that their correlation is indeed a matter of nomenclature only.

Nemčiňany Formation corresponds to Kálla Fm, representing locally derived course-grained deltas and gravelly shores along the basin margin (11-9.5 Ma) developed during the early transgressive phase of Lake Pannon. The deep or open lacustrine sediments are collectively designated Ivanka Formation without considering genetics in Slovakia, whereas they are subdivided into four formations in Hungary depending on their position and depositional processes. Endrőd Formation, calcareous to clay marls are found in center and flanks of deep lacustrine depressions (11.6-10 Ma) up to a thickness of several hundred meters, while Szák Claymarl marks floodings of the basement highs (ca. 10.2 and 8.9 Ma) and is only a few tens of meters thick. This latter comprises a thin transgressive lag overlain by open-lacustrine fossiliferous marls formed in water depth less than 100 m. Szolnok Sandstone represents deep basin turbidite systems (10.5-9.5 Ma) occasionally up to a thickness of 1000 m. Algyő Formation comprises the fine-grained slope deposits and related thin turbidites prograding through the basin between 10-9 Ma ago. Beladice Formation represents nearshore lacustrine and deltaic deposits, fully corresponding in its definition to Újfalu Formation (10.5-8.5 Ma). The fluvial deposits, assigned into Volkovce Formation in Slovakia are designated Zagyva Formation in Hungary (10-6 Ma).

The synoptic description and characterization of the formations offer a basin-wide insight into the development of this sedimentary basin during the Late Miocene.

The turbidite systems, the slope, the overlying deltaic and fluvial systems are all genetically related and are coeval at any time slice after the regression of Lake Pannon initiated about 10 Ma ago. All these formations are younging to the S, SE as the progradation of the shelf-slope went on. The Danube-Kisalföld Basin got filled up to lake level by 9 Ma, since then fluvial deposition dominated in areas of subsidence, transmitting huge amount of sediment to the SW and SE parts of the Pannonian Basin.

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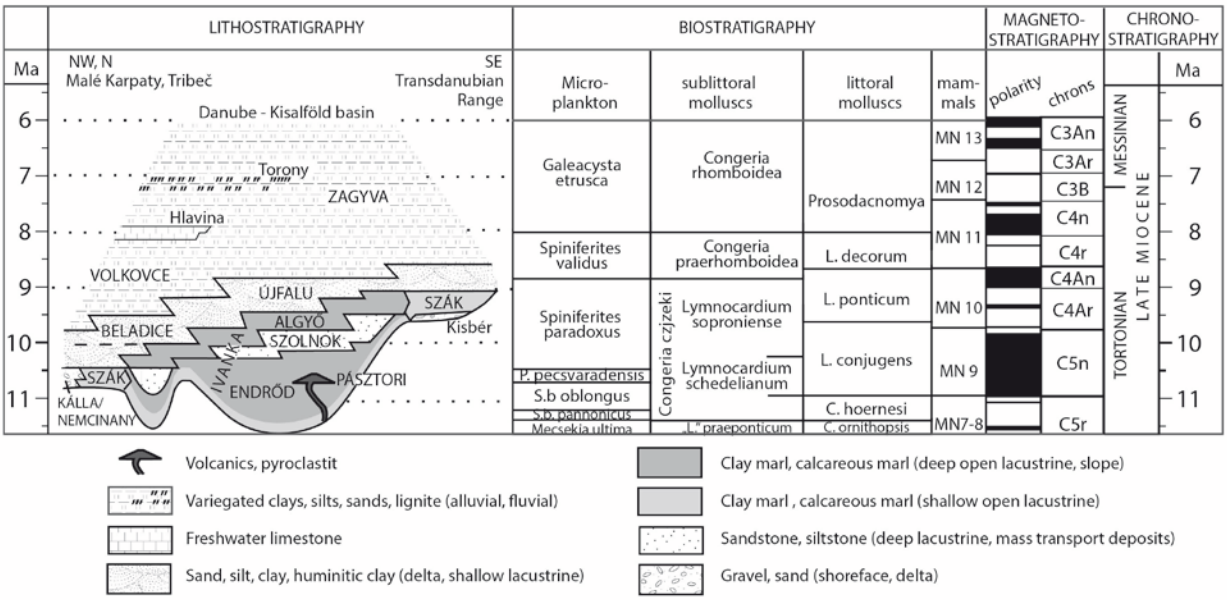

Figure 1: Litho-, bio-magneto and chronostratigraphy of the Late Miocene sedimentary fill of the Danube-Kisalföld Basin

What's common in Železovce Depression, Slovakia and Makó Trough, Hungary?

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Basin topography significantly alters the route of turbidity currents and determines the depositional architecture of turbidite systems, thus plays a confining role. This large scale of confining topography is 10s of kms in length, and up to several 100 meter high and are mainly related to the overall structural setting (Sinclair & Tomasso, 2002). Here two examples are presented from the Late Miocene lacustrine fill of the Pannonian Basin (PB).

The Makó Trough (MT) is one of the deepest depressions in the PB, where the Late Miocene lacustrine record exceeds 4200 m. It was a 60 km long and 30 km wide elongated basin with more than 1000 m high topographic relief along its flanks. The oldest turbidite systems deposited when the basement highs on the flanks were subaerially exposed. Beds of coarse- to fine-grained sandstones with Bouma-sequences and poorly sorted gravelly, silty sandstones with a variety of soft-sediment deformations appear between the open/deep-water siltstones. Despite the very short transport distances not only sandy grain flows but turbidity currents were active, the latter most likely reflected from the opposing slopes. Afterwards gradual flooding of the basement highs took place. These marls, however still contain intercalations of conglomerates, coarse sandstones still of local origin from debris flows and gravelly- to sandy turbidity currents. A very strange lumpy, silty-sandy facies also occur, interpreted as hybrid even beds (HEB, Haughton et al., 2003), one of the best indicators of confinement. With the overall regression, at about 7 Ma ago the delta-shelf-slope feeder system bypassed the largest topographic barrier northwest to MT. Turbidity currents, transporting sand from distal Alpine-West Carpathian sources arrived to the ultimate sink without being trapped in upstream depressions. In the still deep and narrow trough in the following 1 Ma basin-centered sandy turbidites accumulated up to a thickness of 1000 m in form of small compensationally stacked lobes. Presence of HEBs, lack of clays and silts and direction of channels reveal that the eastern flank of MT still acted as a topographic barrier. Finally the differences in relief got mostly eliminated by filling up the depression, and the feeding shelf-slope progressed with 600 m high clinoforms. The reduced thickness of lobes in the related turbidite system indicate fairly free spreading and the cease of confinement.

Železovce Depression (ZD) is the 70 km x 50 km eastern portion of the Danube-Kisalföld Basin (DKB). As the ZD was connected to the deep central part of the DKB from the east it does not look like as a classic confined setting. However, from the east it was bounded by a large Middle Miocene volcanic edifice, from the Kozmálovce High (the SW part of the Štiavnica Stratovolcano) in Central Slovakia to the Börzsöny Mts. in Hungary. Although direct sediment input into Lake Pannon is not known from these volcanoes, it is supposed that they were exposed during the Late Miocene. From the south ZD was bordered by the Gerecse Hills, which was an exposed Mesozoic-Palaeogene block up to 9.2 Ma ago, but afterwards it became a flooded basement high, later covered by offshore clays and deltaic lobes (Magyar et al., *this volume*; Bartha et al., *this volume*). A similar situation is reflected by the nearby Modrany-1 and Nova Vieska-1 wells: its block shows a deeper position, because offshore clays are overlain by ca. 350 m thick slope shales, followed by deltaic lobes coeval with those of the Gerecse Hills (Šujan et al., 2016). Lack of turbidites indicates that both of these blocks were high enough to form a topographic barrier for turbidity currents arriving from the prograding shelf-slope at E-NE-N (Magyar et al. 2013). Deposition of turbidites might began at about 10 Ma ago at this area, but with the progradation of the slope the basin gradually became smaller, by 9.2 Ma ago <40 km wide only, practically with full confinement. This is revealed by the thickness of stacked turbidite sands (up to 1000 m) in Kolarovo-1 and -2 wells (Šujan et al., 2016). This is an extremely thick value if compared with the thickness of turbidites in the S, SW parts of the DKB, where it rarely attains 300 m. The topographic difference between the central and marginal parts of ZD might have exceeded 1000 m over a distance of 20 km, which may indicate a coeval structural control at the basin margin. Small-scale proofs of confined turbidites can be found by revisiting the cores of these wells.

Due to the structurally complex character, the highly variable lake-floor topography several other depressions in the PB are candidates of confined turbidite accumulations.

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Deep-water conduits of the Lake Pannon, southern Transylvanian Basin, Romania

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The Carpathians were the major source of sediment for the Pannonian Basin during the late Miocene. Tectonic pulses and climatic changes in the source area could readily influence the sedimentary patterns even in the deep basins. The Transylvanian Basin offers outcrops of turbidites fed by the uplifting South Carpathians. High-resolution facies analysis was carried out in order to reveal the internal anatomy of the architectural elements.

Primary channelform surfaces in the outcrop near Daia are smooth and steep sided. The middle of channelform bodies are made up of conglomerate lags, passing upwards into thick amalgamated sandstones with rip-up clay clasts and rare cross stratification. These beds laterally transition into a thin-bedded mixed sand-mud facies association, containing abundant parallel and cross laminated intervals. Secondary channelform surfaces and erosional bases of beds are present within primary ones. The primary surfaces are dominantly laterally, slightly vertically stacked. The offset stacking preserves the evolution of the channel.

High density pebbly and sandy turbidity currents were the major agents in this system. The highest energy and volume flows could carve the channelform surfaces. As erosion changed into bypass, conglomerate lags were left as the coarsest sediment load. As flows became more depositional at the point of observation, thick sand beds were produced in the axis of the channel. The upper, low density parts of the same flows formed traction deposits and mud drapes on the confining margins of the channel. The filled channel gave way to a new suit of flows, but the conduit laterally migrated. The multiple cut-and-fill cycles were terminated by the final abandonment of the channel complex, recorded by a capping mud unit. Erosion-bypass-deposition cycles are driven by the changing magnitude of flows, probably resulting from hinterland tectonic pulses, climatic changes or the relative water-level changes.

Depositional cycles are also preserved in the downstream counterparts of the channel in the Transylvanian turbidite system. Another compound channel fill has more lateral migration and is more homogenous in grain size, no lag deposits and mud drapes are present. However, the basal incisional surface is preserved, and scattered outcrops indicate that isolated channels formed probably as a result of avulsions and low aggradation rate. The lobes of the system record upward thinning and fining cycles. Amalgamated pebbly sandstones and scour surfaces suggest a channelized lobe, probably a proximal axial or medial axial part of a lobe. A mixed sand-mud facies association with laterally varying bed thickness indicates a proximal lobe fringe setting. Upward thinning cycles are attributed to lateral or upstream stepping of lobe elements. Signs of lobe abandonment and switching are preserved by thin-bedded turbidites, mud drapes and erosional bases of lobes. The diverse architectural elements could develop in one turbidite system, reflecting downstream and along strike variations.

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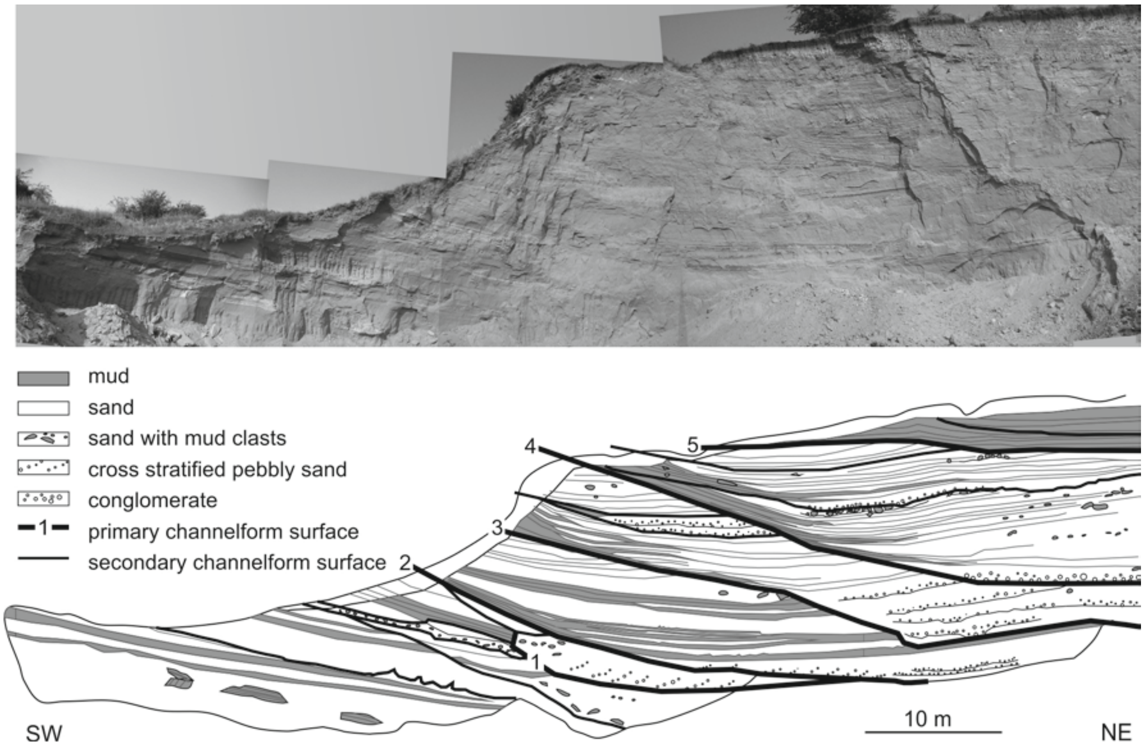

Figure 1: Channelform surfaces and bodies of the Daia outcrop.

Microfossils accompanying some Perisphinctoid Ammonites from the Štramberk Limestone (Tithonian to Early Berriasian from the Silesian Unit, Czech Republic)

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In Moravian-Silesian museums in the Czech Republic, Vienna Museum of Natural History and Bayerische Staatssammlung für Paläontologie und historische Geologie of the University in Munich, ammonites collected previously in the Štramberk Limestone are deposited. A common feature of all of these older collections is that the finds miss precise localization. Museum original labels usually state only Stramberg or Štramberk. The oldest finds come before the year 1861especially from the Castle Hill (Zámecký vrch) Quarry. This material was taxonomically processed in a monograph by Zittel (1868). Another collection was processed by Blaschke (1911). His specimens come largely from the Kotouč Quarry (formerly Gutmann Quarry).

At present, the stratigraphic position of the presented ammonites can be derived in the case of well determinable species only on the basis of data in literature if such species were also found in other stratigraphically dated sections in foreign localities. Moreover, a significant auxiliary element is the occurrence of guide microfossils provided by microfacies analysis of associated rocks surrounding or filling the ammonites.

We make efforts to define a more precise stratigraphic position of the above-mentioned finds containing stratigraphically important microfossils. For this reason, from of 27 ammonite specimens 38 thin sections were prepared. Only a small part of them (17 cases) contain however guide microfossils.

The oldest of the established species belongs to a large specimen of *Lithacoceras eigeltingense* Ohmert & Zeiss, 1980. According to Schweigert and Scherzinger (1995) and others, this species occurs there as a guide “eigeltingense-Horizon” in the basal part of Lower Tithonian ammonite zone with *Hybonoticeras hybonotum*. A specimen of the mentioned species represents the stratigraphically oldest species yet found in the Štramberk Limestone. The Early Tithonian age is also documented by the occurrence of common cyst of *Parastomiosphaera malmica* (Borza) observed in pelbiointraclastic wackestones to packstones.

Based on study of the type material of *Blaschkeiceras schoepflini* (Blaschke, 1911) deposited in Vienna and a single specimen found by us recently in the Kotouč Quarry, we have come to the conclusion that *B. schoepflini* represents microconchs to *Blaschkeiceras kittli* (Blaschke, 1911). Pelbiointraclastic wackestones, packstones to grainstones contain cysts of *Parastomiosphaera malmica* and morphological varieties of saccocomid skeletal elements indicating Early Tithonian age of sediments.

To the same subfamily, *Kutekiceras pseudocolubrinus* (Kilian, 1895) belongs as well. The mentioned species is abundant in the Early Tithonian of Mediterranean Bioprovince.

The both smaller specimens (less than about 100 mm in diameter) and larger specimens (from 100 mm to 260 mm) of *Paraulacosphinctes transitorius* (Oppel, 1865) were identified. With reference to the development of ribbing of both size groups, we regard this as a result of sexual dimorphism, i.e. we consider them as microconchs and macroconchs. According to Zeiss (2001), *P. transitorius* occurs in the Early Tithonian at Štramberk and in Lower Austria. Even the content of microfossils in the thin sections does not contradict this.

What is remarkable in the Štramberk Limestone is the occurrence of Riasanites cf. swistowianus (Nikitin, 1888). The riasanitids belong to the category of boreal ammonites. Pelbiointraclastic packestones to grainstones contain rare but predominantly small forms of *Calpionella alpina* Lorenz, *Crassicollaria parvula* Remane and *Globochaete alpina* Lombard among small fragments of hydrozoans, algae, sponge spicules, crinoids, ophiurids, echinoids, ostracods, bivalves, brachiopods, benthic foraminifera indicating their Early Berriasian age.

The last representative of ammonites belongs to *Pseudargentiniceas abscissum* (Oppel, 1865). In the thin section, small forms of Calpionella alpina predominate over loricas of *Crassicollaria parvula*, *C. brevis* and *Tintinnopsella carpathica*. Similarly to the previous case, it is rather Early Berriasian calpionellid assemblage.

In addition to the knowledge of sexual dimorphism of some species, the most important acquired findings are stratigraphic data. The occurrence of *Lithacoceras eigeltingense* moves the existing stratigraphic range of the Štramberk Limestone from the higher part of Early Tithonian to the basal part of Early Tithonian (ammonite Hybonoticeras hybonotum Zone). The stratigraphically youngest finds belong to the Early Berriasian (Berriasella Jacobi Zone), which corresponds to currently accepted knowledge.

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Tectono-thermal evolution of the Veporic Unit in the Western Carpathians (Slovakia): evidence from geochronological data

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The Western Carpathians are the north-eastern most part of the Alpine orogenic belt in Central Europe. The Carpathians share a Variscan and Alpine tectono-metamorphic history that is in the Tatric, Veporic, and Gemeric units. The Veporic Unit, the central unit of these three major south dipping, thick-skinned basement/cover imbricates, overrides the Tatric-Fatric units in the north-west along the Čertovica thrust. It is overthrust by the Gemeric Unit that is tectonically overlain by a Jurassic subduction-accretionary complex emplaced during the closure of the Meliata Ocean and by the Hronic and Silicic superficial nappes. Tectono-thermal evolution of the central portion of Veporic Unit (Western Carpathians) was revealed by multiple geochronological methods, such as ^{87}Rb/^{86}Sr on muscovite and biotite, zircon and apatite fission track, and apatite (U-Th/He) analysis. Based on the newly obtained geochronological data, several Alpine tectono-thermal stages can be distinguished. During the Cretaceous nappe stacking (~120–90 Ma) the Veporic Unit was buried beneath the Gemeric Unit and Jurassic accretionary wedge of the Meliata system nappe pile and suffer metamorphic peak of greenschist- to lower amphibolite facies. After the nappe stacking the Veporic Unit was exhumed in response to orogen-parallel extension followed by denudation at the Late Cretaceous to Eocene time (~90–35 Ma). This tectonic process led to formation of upright large crustal-scale folding resulting in fundamental differences in the Alpine peak PT conditions (from up to 650°C in the antiforms to 380°C in the synforms) of the exhumed Veporic Unit. According to new geochronological data (biotite ^{87}Rb/^{86}Sr, zircon and apatite fission track data), the whole central portion of Veporic basement cooled en-block from temperature of ~350°C up to 60°C between ~80 and 55 Ma. Tectonic exhumation was replaced by denudation processes, indicating by obtained older group of apatite (U-Th/He) ages of ~55–35 Ma. The erosion/denudation processes resulted in formation of planation surface before the Late Eocene transgression. However, the Central Carpathian Palaeogene deposits did not exceed a thickness of ~1.5–2.0 km, revealing by the younger group of apatite (U-Th/He) ages of ~21–17 Ma. The Early to Middle Miocene is characterized by destruction and denudation of intra-Carpathian Palaeogene basin (~20–13 Ma) and formation of the Sarmatian Veporic volcano-plutonic complex (~13 Ma). The final shaping of the Veporic domain has been linked to destruction and denudation of volcanic structure since the Late Sarmatian. A relatively young uplift (Pliocene and Quaternary), but not so intensive or most probably delayed, can be inferred from considerable preserved initial planation surface (midmountain level) which has not been destroyed yet (Vojtko et al., 2016).

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Kiscellian sediments in deep oil wells of the Danube Basin

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We present the results of microfauna reevaluation of Tertiary sediments in Želiezovce depression of Danube Basin in terms of presence of chrono and lithostratigraphic units in problematic sections of two selected deep oil wells excavated in the 60s of 20th century by former company ČND Hodonín.

In the past, the oil boreholes were realized with intention to determine the stratigraphy and lithology of Neogene sediments, to verify their oil and gas carrying capacity. Altogether, 22 samples have been analyzed from boreholes Modrany 1 (M 1) and Nová Vieska 1 (NV 1).

Borehole Nová Vieska 1 (according to our results terminated at a depth of 3 171 m by Kiscellian, originally by Priabonian) did not reach pre-Neogene, respectively pre-Tertiary subsoil, not even after deepening the projected footage.

In the Neogene we found sediments of two stratigraphic stages: Badenian and Sarmatian. The Sarmatian sediments as Vráble Formation, foraminiferal biozone with *Elphidium reginum* (Grill, 1941), have been ascertained in the well Modrany 1, in depth 1 050–1 056 m. Middle Badenian as Pozba Formation, microfaunistically appertaining to biozone of *Spiroplecatmmina carinata* (Grill, 1941), in the well Modrany 1/ 1 098–1 303 m. Lower Badenian as Bajtava Formation, microfaunistically appertaining to lagenida biozone (Grill, 1943), is represented in the well Modrany 1/ 1 402–1 760 m and Nová Vieska 1/ 1 797–2 562 m.

In the Paleogene, there were in chronostratigraphy the most striking differences in comparison to previous evaluation. Upon foraminifera we reclassified sediments formerly classed with Priabonian and Latorf to Oligocene (Kiscellian and Egerian) (Fig. 1) and those with Rupelian to Lower Badenian.

An important step was that in the Danube basin been for the first time applied the lithostratigraphic units of Buda Paleogene (Budai & Konrád, 2011). Acquired microfauna gave and furnished proof of the age of Kiscellian Formation to Kiscellian up to lower Egerian. In the well Nová Vieska 1 (from about 3 148 m), under Kiscellian Formation there is Hárshegyi sandstone.

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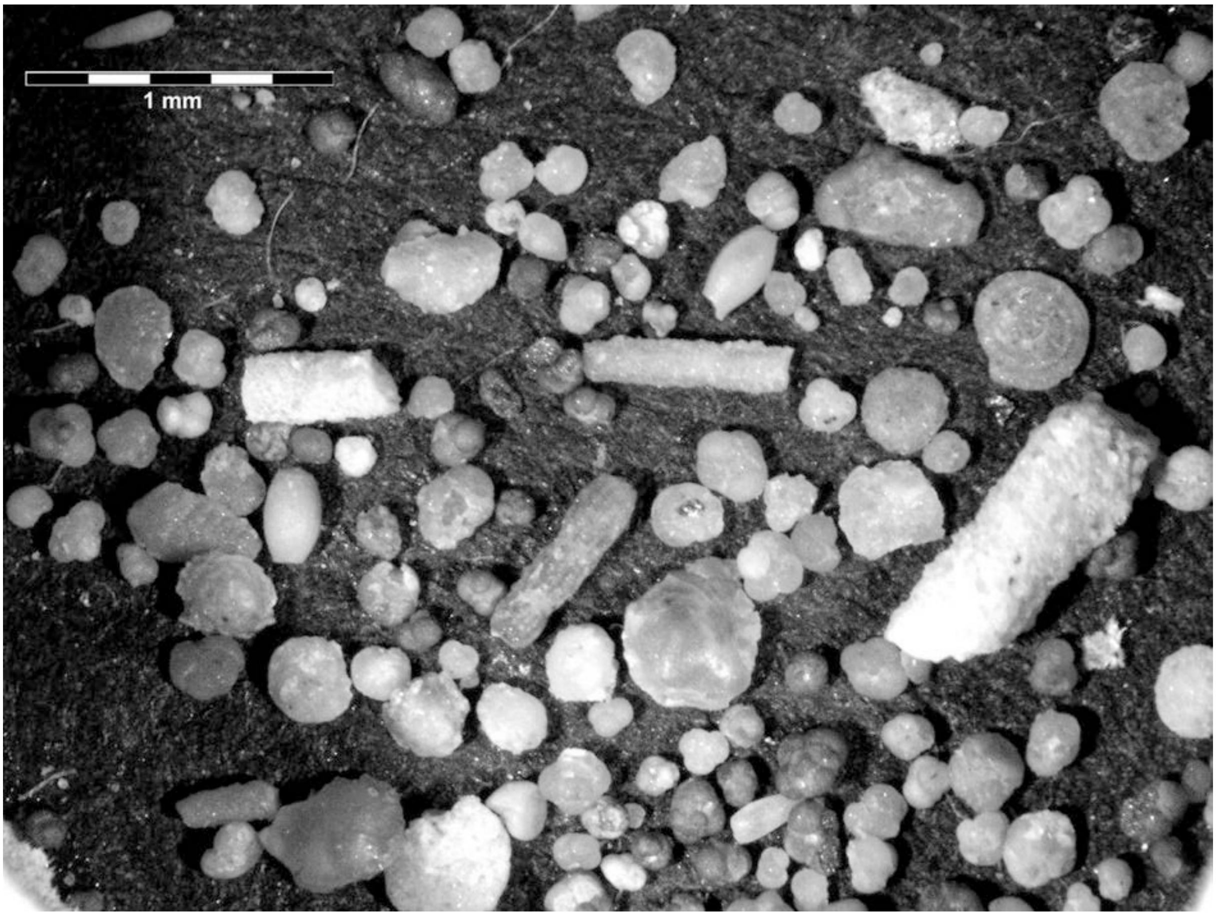

Figure 1: Intercommunity of foraminifera from borehole Modrany 1 in depth 1 990 –1 995 m.

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